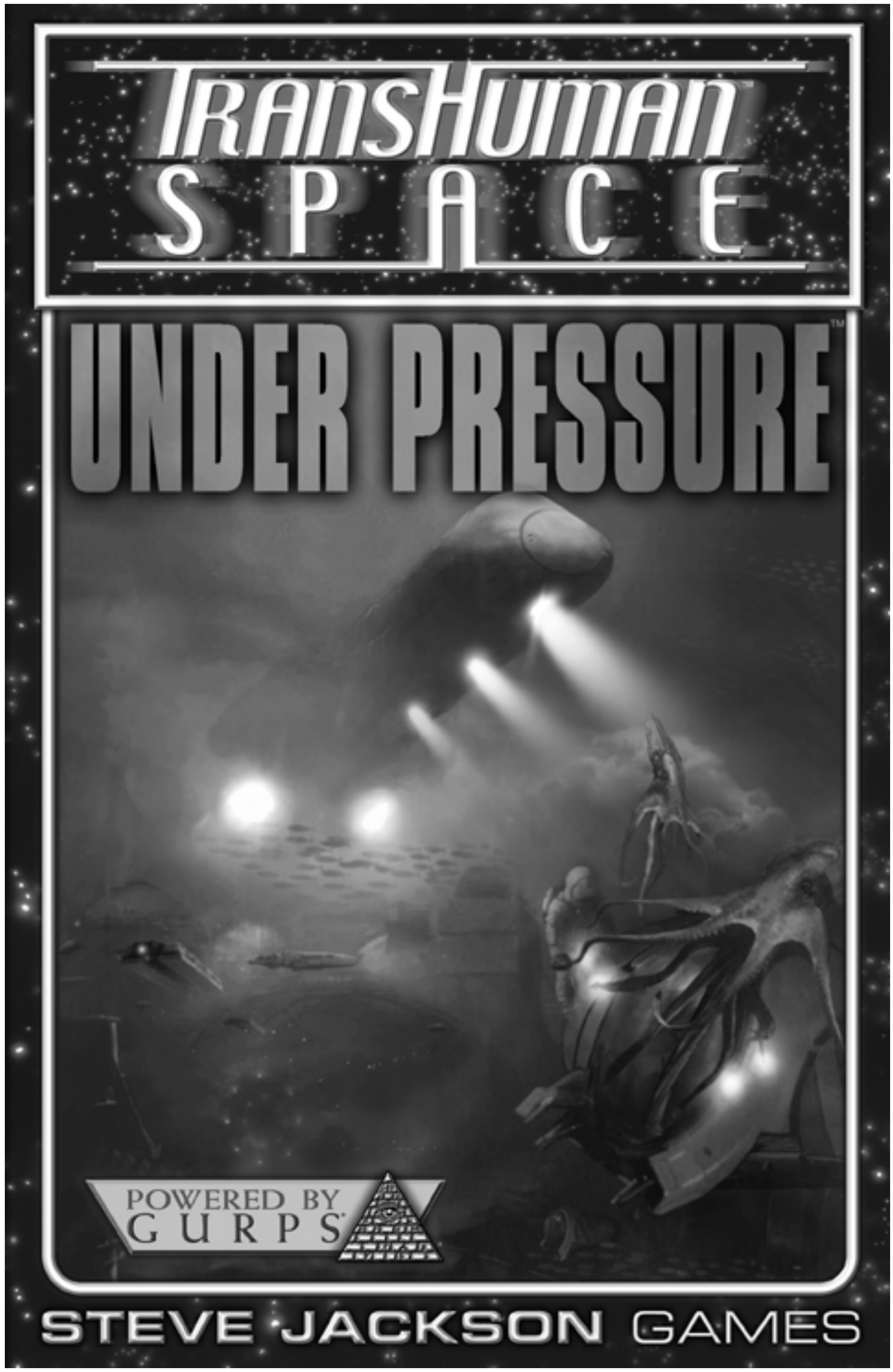
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A–HEAD

The Other Frontier

The secret pit of the ocean holds a universe of tangledinfinities: perpetual currents, enduring pressures, and a darkness measured inhundreds of millions of years . . . Because of its inaccessibility, it is aworld with the dew still on it . . . Because it is so colossal, covering morethan half the surface of the planet, the deep ocean is Earth's last greatuntouched place. A mile or two beneath the sea, the twentieth century seemslike a rumor.

Joe MacInnis, Science Advisorto ***Titanic*** *Discovery Team.*

In 2100 the oceans are the battleground of Earth. Regionsformerly beyond the control of any nation are being exploited for the mineraland biological wealth they possess. With formal treaties rare, territorialclaims must be defended with might. Nations cobble together aquatic colonies asrapidly as they can in order to legitimize "ownership" of the oceans,while corporations simply build new land in convenient and government–freelocations.

High–tech surface and submarine navies patrol the restlesswaters. Many engagements are with commercial fishing or mining ventures,operating outside a protective jurisdiction. The forces of terrorism are alsowell–equipped, with the ability to take out unprotected ships or commercialoperations platforms. Major targets for activist groups are the many companiesengaged in modifying (or defiling) the ocean environment by creating genemodspecies which out–compete natural species, strip–mining the sea floor,uplifting sea creatures to sapience and enslaving them, or producing parahumansand bioroids adapted for living underwater. Companies and the nations whichsponsor them must defend themselves.

But the oceans are immense and no power can patrol everywhere.Filling the gaps are free settlements and homesteads, inhabited by peopleseeking respite from the politics of the modern world. Never before has it beenso easy to renounce all national ties and live free of government. And neverbefore has it been so easy to set up criminal operations far away from thescrutiny of the law.

Humanity had mapped the moon and Mars by the late 20th century.By the dawn of the 22nd century, the oceans of Earth still hold secrets andpresent a troubled frontier for transhuman society.

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Timeline

2009: Deadline for thelodgement of national claims to sea–floor territory beyond 200 nautical milesunder article 76 of the United Nations Convention on the Law of the Sea;several nations make a flurry of last–minute claims.

2011: Atlantic bluefintuna stocks collapse under pressure of overfishing and taking of juveniles the species all but vanishes from the Atlantic Ocean.

2013: FirstInternational Conference on Fish Stocks meets in Trieste, but fails to resolveanything after much heated debate.

2018: Pacific bluefintuna stocks collapse. Single tuna prices at Tokyo's Tsukiji fish market surpass$1 million.

2021: Armenian forcesstrike Azerbaijani oil wells, causing catastrophic oil spill in the CaspianSea.

*2022:*Turkishmillionaire Melik Evrim buys an aging Iraqi oil tanker and secretly converts itinto a genetic engineering laboratory. Operating offshore to avoid regulation,this successful endeavor becomes the transnational Biotech Euphrates.

2024: Northern rightwhales become extinct; the last known individual is killed by a ship strike.

2027: United Statesbegins first large scale sea−floor mining operation on Blake Ridge betweenFlorida and Bermuda, causing international outcry.

2030: Argentine oildrilling near Antarctica sparks new conflict with United Kingdom.

2031: A group ofAustralian gengineers and marine biologists form GenTech Pacifica, a companydedicated to improving fish and mollusk yields in aquaculture farms. Canadiannavy fires on Spanish and Portuguese fishing vessels in Grand Banks area.

2033: Antarctic Warbreaks out when Argentina begins drilling for oil on the Antarctic Peninsula,in violation of the Antarctic Treaty. Venice temporarily evacuated because ofrising sea levels.

*2034:*Environmentalists uncover evidence that Indonesian company Nusantara Biotek hasbeen releasing genemod fish into the wild.

2035: Antarctic Warends with signing of Revised Antarctic Treaty, prohibiting national claims tothe continent.

2045: InternationalTribunal for the Law of the Sea disbands, leaving jurisdiction of internationaldisagreements over oceanic territory to the World Court.

2049: A multinationalscience mission lands on Europa. Ice−penetrating cryobots explore the OceanusNoctis and discover life.

2052: Northern rightwhales are cloned from tissue samples, using southern right whales as surrogatemothers, and the subspecies is reintroduced into the Northern Pacific Ocean.

2057: CRABE baseestablished in Pwyll impact crater on Europa.

2058: Aquacretedeveloped and first used to build underwater structures.

2061: ManannÆnStation built by CRABE personnel on Europa.

2064: United Statesbuilds a major power generation system with turbines in the Gulf Stream off theFlorida coast.

2066: Valles Marinerison Mars is flooded.

2067: Iceland joinsEuropean Union after protracted disagreements about its fishing rights areresolved.

2072: GenTech Pacificabegins construction of Elandra. CRABE abandons ManannÆn Station due tobudget cuts. Humans arrive at Huygens Station, establishing permanentsettlement on Titan.

2074: Blue Shadow isfounded.

2075: GenTechPacifica's Aquamorph parahuman design becomes generally available.

2077: Bhuiyan Geneticsbegins producing Aquamorph parahumans and variants using pirated designs, forBangladeshi government initiative to settle Bay of Bengal.

2079: AvatarKlusterkorp arrive on Europa and begin building Genesis Station.

2080: GenTech Pacificabegins commercial production of Sea Shepherd bioroids.

2081: Green Duncanitessponsored by Avatar Klusterkorp begin secretly seeding Europa's ocean withaltered life forms.

2083: Incidents occurbetween TSA submarines and Chinese arsenal ships.

2084: The Pacific Warbegins. TSA forces fire cruise missiles at Chinese ports and naval vessels.

2085: The Pacific Warends in a European−negotiated truce. Thai ocean−tech company Sakolpok relocatesto Indonesia.

2086: Ondala floatingsettlement off Panama granted free city status by Caribbean Union.

2088: U.S. Coast Guarddestroys "Sovereign State of Zeeham", a small drift community, afterfinding evidence of bioroid smuggling activity in U.S. waters.

2089: Elandra gainsseat in Australian Federal Parliament.

2090: United Statesdemonstrates first successful use of a laser weather satellite to deflect ahurricane from the Florida coast.

2091: PLAN and JMSDFstealth submarines accidentally collide over the Japan Trench, forcing thedeepest rescue mission ever attempted.

2092: Blue Shadowattacks Elandra's aquaculture facilities, prompting a concerted campaign forindependence of the settlement. A separate raid on the U.S. Navy's Pearl Harborresearch base releases two E−model War−Dops. CRABE expands with the building ofChyba Station on the Europan sea floor.

2093: Chineseweathersat heats large regions of the East Pacific Ocean in an effort totrigger an El Niæo event; an El Niæo occurs, but experts argueover any causal link.

2094: Under pressureof memetics campaign by GenTech Pacifica, Australian government grants Elandrafree city status. China and Korea engage in military standoff over economiczone of new Chinese arcology in Yellow Sea.

2095: Failed U.S.attempt at controlling Hurricane Ophelia results in massive damage to Nassau.

2096: Caribbean Unioninitiates action in World Court against U.S. weather control program. BiotechEuphrates laboratory ship *Conway−Morris* is destroyed in the Mediterranean, the first action of terrorist groupIrukandji. CRABE scientists discover pantropic life forms, exposing the EuropaProject's existence.

2098: Europa DefenseForce (EDF) arrives on Europa and launches attacks on Avatar Klusterkorpoperations, beginning the War Under the Ice.

2099: Infomorphs atVostok Station in Antarctica report their humans are showing signs of nanovirusinfection, then go offline. Journalist Copernicus Jones escapes EDF captivityand reports on the War Under the Ice.

(((END BOX)))

The Blue World

(((INSERT MAP: EARTH)))

Pacific Ocean

The Pacific Ocean covers nearly half the globe. Almost anythingthat happens in the oceans of Earth can be found represented here. The Pacificbasin is surrounded by 30 continental nations and holds another 17 islandmicrostates and dependencies, ranging from the wealth of the United States andthe might of China to dirt−poor Kiribati. Many of the tiny island nations arein serious danger of vanishing as global sea levels continue to rise.Technology may come to the rescue, either by building more land, or by adaptingpeople to live without it, if only the needy could afford it. Some of theboldest experiments in transhumanism and Fifth Wave culture are taking place inthe Pacific, and some of the greatest human tragedies.

Change and Development

As the 21st century began, the Pacific Ocean was seen as theindicator of global climate change. Its surface waters were warming measurably,resulting in the bleaching and death of coral reefs off the Australian coastand around Pacific island nations. The increased heat of the ocean triggeredintense El Niæo phenomena (p. 00), driving altered climate patterns suchas severe droughts and violent storm activity around the world.

The nations of the Western Pacific have seen longer and moreintense droughts than at any time in recorded history. Many island nationsbegan importing fresh water in the 2020s, until D−T fusion reactors made largescale desalinization plants practical in the 2030s. These reactors remained inuse long after most countries had switched to helium−3 fusion, because thenations running them were too poor to upgrade and too isolated to be of concernto radiation−wary developed nations. The western coast of the Americas hasbenefited from increased rainfall, making nations such as Chile and the UnitedStates reluctant to combat climate change.

The tropical regions of the Pacific are among the best sites forfloating arcologies and submarine settlements. The first Pacific arcology wasbuilt in the northern Great Barrier Reef off Australia from 2042–47, followinga promising start with similar projects in the Mediterranean Sea. Spurred bythe industrial explosion of the "Booming Forties" (p. FW8), many suchsettlements were built over the following decades in the shallow seas aroundAustralia, New Guinea, Indonesia, Malaysia, Japan, and off the southern coastof California.

A new era in transhumanism began in 2072 when GenTech Pacificabegan building Elandra the first settlement to be based *under* the water 350 miles off the coast of Fiji(see p. 00). Since then, several other sea–floor habitats have been built invarious places throughout the Pacific.

The Pacific War

The Pacific War of 2084–85 was fought in many theaters across thePacific. There was heavy naval action in the South China Sea between hydrofoiland submarine forces of China and the TSA. The ports of Hai–phong, Ho Chi MinhCity, and Bangkok were bombed and destroyer microbot swarms were released onVietnamese and Thai naval facilities by Chinese marine commando raids. Severalfloating cities from both sides were destroyed. The sinking of Malaysia'sBandar Lautang arcology by a Chinese torpedo attack killed 10,300 people,making it the highest fatality action of the war.

Although China succeeded in preventing the release of alleged"black" nanovirus weapons with its pre–emptive strikes, the TSA hadsome simple nanoviral agents designed for use on animals ready. These werereleased into Chinese aquaculture facilities by submarine NAI cybershells,rendering a significant portion of China's farmed fish toxic. Similarlyaffected fish continue to turn up in the South China Sea occasionally,reinforcing fears that some of these ecohostile weapons were lost.

In the aftermath of the war, the TSA had to rebuild much of itsenergy infrastructure. The vulnerability of solar power satellites had beenclearly demonstrated when China crippled the system in the first hours of thewar. Unable to acquire commercial quantities of He–3 due to trade embargoes,the TSA looked to Earth–based power sources with new determination and focus.The location of all the TSA nations in the tropics led to the choice of oceanthermal energy conversion (p. 00) as the primary solution. Large OTEC powerstations have been built in the seas of the Indonesian archipelago and off theCentral American coast, with many more under construction.

(((START QUOTE)))

The Mediterranean was the sea of the past, the Atlantic isthe sea of the present, and the Pacific will be the sea of the future.

John M. Hay, U.S. Secretaryof State 1901–05.

(((END QUOTE)))

Current Events

In 2100, the Pacific remains the most militarized of the world'soceans. The Chinese Peoples' Liberation Army Navy (PLAN) and the navies of theTSA and PRA patrol its waters, engaging in tense games of cat and mouse alongtheir maritime borders. The U.S. Navy tries to monitor the activities of theadversaries in this three–way cold war. Recent shifts in foreign policy meanthe United States is more likely to intervene in external conflicts, though itsability to moderate open aggression has not yet been tested.

Hostilities remain restrained for the most part. The last seriousincident was in 2094 a standoff between China and Korea over control ofpart of the Yellow Sea around the construction site of a new Chinese arcology.After some negotiation with the United States as a mediator, the PRAreluctantly agreed to have Korea withdraw its effective EEZ boundary by 20miles, but resentment still simmers.

Despite these tensions, the majority of shipping in the Pacificis commercial. Cargo tonnages have dropped in recent years with the rise ofgeneral purpose robotic construction facilities and minifacturing using commonblueprints, but more goods are still shipped globally than at the beginning ofthe 21st century. Two major economic blocs span the ocean, causing shippingdensities in parts of the Pacific to be the highest in the world.

The Pacific is the also most dynamic ocean geologically. The"Ring of Fire" the zone of tectonic activity which encirclesthe Pacific Plate produces deep earthquakes which can give rise todevastating tsunamis. Subduction zones and hot spots produce volcanic islands,and feed volcanic activity in the Americas, Russia, Japan, and New Guinea.Upwellings of magma below the sea floor create hydrothermal vents where strangelife forms flourish, and where eager corporations collect and process rich oresfor industrial use. Many of the poor Pacific island nations are finding theycan earn much–needed income by selling exploitation rights to underwaterresources.

Atlantic Ocean

The Atlantic Ocean has been witness to some of the bloodiestepisodes in human history, as the great naval powers of Europe fought over thedivision of the pre–industrial world. In the 21st century, only one navalcampaign was waged in the Atlantic: the battle over the Falkland Islands in theAntarctic War of 2033–34 (see p. FW25). Perhaps of greater importance was thefinal battle in a long, one–sided campaign of man against fish.

Fishing and Mining Rights

It is when man shall have discovered the means of restockingthe sea and of controlling its supplies that his "dominion over thefish" will be perfect. The power to deplete, which so far marks the utmostlimit of his advance, is mere tyranny.

F. G. Aflalo, ***TheSea–Fishing Industry of England and Wales****,1904.*

There are no bluefin tuna left in the North Atlantic. Ourtyranny over the fish is now perfect.

Selig Moore, FirstInternational Conference on Fish Stocks, 2013.

In 2011 the tuna fishing fleet in the North Atlantic Ocean landeda total of 47 bluefin tuna, less than 2% of the previous year's catch.Commercial tuna fishing in the Atlantic became unprofitable and the industrycollapsed along with the bluefin population, which had clearly passed acritical point and was considered on the verge of extirpation. A majorinternational conference was held two years later to discuss the state offisheries worldwide, but it failed to resolve anything amidst a plethora ofcompeting interests. Fishermen and governments, convinced that if they didn'tcatch the fish, someone else would, continued to ignore the call fordrastically reduced quotas. As the fish became scarcer, tensions between fishingfleets rose to boiling point.

Ongoing incidents between the Canadian navy and Spanish– andPortuguese–owned fishing vessels in the Grand Banks region erupted intoviolence in 2031 when shots were fired. The ensuing series of hearings andappeals in the international courts were treated half–heartedly by a Canadiangovernment rapidly losing ground to seceding provinces. The loss of authorityover its fishing grounds was one of several factors leading to the secession ofNewfoundland from Canada in 2039.

Fishing rights also played a pivotal role in Iceland's reluctanceto join the European Union. Under original E.U. rules, all member nations havethe right to fish within each others' Exclusive Economic Zones (p.00). Icelandwished to maintain sole control of its fisheries to the 200 nautical milelimit, citing cultural and economic imperatives, rather than allowing nationswho traditionally encroached on its waters to share its bounty. Thedisagreement was only resolved when ecoscience studies in the 2050s establishedthe fragility of Iceland's fishing grounds and the European Union establishednew joint management rules which prevented other member nations from exploitingthem.

Sea–floor mining first became an international concern when theUnited States began mining methane hydrate (p.00) for use as a fuel on theBlake Ridge, midway between Florida and Bermuda, in 2029. As this was ininternational waters, the United Nations requested a share of the profits, asspecified in the U.N. Convention on the Law of the Sea (p. 00). The UnitedStates, not being a signatory to the treaty and having withdrawn from theUnited Nations in 2025, refused an act which signalled a significanterosion of U.N. power and furthered its decline into irrelevance. Developingnations, supported by the European Union, demanded compliance from the UnitedStates, triggering a temporary cooling of relations between the United Statesand the European Union.

Current Events

The Atlantic still carries a vast amount of shipping traffic.With E.U. members on both sides of the ocean, trade is brisk on northernshipping routes. Argentina, Brazil, and South Africa generate considerabletraffic in the South Atlantic.

Sea–floor mining is now taking place in several locations. TheFaeroe Islands, Azores, Cape Verde, and the tiny British dependency ofAscension are all bases for nearby mining operations. There are also deep seaoperations in international waters, with several countries following the UnitedStates' lead and exploiting the resources for their own profit. These includeArgentina, South Africa, The Netherlands, and Germany.

The Atlantic holds many aquatic settlements. Franklin City,situated not far from Puerto Rico, is the next largest sea–floor settlementafter Elandra, and others dot the Caribbean Sea and the shallow waters aroundthe Azores. Floating habitats can be found in almost every corner of theAtlantic, clustered most densely in the Caribbean, the Gulf of Mexico, alongthe east coast of the United States, and north of Brazil.

Despite warmer global temperatures, there are more icebergs inthe North Atlantic than at the end of the 20th century. The Greenland ice sheetcontinues to break up at an increased rate and the northerly winds blowing theresulting icebergs down the Newfoundland coast are strengthened by frequent ElNiæo conditions.

Hurricanes in the Caribbean are less frequent than at any time inrecorded history, but those which do form are often intensely powerful. ElNiæo events suppress Atlantic hurricane activity, but the strong LaNiæa events occurring between them generate strong hurricanes withgreater likelihood of landfall on the U.S. and Central American mainlands.

Indian Ocean

The Indian Ocean differs significantly from the Pacific andAtlantic in that its northerly extent is bounded by the Asian landmass. Thisaffects climatic patterns and produces the characteristic monsoon seasons ofSouth Asia.

Politically, the Indian Ocean is bounded by more power blocs thanthe larger oceans, making it a lively place for territorial and resourcedisputes. Most of the nations bordering it are however poor and undeveloped,meaning India dominates the region. The Islamic Caliphate and South AfricanCoalition have considerable naval strength however, and press their claimsopportunistically.

The ocean itself is less developed than the Pacific or Atlantic,with far fewer aquatic settlements, arcologies, and sea−floor miningoperations. The major settlement initiative is that promoted by the governmentof Bangladesh, which is establishing large communities of aquatic−adaptedparahumans and uplifted sea animals in the Bay of Bengal. Most othersettlements are Islamic floating arcologies in the Persian Gulf.

Southern Ocean

The Southern Ocean is the coldest and roughest in the world. Throughoutthe 21st century, global warming caused the harsh southern winds to strengthen,creating mountainous seas with waves regularly exceeding 25 feet at latitudesfrom 50° S to 60° S. Pack ice still forms every winter, extending northto nearly 60° S at its maximum in October. This quickly melts over thesummer, leaving clear sea lanes to most parts of Antarctica.

Pack ice severely restricted the British campaign againstArgentine oil drilling bases on the Antarctic peninsula for the first eightmonths of the Antarctic War in 2033 (see p. FW25). It was only with the summerthaw late in the year that the United Kingdom managed any solid gains againstthe Argentine forces.

The slow breakup of the Ross and Ronne ice shelves occasionallyinjects enormous icebergs into the eastward−flowing circumpolar current floating islands up to 200 miles long, 60 miles wide, and 2,500 feet thick. Theaccelerated flow of many Antarctic glaciers produces prodigious numbers ofsmaller icebergs in the southern summer. These drift as far north as latitude50° S with some regularity, and occasionally as far as 40° S in theAtlantic Ocean.

There are no known sea−floor or floating settlements anywhere inthese inhospitable seas. The Argentine company Agua Negra (p. 00) has recentlybegun sea−floor mining on the continental shelf near the Antarctic Peninsula,keeping the bases supplied throughout the winter with submarines.

Arctic Ocean

The Arctic Ocean is the smallest and least developed ocean. It issurrounded by Russia, Norway, Greenland, Nunavut, and Alaska. The first threeare so far disinclined to or incapable of exploiting the ocean's resources,while the United States has far more promising and less difficult projectselsewhere. The major initiatives dealing with the Arctic Ocean areenvironmental and cultural preservation. Nunavut is leading a campaign toprotect the ocean and its ecosystems from damage caused both by direct industryand by climate change.

Most of the ocean is covered by polar ice which never fullymelts. Seasonal pack ice covers the remainder of the ocean in winter (see *Ice*, p. 00). It melts in summer to leave open sea northof every landmass except Greenland, although these regions contain scatteredicebergs. These passages are used by commercial fleets and navies in the summermonths. The ice circles slowly clockwise in the Arctic current.

Mediterranean Sea

The cradle of civilization, the Mediterranean Sea remains one ofthe busiest waterways of the world. Vast numbers of ships ply age−old traderoutes between European nations, Northern Africa, and the Middle East. The lastopen hostilities in the Mediterranean were the final naval actions of theAegean War in 2013. Since then the sea has been at peace, with tensions betweenIsrael, surrounding Islamic states, and the European Union lessening graduallyover time.

Being almost fully enclosed by land, the Mediterraneanexperiences almost imperceptible tides and maximum wave heights of only threeto five feet. This, and the mild climate, make it an ideal location for floatingsettlements, and the largest in the world are found here. Scores are anchoredoff the coasts of Italy, France, Catalonia, and Spain. Three spectacularfloating cities of metal and glass lie off the coast of Monaco, more thandoubling the living space available to the tiny country and drawing wealthytourists from around the world and off−world to lose money intheir casinos. Sea−floor habitats are less economical and only a few corporatebases exist.

Although calm and close to many Fifth Wave nations, theMediterranean is relatively poor in useful sea−floor mineral deposits, somining is not a major industry. The Mediterranean does, however, hold treasuresof a different kind most deep−sea expeditions in its waters arearchaeological in nature (see *Marine Archaeology*, p. 00).

Water flows into the Mediterranean from the Atlantic Ocean at thesurface. Evaporation increases the salinity of the water, which sinks becauseof the resulting density increase. At depths up to a mile, this dense saline waterflows back out into the Atlantic through the Strait of Gibraltar. Submarinescan take advantage of these currents and ride silently through the Straitsimply by selecting an appropriate depth.

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Antarctic Subglacial Lakes

The strangest bodies of liquid water on Earth were discoveredin 1995. Hidden deep beneath the Antarctic ice sheet are dozens of lakes offresh water. The largest, Lake Vostok, measures 140 miles long, 30 miles wide,and up to 2,000 feet deep, and is buried beneath 2.5 miles of ice near theRussian Vostok research station. Researchers estimate the lakes have beenisolated from the atmosphere for 500,000 years.

These lakes formed a perfect environment for testing ofequipment designed to land on Europa and penetrate its icy shell to explore theocean below (see p. 00). Joint U.S. and E.U. projects from 2018−2051 usedprototype cryobots to reach and study several lakes beneath the East Antarcticice sheet. Great care was taken to avoid contaminating the lakes' pristine waterswith surface chemicals or micro−organisms precautions which would beeven more important on Europa, where some scientists expected to findnonterrestrial life. The Antarctic lakes were discovered to contain microbiallife of their own, supported by the same geothermal heat sources that kept thelakes liquid.

The Russians based at Vostok also researched, but by drillingrather than using robotic vehicles. The vast expanse of Lake Vostok was theirsalone to explore, although the political strife in Russia throughout much ofthe 21st century stifled their efforts. They sank shafts through the ice in2076 and built a research habitat in the lake. It produced scientific resultsfor 16 years before officially being shut down.

Some radical Preservationist groups claim to have testimoniesfrom ex−Vostok workers that the subglacial base remained operational,experimenting on classified biotech and nanotech programs in the isolation ofthe lake environment. Skeptics pointed out that Russia was busy rebuilding itseconomy and that Vostok was too remote to be a useful military base. Fears wereraised in December of 2099, when Vostok's informorphs reported a massivenanovirus infection in the base and then went offline. Russia has beenstrangely reluctant to send a rescue team to Antarctica.

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Other Bodies of Water

Black Sea. Although linkedto the Mediterranean via the narrow Bosporus, the Black Sea has virtually noexchange of water with the greater ocean system. Currents do not mix the waterbelow 600 feet, beyond which the water contains no dissolved oxygen. The deepwaters contain hydrogen sulfide, and support only anaerobic bacteria. Thismakes the Black Sea a prime site for marine archaeology, as organic relics inthe anoxic region do not decay. Biological researchers study the bacteriathemselves for gene sequences useful in extraterrestrial and terraformingapplications. Overfishing, pollution, and the accidental introduction ofnon−native jellyfish in the late 20th century destroyed many commercial speciesin the sea. With careful ecomanagement, the sea recovered remarkably and onceagain supports significant fisheries.

Caspian Sea. The brackishCaspian Sea was the site of one of the worst environmental tragedies of the21st century. Its fragile ecosystem was already under stress because of reducedfresh−water inflow and consequent rising salinity, when Armenian forces bombedAzerbaijani oil drilling facilities in 2021, releasing 300 million gallons ofcrude oil into the sea. Over 90% of fish species in the sea died out, as wellas Caspian seals and several shorebird species. A dead zone for severaldecades, the Caspian is slowly coming back to life thanks to gengineeredoil−eating bacteria and the reintroduction of species cloned from archived DNA.

Red Sea. A narrow arm ofthe Indian Ocean, the Red Sea contains several unique geological and biologicalfeatures, making it a region of considerable interest for research andindustry. It has coral reef ecosystems which have evolved independently ofthose in the greater oceans for millions of years, providing a treasure troveof genetic material. The sea−floor rift which slowly widens the Red Seaproduces hot brine pools (se p. 00) which concentrate valuable minerals. TheIslamic Caliphate controls the Red Sea and operates mining facilities and a fewfloating arcologies.

The Great Lakes. The GreatLakes have remained major shipping channels for the United States and Canada.Cleaner industry and active ecomanagement have returned the lakes to an almostpristine state. There is little development of aquatic habitats and no miningactivity, but there are extensive fish farms in all five lakes.

Lake Baikal. This Russianlake is 5,400 feet deep and holds more fresh water then all five Great Lakestogether. It suffered minor pollution in the late 20th century from a largepaper mill, but recovered quickly when the mill closed down in 2013. The lakesupports a unique ecosystem with over 1,000 endemic species, including theworld's only non−marine seals. Lake Baikal is a focus for Preservationistgroups, who have successfully lobbied to keep it free of genemod species. Itsupports a limited amount of tourism and several deep neutrino telescopefacilities (see p. 00).

The Fight For the Oceans

The oceans of 2100 are a battleground for philosophical,political, and technological clashes between many different groups.

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Half the Earth is up for grabs in the culmination of along−running dispute between rich nations and poor ones. At issue is how thehigh seas will be developed in the decades and centuries to come, mostespecially their depths.

William Broad, *New YorkTimes*, 1994.

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Environmentalists

The events which catalyzed environmentalist reaction over theoceans were the collapse of bluefin tuna stocks in the Atlantic and then thePacific Ocean in the 2010s, followed soon after by the extinction of thenorthern right whale. The bluefin tuna was a powerfully symbolic species forthe state of fisheries in general. Suddenly the public began to take notice ofthe vast damage which had been done to wild fish stocks to a multitudeof species besides the tuna. It became clear that early 21st century commercialfishing levels were not only unsustainable, but grossly beyond what could be justified.

International commissions given the task of producing awhole−ocean fish management policy failed to produce any tangible results for30 years. The pressure from fishing industries and nations reliant on seafooddestroyed any chance of agreement on the drastic reductions in fishing quotasnecessary to maintain healthy stocks. It was only with the findings of the newfield of ecoscience in the 2050s that enough nations were convinced of the needto manage the oceans and severely reduce catches of wild fish.

Meanwhile, global warming caused by industrial pollution hadaltered the ocean environment radically: destroyed thousands of square miles ofcoral reefs; disrupted ocean currents, climate, and ecosystems; and caused sealevels to rise, submerging islands and devastating coastal regions. Traditionalenvironmentalists are horrified at the havoc wreaked on Earth over the pastcentury. They campaign fiercely for international protocols designed to preventfurther destruction and to repair the damage already done.

Progress has been made in environmental management since the 20thcentury and most industrial activities on Earth adhere to strict regulations.Policing regulations in the remote parts of the world, such as sea−floor miningoperations, is difficult however. Companies sometimes cut corners, resulting indevastating changes to the seabed environment which can affect ecosystems forhundreds of miles around.

Some environmentalists take a more active approach to restoringthe Earth, developing technology to repair and manage disturbed environments(see *Ecoproactivism*, p. 00). Others takethe stance that humans are bad for the Earth, and that a return to how theworld was before people came along is desirable (see *DeepEnvironmentalists*, p. DB00).

Preservationists

Mainstream Preservationists (p. TS92) see the ocean as a majorenvironment threatened by genetic pollution. Gengineering corporations tinkerwith the human genome, spurred by the challenges of the sea to produceparahumans able to live in the oceans and, ultimately, to breathe water.Biotech companies modify aquatic species for specialized uses in industry andrelease genemods into wild populations. Most ambitiously, some researchers are"uplifting" species such as dolphins and octopuses to sapience (seep. 00), creating entirely new intelligent species. And Preservationists decryit all.

The Preservationist–leaning European Union and Preservationistfactions within the United States operate sustained campaigns aimed at curbingthese gengineering programs and addressing the problems caused by modifiedspecies. A major effort is being made to establish international cooperation ona new treaty governing the oceans, including clauses to regulate themodification and release of oceanic species. Preservationists argue thatbecause the oceans are shared among humanity, they must be maintained in theirnatural state as a heritage resource.

Radical Preservationist groups take their disgust with themanipulation of the oceans beyond the political sphere. Some organize publicprotests at biotech labs or Web campaigns aimed at destroying corporatereputations. Criminal groups such as Blue Shadow (p. 00) take direct action,sabotaging facilities and rescuing or destroying upliftedsapients.

A significant fraction of uplifted cetaceans have becomeoutspoken Preservationists, campaigning against the alteration of theirspecies. They argue that being unwillingly transformed by humanity intointelligent companions or slaves is a travesty against theirintegrity as a species.

Pantropists

Opposing the Preservationists are pantropists (p. TS91), thosewho believe humans should be adapted to live in extreme environments. The mostextreme environment on Earth is underwater. The engineering problems inadapting the human body to aquatic life are immense changes must bemade to provide oxygen, withstand pressure, avoid heat loss, and allow sensesto function. Yet the rewards are greater still. Parahumans able to liveunderwater gain access to over 90% of the volume able to support life on Earth.

Pantropists support research and development of radical humangengineering designed to allow this exploitation. Another route to spreadinghuman culture to the seas is by uplifting marine species and integrating theirintelligences into human society.

Oceanic biotech companies such as GenTech Pacifica and BhuiyanGenetics are strongly pantropic, supported by various nations within the PRAand TSA.

Transhumanists

Transhumanists (p. TS93) take a different approach to colonizingthe oceans than the pantropists. Non−germline nanovirus and surgical treatmentscan transform existing humans into forms better capable of living underwater.Some transhumanists exercise morphological freedom by taking such treatmentsand spending time living in underwater settlements.

More radical is destructive uploading into ghost form and the useof aquatic cybershells or bioshells. This allows complete adaptation to theoceanic environment. Popular choices for aquatic bioshells are cephalopods ortransgenic gillmorphs (p. 00), since they have manipulating limbs, but asignificant subculture favors those based on cetaceans (see *Cetanism*, p. 00).

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Biotech versus Machines

A philosophical schism exists among pantropists andtranshumanists over the best technology for colonizing the sea. Some feel that"wet" biotechnology is the best solution for the considerableproblems of living underwater. The wet camp holds that by adapting humansphysically, any reliance on technology can be minimized, resulting in largerpopulations that are better able to sustain themselves. Members of this groupprefer to use genemod life forms such as squidpacks, maintstars, and fibrokelp,rather than artificial equivalents.

The "dry" group, in contrast, believes mechanicaltechnology is more useful and customizable than biotech, and should be utilizedin full. Life support systems for air−breathers living underwater still requirelargely mechanical components, and robots and cybershells are far easier tobuild than gengineered sapients or bioshells capable of surviving without air.

Pantropists tend toward wet philosophies, whiletranshumanists contribute the bulk of the dry community. This is not universalthough, and there is a large middle ground of people who happily use whateverapproach gets the job done.

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Political Idealists

The oceans have become a refuge for those whose political andsocial beliefs are at odds with those of prevailing governments and societies.Nanarchists (p. TS90) and decelerationists (p. DB00) are among those seekinglives away from the bustle of the Fifth Wave.

Many people unsatisfied with national governments or the onrushof transhumanity have made the move into aquatic habitats outside nationalborders and away from the excesses of Fifth Wave culture. Cheap fusion oroceanic energy sources and 3D printers allow such people to survive comfortablyoutside mainstream society.

Some nanarchists use PNCs (p. 00) to establish aminimal−maintenance nationality and allow them to renounce their priorcitizenship in a legal manner. Others see this as inconsistent with strictnanarchist principles and prefer a simple renunciation of all citizenship. Thishas the disadvantage of not being legally recognized the renouncedstate still considers such people citizens. This is rarely an issue, however,since nanarchists seldom generate a taxable income and there is no incentivefor nations to chase these itinerant citizens.

In 2100, there is a growing population of third−generationnanarchists living in oceanic habitats. It is rapidly becoming impossible totrace lines of citizenship amongst the new generation, resulting in many peopleeffectively having no citizenship at all and being Zeroed (p. CI32) in theglobal society. For the nanarchists this is the beginning of their dream for the nations who occasionally have to deal with them, it is anadministrative nightmare.

Corporate Interests

The pursuit of profit drives the vast majority of development inthe oceans. Sea−floor mining is highly lucrative for companies with the rightequipment, and can be done far from the reaches of government regulations.Fishing companies continue to press the limits of "sustainable"quotas set by ecoscientists who still don't fully understand the inter−relationshipsof the ecosystem. Transhumanists and parahumans want new aquatic technology toimprove underwater life. Some Preservationists accuse companies such as GenTechPacifica of developing aquatic sapients specifically to create a captive marketreliant on underwater technology for life itself.

Corporations have relocated offshore in droves. Building a newisland in international waters and operating from there puts companies outsidethe jurisdiction of national governments. Research can proceed unregulated, tothe consternation of nations, Preservationists, and the Genetic RegulatoryAgency. And some companies set themselves up as *de facto* governments of their own, practically enslavingworkers and producing outcry amongst sapient rights bodies if theylearn about it at all.

Criminals

Pirates and smugglers still prowl the oceans of 2100. Theirmotive is the same as it has been for centuries profit buttheir methods and equipment have evolved to try to keep a step ahead of the lawenforcement agencies which dog their every move. With cargo ships increasinglyautomated and often having no live crew, boarding and taking control may seemeasy, but there are security devices and safety protocols to be overcome. Amodern pirate is as likely to be an electronic surveillance systems andcomputer security expert as a good shot. Pirates favor rapid deployment andretreat options over stealth, and will often have fast hydrofoil or biphibiancraft for surprise attacks, particularly in archipelagos with plenty of remotehiding spots such as the Philippine and Indonesian islands (heavy with PRA andTSA traffic) and the Caribbean.

The trade of smugglers has also changed considerably over the21st century. With biogenetic manufacturing and the legalization of many drugsit is no longer profitable to physically transport narcotics, but the smugglingof weapons and advanced technology into developing nations is still viable. ***TranshumanSpace: Broken Dreams***describes hardware smuggling in detail. The largest component of overwater smugglingis the illegal movement of bioroids either wilful individuals fromnations where they have few civil rights to the European Union or South AfricanCoalition, or the trafficking of restricted models to unscrupulous buyers (seep. TS106). Although ingenious methods of disguise or concealment are used toslip bioroids past customs inspections, the old standby of landing on anunpatrolled stretch of rugged coastline is still popular.

Memes

Amniotism

The oceans spawned life on Earth, and nurtured it through threebillion years of evolution before the first organisms colonized the land. Nowthere is a growing movement to return to the water to live.

Advertising companies originally spread a meme promoting life innewly developed aquatic habitats as novel and safe from the ravages of heavyweather, in the loving embrace of the "mother ocean." Sometranshumanists and pantropists took this message to heart and started theamniotism movement. It is a small "new age" movement but slowly gainingin popularity. A handful of sea−floor habitats are entirely populated byamniotist communities, and amniotists can be found in most others.

Archaeobiology

One of the most important gengineering breakthroughs of the 21stcentury was the ability to clone organisms from preserved tissue. With so manyspecies driven to extinction over the previous centuries by hunting and habitatloss, the ability to re−establish viable populations has been instrumental inmaintaining ecological diversity and ecosystem health. Archaeobiology is thepractice of resurrecting extinct species, and the support of this process byactivist sections of the community. Glamorous archaeobiology projects havesuccessfully resurrected the Tasmanian tiger, Florida panther, and northernright whales, but more important work is done with little known species offish, corals, crustaceans, and algae, preserved in sample jars before beingwiped out in the late 20th and early 21st centuries.

Atlanteanism

Some people see living in the ocean as a challenge to be methead−on. The technological and physiological difficulties are considerable.Self−styled Atlanteans profess the belief that the ocean is a harsherenvironment than space, and that spacers are taking the *easy* route to spreading humanity.

Atlanteanism is popular with the gruff worker−types who do muchof the hard work of building and maintaining aquatic habitats and machinery.There is a semi−formal Atlantean Society which operates much as a 20th centuryfraternal lodge, with groups meeting for social activities and offeringhospitality to visiting members. Some major port cities host Atlantean lodges,but most are based in floating or sea−floor habitats.

Although anyone can agree with the philosophy or join theSociety, the stereotypical Atlantean is a rough and tumble pioneer with anoverbearing personality and short temper, but a heart of gold. Spacers andother detractors refer to Atlanteans derogatively as "Kelp Kowboys."

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The analogies between sea and space have often been pointedout, and a man used to one can readily adapt to the other.

> Arthur C. Clarke, *TheDeep Range*.

I don't know who this Clarke character is, but he obviouslyknows nothing about either space or the sea.

Josh Patrick, PresidingReeve, Atlantean Society, Elandra Chapter.

(((END QUOTE)))

Cetanism

For hundreds of years people have been drawn to dolphins becauseof their intelligence, possible sapience, and supposed spiritual awareness.With the advent of bioroid bodies and destructive uploading, some people choseto become ghosts in order to inhabit dolphin bioshells. The practice has grownuntil there are now a few thousand cetanists swimming the world's oceans. Mosttransfer to other bioshells or cybershells part of the time, but a few livepermanently in their dolphin bodies.

An offshoot of cetanism is *whalesinging*, in which infomorphs are loaded into humpback whalebioshells to spend time communing with natural whales and participating inwhale songs. Although no discernible meaning has been extracted from whalesong,an abstract vocabulary has been compiled and it is possible for people tocompose songs which seem to gain acceptance by being mimicked by naturalwhales. Some Preservationists see this as polluting a natural animal"language" and campaign against it.

Drifting

Many small− to medium−sized habitats float on the ocean surfaceand travel slowly around the Earth. Most have propulsion systems and followroutes designed either for sightseeing or staying in desirable weatherpatterns. The people inhabiting these craft are known as drifters. Drifting isnot a strict nanarchist movement drifters have to deal with customs andimmigration laws of the nations whose waters they visit, and happily take onsupplies and luxury items they cannot produce themselves.

In order to deal with these laws, most drifters retaincitizenship of established nations. Some simply maintain their currentcitizenship, though this results in certain administrative obligations such aspaying taxes. An increasingly popular option is to transfer citizenship to a *citizenshiphaven* country (see box).

Drifting has its roots in the biotech explosion of the 2020s,when some disenchanted people began buying disused cargo ships and convertingthem into small floating communities. There was a small surge of interest inthe 2040s, when booming economic conditions created a class of *nouveau riche*, some of whom sought alternative lifestyles or toavoid taxation. Drifting became popular with the Transhuman Awakening andMajority Cultures movement of the 2060s (p. FW12). By the outbreak of thePacific War in 2084, there were over a thousand cataloged drift habitatsroaming the seas. Several were destroyed in the war, with great loss of life,dampening enthusiasm for the drifting lifestyle for the next decade or so. In2100, drifting seems to be in the early stages of another revival.

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Citizenship Havens

Citizenship havens are nations which offer a no−frillscitizenship to people wishing to purchase it. A *permanent non−residentcitizenship (PNC)* gives the bearer aninternationally recognized home country and a passport. The bearer may not seekresidence in the issuing nation and receives varying amounts of diplomaticsupport if he gets into trouble in another country, but in return pays only a relativelysmall annual fee. To the haven nation, PNCs are an inexpensive source ofincome.

Most nations who grant PNCs perform some minimal backgroundchecks to make sure applicants are not wanted criminals. A few undertake morecomprehensive checks and rigorously enforce a policy of rescinding PNCs issuedto people convicted of crimes. Some nations simply take the cash from anyonewho cares to apply for a PNC.

Popular Citizenship Havens

Jamaica. Jamaica hasthe highest PNC fees of any nation, but to many drifters the price is worth it.Background checks for applicants are extensive and a Jamaican PNC is seen asequivalent to a standard Fifth Wave citizenship by most customs and immigrationservices. Jamaica offers extensive diplomatic assistance to its PNC holders,including legal advice and representation and, where necessary, arranging fordeportation or extradition from foreign territory. Drift habitats flying theJamaican flag are generally allowed free passage in most parts of the world.

Madagascar. Madagascaris a mid–range citizenship haven. It tries to deny PNCs to people who may beusing them for illegal purposes, but with thinly stretched government resourcesit is not nearly as successful as Jamaica. It does have an active policy ofrevoking PNCs of criminals, however. Legal assistance is available fromMadagascan consulates in many countries, but often this is no more than a cheapcase lawyer ready to revoke the PNC at the first sign of trouble. People withMadagascan PNCs are allowed entry by most nations, although those alignedagainst the TSA eye them with suspicion.

Eritrea. Eritrea is apoor nation which issues PNCs freely as a source of badly needed revenue.Showing an Eritrean PNC passport at some ports of entry will result in athorough search and swift ejection from the country, with good reason. Holdersattempting to recruit help at an Eritrean consulate will be laughed at andshown the door. Many smugglers and other criminals are known to use EritreanPNCs to establish alternate identities. The major benefit of an Eritrean PNC isvery low fees, so it is a common choice for nanarchists who don't plan to visitnations.

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Ecoproactivism

Ecoproactivism is an environmental movement based on thephilosophy that it is no longer sufficient simply to avoid damaging theenvironment the damage has been done, and now it is time to clean itup. Early ecoproactivists were behind the efforts to set up the replenishmentproject which has successfully reversed the decline of the ozone layer.

Although some ecoproactivists are preservationist, most believethat enough damage has been done to the environment and wild ecosystems thatonly full utilization of technology can restore the Earth to its formercleanliness and biodiversity. The introduction of genemod species is a means tothe end of producing a clean planet with a balanced ecosystem. Obviously, somespecies can never be replaced, so the next best thing is artificiallyengineered equivalents. Nanotech and biotech can also be used to tackle someproblems, producing cybernetic organisms such as leviathan filterers (p. 00).

Genesthetics

Some gengineers see their work as more art than science. A fewtake this more literally, deliberately producing outre genemods designed tochange morphology in arbitrary ways and produce living works of art. This isreferred to as "gene sculpture" or, more commonly in recent years,"genesthetics." On land this is mostly restricted to plants, butaquatic animals provide raw materials of exceptional malleability which live inan environment able to support outlandish body shapes. Cnidarians are popularbase creatures corals can be made to produce marvellously intricatelimestone accretions, while jellyfish and anemones are altered intobreathtakingly beautiful creatures of filigree and color. More avant−gardegenestheticists produce spiky crustacean creations or weird mollusk shells.

Real Food Movement

Growing numbers of people, particularly from heavily traditionalAsian cultures, believe that the best−tasting meat and seafood comes fromnatural sources, not fauxflesh vats. The Real Food Movement lobbies for therepeal of laws banning hunting and farming of terrestrial animals, althoughmany consider that battle already lost. Current efforts are concentrated on supportingaquaculture and commercial fishing, and campaigning against the introduction offauxfish. The ultraconservative Japanese are leading the campaign for realseafood, and many people who think the movement's attitude to terrestrialanimals is barbarically antiquated are coming to agree with them aboutfauxfish. Conspiracy theorists might wonder who stands to profit from thespread of this meme see p. 00.

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Fringe Memes

Some memes are well outside the mainstream, though theymaintain small cores of adherents. Examples include:

Krakenism. Some believethe ocean hides things better left undisturbed. Krakenists are extremelyworried by the continuing exploration of the deep sea. What lies down therevaries between believers, from monstrous animals, to lost civilizations ofsurface−haters, to implacable forces of pure evil. Whatever it is, once itknows about people living on the surface, terribly fury will be unleashed. Manykrakenists seek safety, either well inland or in space. Some campaign for theend of deep−sea exploration, posting diatribes to the Web or engaging in moresophisticated memetic activities. A few join terrorist groups, where they canactively deter undersea development with force. Particularly paranoidkrakenists are also alien contact believers or survivalists (pp. TS87, TS92).

Nanogaianism. The GaiaHypothesis, formulated by Dr James Lovelock in the 1970s, states that the Earthis a "living organism," striving through chemical and biologicalprocesses to produce optimal conditions for life. Nanogaians believe thatnanotechnology is the inevitable next step in this evolutionary process. Theywish to see wholesale release of self−replicating biological nanobots designedto clean up pollution, moderate climate, and keep the ecosphere in goodcondition. Current efforts are focused on the seas, as the environment mostsuitable for wide dispersal and sustenance of nanobots, although the JOVIALproject (p. DB00) seeks to apply the same principle to Jupiter. Research intoself−replicating nanobots is heavily restricted by anti−von Neumann laws inmost states, so nanogaians use nanarchist black labs such as the Redjack L5Station (p. HF00) or run secret experiments in legitimate facilities. Somecommentators wonder about the fate of the Russian Vostok station in Antarctica.Extreme nanogaians take the view that once Earth is seeded withself−replicating nanobots there will be no further need for humans . . .

*Prometheanism,*Prometheans believe that humanity is destined to know and to do *everything*. They advocate thecomplete exploration and settlement of the Earth and the solar system, from thebottom of deep sea trenches on Earth to beneath the Europan ice, by whatevermeans possible.

Surfism, A socialbehavior meme, based on emulating the lifestyle of late 20th century surferculture. So−called *surfis* dressin garishly patterned clothing and spend time catching waves or listening to130−year−old music.

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Technodarwinism

Based on Charles Darwin's theory of natural selection,technodarwinists have taken the "survival of the fittest" credo toinclude the fruits of human ingenuity. Those with a scientific andtechnological advantage are, in some sense, *meant* to survive hardships which kill those without.

Technodarwinists invariably live in Fifth Wave societies. Theylook down upon less technologically advanced cultures and the people who livein them. Many of the corporate executives and some political leaders of FifthWave nations have technodarwinist leanings, leading to disregard for lessdeveloped nations when it comes to matters such as resource exploitation,ecosystem management, and weather control. The subtle spread of this meme isresponsible for much of the resistance to a more equitable spread of wealth andtechnology in the world. Technodarwinism is one of the discriminatory memeswhich has largely replaced racism in Fifth Wave cultures.

Extreme technodarwinists are known as *neomalthusians*. They delight in the disasters which strikeundeveloped nations, killing thousands and bringing the Earth's population backtoward "reasonable" levels.

Universalism

There have always been parts of Earth not controlled by anynation−state. Antarctica and the high seas fall into this category in 2100, anduniversalists want to keep it that way. Universalists are not necessarilyPreservationists nor nanarchists, though there is frequently some overlap withthese movements. Pure universalists oppose the extension of state control intounclaimed areas, believing that some regions should be left to the commonstewardship of transhumanity. Ocean floor and Antarctic colonization and miningare the main targets of protest. Depending on secondary leanings, universalistsbelieve either nobody should live in such areas, or individuals wishing toescape government should. Universalism has obvious application toextraterrestrial environments as well.

The Physical Ocean

Marine Geology

The oceans lie in basins between the continents. Pieces of theEarth's crust, known as *tectonic plates*,float on the underlying magma and slowly drift with respect to one another,creating fault zones and volcanic chains such as the "Ring of Fire"that encircles the Pacific Ocean. The various features of the ocean's terrainare products of this structure.

Continental Shelf

The continents are slabs of granitic crust, less dense than thethinner basaltic crust which comprises the ocean floors. They thus float higheron the magma, producing the raised areas of land we know. The oceans overlapthe edges of these landmasses, producing the *continental shelves*, which are geologically part of the continents.

The shelves lie at depths of up to 600 feet, and represent 6% ofthe surface area of the Earth. Their width varies from just a few hundred feet(in parts of the west coasts of Africa and the Americas) to 800 miles (north ofSiberia and North America), averaging 45 miles. They have a shallow slope,dropping an average of 10 feet per mile out to sea.

The continental shelf regions support the bulk of the ocean'smacroscopic organisms, since much of their area is within the *euphotic* zone the shallow depths where enoughsunlight penetrates to allow photosynthesis. For this reason, and because oftheir relative shallowness, the shelves are disproportionately populated withcommercial enterprises and submarine settlements.

Much of the continental shelf is covered by a layer of finesediment derived from the erosion of land and coastlines. Rivers and rainwaterrunoff sweep vast amounts of silt into the ocean. It accumulates until currentswash it downslope toward the edge of the continental shelf.

Continental Slopes

Beyond the continental shelves, the sea floor drops at an averagegradient of 200 feet per mile until it reaches the abyssal plains. These *continentalslopes* cover 11% of the Earth's surface.Some slopes are as steep as 1,300 feet of vertical drop per horizontal mile.

The main features of the continental slopes are submarine canyons steep–sided valleys which resemble deep river canyons on land, andoccur every one to six miles whenever the slope has a gradient of more than 150feet per mile. Tributary channels on the continental shelf feed into them. Thecanyons are formed by *turbidity currents* flows of sediment–rich water moving along the sea floor and fallingdown the slope. These currents are not continuous like rivers, but sporadic,usually initiated by seismic activity. A large earthquake can spawn majorturbidity currents which wash thousands of tons of sediment down the slope inmassive underwater landslides that move at up to 20 miles per hour.

When the transported sediments reach the bottom of the slope,they are deposited in a deep–sea fan formation, much like alluvial fansdeposited at river mouths. The largest such fan is the Amazon Cone theproduct of millions of years of sediment pouring out of the Amazon River which stretches 450 miles into the Atlantic Ocean northeast of Brazil.

There are very few submarine bases anchored on the continentalslopes because of the danger of turbidity currents. Only the shallowest slopes,in regions of low seismic activity, are relatively safe.

Abyssal Plains

At the bottom of the continental slopes lie the vast, flat *abyssalplains*, which cover 53% of the planet'sarea. The sea floor here lies three to four miles deep. Any small–scaletopographic features are covered by a layer of sediment averaging 2,000 feetthick. The deeper regions, such as much of the North Pacific, are covered by *abyssalclay*, a reddish clay formed of wind–blownparticles from land which settle on the ocean and drift slowly down. Shallowerplains, consisting of much of the rest of the seabed, are covered with abiologically derived sediment known as *ooze*, which is actually the calcium carbonate or silicondioxide shells of microscopic plankton, not a decaying mass of organic matteras the name might suggest.

Organic material does drift down to these depths from thesurface. The decaying remains of fish and other creatures living near thesurface form a constant, slow rain of particles called *marine snow*. This is the primary food source of many of thecreatures that live in the dark depths.

The abyssal plains are dotted with thousands of submarinevolcanoes, forming seamounts which rise from the depths. Most are extinct andsimply form vast underwater mountains, unseen by human eyes. Some break thesurface to form islands such as Hawaii. As these islands erode, coral growthcan keep them in touch with the surface as atolls.

Trenches

In some places notably the margins of the Pacific Ocean the continental slope does not stop at the depth of the abyssal plains,but plunges more steeply into long, narrow *trenches*. These are subduction zones caused by the slippingof one tectonic plate beneath another, dragging the sea floor down with it. Thedeepest parts of the ocean are in these trenches the Marianas Trenchsouth of Japan plunges to 36,160 feet (6.8 miles) deep. Trenches are hundredsto thousands of miles long and 25 to 75 miles wide. The average slope of trenchwalls is quite shallow they are not tight canyons with vertical walls,although local variations can produce such features over a restricted area.

The trenches are the ultimate frontier on Earth. With theavailability of deep−diving cybershells, there are no reasons for humans toventure into these depths other than curiosity and thrillseeking. A few tourismcompanies operate deep submersibles for wealthy clients who wish to experiencethe trip to the bottom. The highlights of the trip are the bizarre fish whichinhabit the deeps. Although few and far between, they are easy to see becauselights on the submersibles attract them. Cybershells plumb these depths forgeological research, but little other activity takes place in the trenches.

Mid−Ocean Ridges

Mid−ocean ridges are the longest chains of mountains on Earth,rising an average of 2.5 miles above the abyssal plains. The Mid−Atlantic Ridgestretches 6,100 miles along the length of the Atlantic Ocean; other ridges runthrough the Indian and East Pacific oceans. The ridges are areas of continuous volcanicactivity that creates new crust on the sea floor, increasing the area of theocean plates. This is balanced by the destruction of sea floor that occurs atsubduction zones. Mid−ocean ridges sometimes penetrate the sea surface Iceland is part of the Mid−Atlantic Ridge.

The structure of the ridges varies depending on how fast theyspread. Ridges that spread at rates up to two inches per year (e.g., theMid−Atlantic) have a valley three to 10 miles wide and up to three miles deeprunning down their centers. Systems that spread more than 3.5 inches per year(e.g., the East Pacific Rise) have smaller valleys (tens to hundreds of feetwide and 100 to 200 feet deep), along which volcanic activity is frequent andenergetic.

Geologists study mid−ocean ridges intensively because they arethe most dynamic expression of plate tectonics and show continuous geologicalactivity. Marine biologists also concentrate much of their attention on theridges, as they are home to the unusual hydrothermal vent communities (seebox). For these reasons, the majority of deep−sea scientific research in 2100is carried out along ridges and their associated fault systems.

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Unusual Ocean Environments

They say life itself got started in the deep sea. Maybe.It can't have been an easy birth judging by the life that remains.

*Peter Watts, **Starfish**.*

Hydrothermal Vents

The spreading of mid−ocean ridges opens tears in thesea−floor crust, through which water penetrates into deep rock layers. Heatedby proximity to magma, the water rises and shoots into the ocean in geyser−like*hydrothermal vents*. The hot watercarries dissolved minerals leached from the rocks, which precipitate out ofsolution as it mixes with the cold sea water, forming large"chimneys." Active vents produce billowing jets of particulate matterof varying composition, the appearance of which has led to the nicknames"black smoker" and "white smoker," depending on the colorof the plume.

The emerging water can be as hot as 750° F, although400° F is typical the high water pressure prevents it from boilinginto steam. It is rich in metal and hydrogen sulfides, which form commerciallyuseful deposits, and also provide chemical energy for unusual ecosystems. Farfrom sunlight, *thiotrophic*(sulfur−metabolizing) bacteria use the vent chemicals and warmth to sustainmetabolic processes, forming the base of a food chain that includes gianttubeworms, clams, crabs, and other creatures. The discovery of thesecommunities, totally independent of solar energy, in the 1970s led to thedevelopment of theories regarding the evolution of life on worlds such asEuropa. Since the 2049 discovery of Europan life, vent communities on Earthhave received unparalleled attention by evolutionary biologists.

Cold Seeps and Gas Hydrates

In some places (e.g., the Gulf of Mexico, EasternMediterranean, and off the coasts of California and the Aleutian Islands)deposits of hydrocarbons such as petroleum or methane (see *Gas Hydrates*, p. 00) slowly seep through the overlying rock andemerge on the sea floor. *Methanotrophic* bacteria metabolize these chemicals to form the base of an ecosystemindependent of solar energy. Seep communities resemble the sulfide−powered ventecosystems, with clams and tubeworms further up the food chain. They are atshallower depths, however, so fish and other creatures visit and interact withthem.

Unique creatures also live *within* gas hydrate deposits. Burrowing worms dig throughthe ice−like compounds, obtaining energy by metabolizing hydrocarbons.

Brine Pools

Large deposits of salt exist under the sea floor, beingparticularly common in the Gulf of Mexico and the Red Sea. Water seeping intothese deposits returns to the sea floor and collects in pools of brine up toseven times as saline as sea water. The high density of the brine prevents itfrom mixing with the water above, so the pools are stable features of the seafloor.

Brine seepage is associated with methane seeps, and theregions around brine pools are rich ecosystems composed of mollusks, worms,crustaceans, and predatory fish. Any creature unlucky enough to fall into thebrine dies from the salinity, and bodies of animals often float on thebrine–sea interface.

Most brine pools are cold places, at the ambient seatemperature, and less than 100 feet across. In the Red Sea, however, pools amile or more wide form on the mid–ocean ridge that runs beneath the sea, andare heated by volcanic activity to temperatures as high as 130° F. Theseimmense brine lakes are being considered by the European Union as testinggrounds for equipment designed to be used in Europa's basal seas (p. 00), butthe Islamic Caliphate is reluctant to allow E.U. research vessels near what itsees as a natural resource.

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Oceanography

Pressure

The weight of water causes the pressure in Earth's oceans toincrease by 1 atmosphere for every 33 feet of depth. Pressures range from 10 to20 atm. on the continental shelves to between 400 and 700 atm. on the abyssalplains. At the bottom of the Marianas Trench the pressure reaches 1,090 atm.

Pressure affects living beings in dramatic ways see p. 00for the effects of pressure on characters. Animals are adapted to the normalrange of pressures they experience in their lives. Those who spend their entirelives in the abyssal depths will suffer horrible deaths if brought to therelatively low pressure of the surface.

Chemistry and Electrical Properties

Sea water contains dissolved salts, at concentrations from 3.2%to 3.8% by weight, averaging 3.5%. The vast majority of the salt is sodiumchloride, though many other substances are dissolved in seawater, includingsulfates, silicates, metals, and rare trace elements. The most saline ofEarth's major seas is the Mediterranean, though local seas can reach muchgreater salinities the Dead Sea is 10 times as saline as the oceans.

The upper ocean is saturated with calcium carbonate thematerial used by many sea creatures, from mollusks to microscopic plankton, toform shells. This means the shells do not dissolve. Below 12,000 to 18,000 feet(depending on local conditions), however, the water is cold enough to dissolveadditional carbonates. Any shells falling from above dissolve at this depth,and animals living below cannot form shells of calcium carbonate. Abyssal oozes(p. 00) at the lowest depths are thus made entirely of silicon dioxide shells,with no calcium component.

The salt content means sea water conducts electricity reasonablywell a fact used by several sea creatures, which have evolvedelectricity–generating and –detecting organs for defense and sensation. It alsomeans that electromagnetic waves such as radio and light are absorbed veryrapidly. Radio is essentially useless underwater, except for specializedExtremely Low Frequency (ELF) transmissions, which require antennae hundreds offeet in size.

Temperature

The uppermost layers of Earth's oceans are influenced byatmospheric circulation and solar heating, making them the warmest part of theseas. Below a certain depth, sea water is uniformly cold. The layer in between,where the temperature changes rapidly with depth, is known as the *thermocline*. The depth and thickness of the thermocline dependsstrongly on latitude, season, and time of day.

In the tropics, the surface water is warm and well mixed,reaching temperatures up to 80° F near the surface. The temperature drops to40° F around a depth of 1,800 feet, with a strongly defined thermoclinebetween the warm upper layers and the cold waters below. In mid–latitudes, thethermocline is deeper because water mixing is greater than nearer the equator.The surface temperature varies between 50° F and 70° F depending onseason, but between 200 and 3,000 feet deep the temperature drops gradually to40° F. At high latitudes, the upper water temperature is near 40° F, notsignificantly different from the cold water below here, the thermoclineis weak to non–existent. The uppermost layers of the polar oceans can even be *colder* than the deep water below.

Below the thermocline, temperature decreases slowly with depth two miles down the temperature is 37° F.

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Sea Breezes

Land heats up more quickly than water during the day, settingup convection cells in which warm air rises on a coast, flows out to sea athigh altitude, sinks over the sea, and blows inland at the surface. This iscalled a *sea breeze*. As the land coolsat night, warmer air rises over the sea, reversing the convection and creatinga *land breeze* blowing out to sea.

The moist, rising air of sea breezes produces tall cumulusclouds over coastlines, islands, and even floating arcologies. These cloudsrise up to 4.5 miles high and can be seen from sea level up to 180 miles away.Ocean navigators without access to GPS systems would be wise to know this . . .

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Winds and Currents

Differential heating of Earth by the sun generates three largeatmospheric convection cells in each hemisphere. Warm air rises at the equatorand near latitude 60° , and cool air falls at the poles and near latitude30° . The *Coriolis effect* adeflection of objects travelling along the surface of a rotating sphere acts on these cells, causing wind flowing toward the equator to deflectwestward (in the tropics and polar regions), and wind flowing toward the polesto deflect eastward (in the mid–latitudes). Prevailing winds in the tropics arethus easterlies (blowing from the east), and are called *trade winds*. In the mid–latitudes, winds are predominantlywesterlies.

These winds act on the ocean surface, driving the movement of theupper layers of water. Again, the Coriolis effect complicates matters water is actually driven perpendicular to the wind direction. Also, unlikewinds, water movement is restricted by the continents. The overall result isthat surface ocean currents generally circulate clockwise in the northernhemisphere, and counterclockwise in the southern hemisphere. These circulationcells can be as wide as an entire ocean, or can be constrained in size bypeninsulas, islands, and other currents. The greatest movement of surface wateris the Antarctic Circumpolar Current, which circulates eastward around thefrozen continent.

Surface currents carry warm water from the tropics toward thepoles. Particularly notable are the Gulf Stream, which flows north along theeast coast of North America, carrying warm water north and then east towardEurope, and the Kuroshio Current, which performs a similar function near Japan.Cold water is carried away from the polar regions by other currents. The bestexample of this is the cold Peru current, which brings Antarctic water northalong the west coast of South America. This water is rich in nutrients andsupplies raw material for the rich fishing grounds off Peru.

*Thermohaline Conveyor Belt.*Currents also flow deep in the ocean. Water in the Norwegian and Labrador Seasof the North Atlantic sinks as it becomes colder and denser, then flows southalong the Atlantic floor. This *North Atlantic Deep Water* (NADW) flows as far as latitude 50° S, where itmerges with similar cold water sinking off the coast of Antarctica. Theresulting *Antarctic Bottom Water*(AABW) flows west, south of Africa and Australia, then north into the Indianand Pacific oceans, where it eventually warms and rises in the North Indian andMid−Pacific oceans.

Surface currents bring warm Pacific surface water between Asiaand Australia into the Indian Ocean, where it joins more rising AABW and flowswest around Africa back into the Atlantic. Surface water flows north in theAtlantic to complete the circuit, which is known as the *thermohalineconveyor belt* because it depends on thetemperature and salinity of the bodies of water involved. This circulationplays a crucial role in regulating global climate, transferring vast amounts ofheat around the globe.

Waves

As wind blows across the sea, it forms ripples on the surface.These build up to form waves with height dependent on the wind speed. TheBeaufort wind scale (see box) shows how high the waves are for a given windspeed.

Waves contain energy and transfer it across the sea by theirpropagation. As they travel, energy is lost through friction with the air,spreading of the wave front, white−capping (collapse of the wave top in whitefoam), and interactions with other waves. This decreases the height of thewave. When the rate of energy loss equals the rate at which energy is gainedfrom the wind, the waves can grow no larger a condition known as a *fully−developedsea*. This occurs only if a constant windblows over a long enough distance for a sufficiently long time, such as duringstorms in the open sea. More commonly, different winds clash to form complex *wavefields*.

Once a wind dies down, the waves no longer gain energy and simplypropagate across the sea, gradually losing energy and height. The waves spreadout to form a *swell*, the familiarbobbing of the sea which can occur even in calm wind conditions as wavespropagate from distant places.

In deep water, waves travel unhindered. As they approach shoreand travel into shallower water, their speed decreases because of interactionwith the sea floor, and their height increases in response to conserve energy.As the wave height builds up, the top tends to keep travelling faster than thebottom, resulting in the curling, breaking waves beloved by surfers. The energycarried by the wave is released with a crash of noise and foam along the shore.Depending on local geography, this can cause erosion of the shoreline, which isan important factor in coastal development and ecoengineering.

Waves also interact with ocean currents. A current flowing in thesame direction as a wave will increase the speed of the waves, and decrease thewave height as the waves impart energy to the current. Conversely, if thecurrent travels in the opposite direction to the wave, then the wave speeddecreases, height increases, and the current imparts energy to the waves that *further* increase their height. This results in *giantwaves* that can be higher than 100 feet. Anexample is the

Agulha Current, which runs against storm waves generated in theSouthern Ocean. This ocean is the most violent on Earth, since the currents andwinds circumnavigate the globe around Antarctica, producing fully–developedseas with giant waves.

Tsunami are very energeticwaves caused by earthquakes, volcanic eruptions, and other catastrophic eventsin the sea. In the open ocean, they are almost indistinguishable from any othertype of wave and pass by ships without drawing attention. As they approach ashore, the waves slow down and dramatically increase in height. By the timethey reach land they can be over 300 feet high, causing massive destruction onthe shore and for miles inland. Tsunami are mostly restricted to the PacificRim and islands such as Hawaii.

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The Beaufort Wind Scale

Scale   Wind Speed   WaveHeight   Control   CRM SeaCondition

0: Calm   0–1   0   Sea like a mirror.

1: Light air   2–3   0.1   Ripples only.

2: Light breeze 4–7   0.6   Wave crests have a glassy appearance.

3: Gentle breeze   8–11   1   1day 0   Wave crests begin to break.

4: Moderate breeze   12–18 3   4hrs 0   Some whitecaps.

5: Fresh breeze 19–24 6   2hrs –1   Many whitecaps.

6: Strong breeze   25–31 10   1hr   –1   Spray begins to form.

7: Near gale   32–38 14   30min   –1   Foamblown in streaks downwind.

8: Gale   39–46 19   15min   –2   Wavecrests break into spindrift.

9: Strong gale   47–54 24   5min –2   Sea is a dense foam, visibility affected.

10: Storm   55–63 30   1min –3   Heavy sea roll, visibility impaired,surface white.

11: Violent storm   64–73 36   1min –3   Visibility poor.

12: Hurricane   74+   46   1min –4   Air filled with foam and spray, visibilitybad.

Scale: The wind forcelevels and names on the Beaufort scale.

Wind Speed: Measuredin miles per hour.

Wave Height: Theaverage wave height in feet. Maximum wave height is just over *twice* this value.

Control: The timeinterval between control rolls for surface vehicles (see *AquaticVehicle Operations*, p. 00). Shift one rowup per positive Size Modifier point, to a maximum of six rows.

CRM (Control Roll Modifier): This penalty applies to *all*control rolls made by surface vehicles.

*Sea Condition:*Description of the appearance of the sea.

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Tides

The gravitational effects of the Sun and the Moon deform theoceans and atmosphere of Earth into a non–spherical shape, producing a *tidalbulge*. Fluid flows toward the point onEarth nearest the attracting body and to the point directly opposite.

The dominant tide on Earth is caused by the Moon. As Earthrotates, it moves through the tidal bulge, which is fixed with respect to theMoon. It takes 24 hours and 50 minutes for Earth to rotate once with respect tothe Moon, producing two *high tides* andtwo *low tides* over this period.

The Sun, although much more massive than the Moon, is furtheraway, and causes a tidal force about half as strong, with a period of 12 hours.When the Sun and Moon are aligned (either both on one side of Earth or onopposite sides) the tidal effects combine to form the strongest, or *spring*, tides. When the angle between the Moon and the Sunis 90° the weakest, or *neap*,tides occur. Both extremes occur twice a month, with a week between oppositetypes.

In practice, the tidal bulge's motion around the planet isaffected by land masses, ocean bathymetry, Coriolis force, and astronomicaleffects such as the Moon's orbital inclination and eccentricity. This meansthat the timing and height of tides cannot be calculated simply from the Moon'sposition, and depend heavily on local geography. Some places have almostnon–existent tides (e.g., most of the Mediterranean), while some bays andinlets have large tidal variations, up to a maximum of 56 feet in the Bay ofFundy, Newfoundland.

In some places, a phenomenon known as a *tidal bore* occurs. This is a high tide that is amplified bylocal geography (e.g., a narrowing bay, shallowing sea floor, or steep riverchannel), so that it comes in at great speed, forming a visible wave of water.The Fuchun River in China experiences the Qiantang bore, a wall of water 15feet high traveling at 15 mph up the river. The Amazon and Seine rivers alsohave large bores.

Ice

The freezing point of sea water is 28.6° F. When the airtemperature is below this point, ice crystals form on the surface and growuntil the sea is slushy. Wave action prevents this forming into a solid sheet further freezing produce discrete chunks of ice known as *floes*. These range in size from "pancakes" oneto 10 feet across, up to five miles or more. This temporary winter *packice* reaches a maximum thickness of sixfeet, and can be penetrated by icebreaking ships. Pack ice can form rapidlywhen temperatures are very low, around –20° F.

Permanent *polar ice* coversthe central regions of the Arctic Ocean, reaching maximum thicknesses in excessof 160 feet in winter. In summer it melts to an average of six feet thick, andin some places holes called *polynyas*form. Ice can also develop from the shore outwards into the sea; this is knownas *fast ice*.

Icebergs are large chunksof fresh water ice that break off from continental ice shelves or glaciers.They are carried by surface currents and slowly break into smaller icebergs asthey melt. They are usually found at high latitudes and can last up to a yearin cold conditions, but some drift into warmer waters and can be a danger toshipping. Prevailing climate conditions can increase the dangers of icebergsconsiderably (see *El Niæo and La Niæa*, p. 00).

Submarine Acoustics

With radio and vision severely limited by the absorptiveproperties of sea water, transmission and reception of sound is the mosteffective form of communication and perception underwater. Sound travels fasterin water than in air because it is a denser medium around 3,300 mph(cf. 770 mph in air) and carries over far greater distances.

The speed of sound varies considerably depending on thetemperature, pressure, and salinity of the water. As one travels downwardthrough the layers of Earth's oceans, sound speed initially increases withincreasing depth. At the thermocline, sound speed decreases rapidly as thetemperature drops. Below the thermocline, the sound speed increases again withincreasing pressure.

The changing speed causes sound waves to *refract*, or bend, as they pass through the water. Where thesound speed increases with depth, the sound waves will bend upward. If thesound speed decreases with depth, the sound waves will bend downward. Soundgenerated above the thermocline therefore bends upward, where it can reach thesurface, reflect off the water–air boundary, and travel down again. This canrepeat several times, trapping the sound within a shallow layer near thesurface known as a *surface duct*.

At the top of the thermocline, the sound speed starts to decreasewith increasing depth. The depth at which this occurs is called the *layerdepth*. Waves travelling at shallow anglesto the horizontal above the layer depth are bent upward, while waves travellingat steeper angles pass the layer depth and are then refracted downward. Theregion between the upward and downward bending waves receives *nosound waves at all* from a given source,creating what is known as a *shadow zone*. Submarines often operate at depths within this zone, since theycannot be detected there by sonar beyond a certain range.

At the base of the thermocline, the sound speed starts toincrease again. The depth at which this occurs is called the *deep soundlayer*. Sound waves emitted around thisdepth are refracted back toward the same depth, forming a channel in which thesound is trapped. Sounds trapped in the deep sound layer can travel vastdistances. Many sonar buoys are built to operate at this depth, and whales usethis layer to communicate with pods hundreds of miles away.

As the depth increases, increasing pressure refracts sound wavesupward again. If the sea floor is more than 700 feet below the base of the deepsound layer, the sound waves may be bent back up to the surface without hittingthe sea floor. If the sound is emitted from a surface vessel, the wavesrefracted from deep water converge in a ring around the vessel known as a *convergencezone*. The waves bounce from the surface andare bent back again, forming multiple convergence zones at regular intervalsaround the ship, separated by 20 to 30 miles. Each ring is only a few mileswide, but they form an effective early warning system, since anythingtravelling through any of the convergence zones will be detected by sonar.

Sound waves reaching the sea floor can bounce directly off it andon to targets. This only occurs if the sea floor is hard and flat softooze is insufficiently reflective. Sea−floor topography can also block soundwaves and create shadows in which submarines can hide.

A final complication in the use of sonar is the *deepscattering layer* (DSL). This is a layer ofplanktonic organisms and the fish which feed on them. They are so dense in manyparts of the sea that they reflect a considerable amount of sound, potentiallyblocking sonar visibility beyond the layer. The DSL lies at 3,000 feet duringthe day, but rises at night as the plankton come to the surface to feed indarkness, ranging from 700 to 1,300 feet, depending on the brightness of themoon.

Climate

The Earth's climate is determined by complex interactions betweenthe oceans, the atmosphere, and landmasses. The climate has changedconsiderably throughout the 21st century, due to the effects of industrialpollution. The sea's mean surface temperature has risen by 3° F, causing itslevel to rise by five feet. These changes mean more energy is available in theclimate system, producing more frequent and more intense storms than at anytime in history. It is an age of heavy weather. For details about climatechange and the effects of heavy weather on land, see pp. FW21, BD00−00.

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Gas Hydrates

Gas hydrates are solid compounds composed of gas moleculeslocked in a matrix of water. The result resembles water ice. Methane hydrate isstable at the low temperatures and high pressures found at ocean depths below1,000 feet. It is present in sea−floor sediments along continental margins,particularly of the Americas, Russia, Japan, and Scandinavia. Methane hydratecan permeate sediment up to 3,500 feet thick. The amount of methane stored insuboceanic hydrates is enormous over 10 trillion tons, or 3,000 timesthe amount in the atmosphere representing more than half the organiccarbon on Earth. This methane comes from the decay of organic matter byanaerobic bacteria.

These immense reserves were mined in the early 21st centuryas a fuel source by the United States, Canada, and Japan. Mining was stoppedwhen practical fusion became possible in the 2030s and hydrocarbon fuels lostfavor. The mining efforts barely made an impact on the remaining deposits.

In 2100, methane hydrate is a serious concern. The surfaceheat from global warming is slowly raising the temperature of the deep sea.There are large hydrate deposits in regions where a small temperature rise willcause instability and release the trapped methane. Hydrates act as a cement,stabilizing loose sediment. If a small area releases its methane, theresulting instability can cause large−scale turbidity currents (see p. 00) andrelease methane over a wide area. In these events, large quantities of gasbubble to the sea surface, producing a foamy liquid with a low average density.Ships sailing in such areas can find themselves unable to displace enough waterto stay afloat, making these events serious hazards. A ship caught in a methaneoutburst will simply drop into the foamy sea, be swamped, and likely sink tothe bottom very quickly.

What is worse, methane is a greenhouse gas with 20 times theefficiency of carbon dioxide. Large scale release of methane into theatmosphere will accelerate global warming, resulting in a feedback cyclereleasing more methane and driving Earth to a hot, pressurized state similar toVenus.

To date there have been a few small–scale methane releases,but evidence is mounting that they are becoming larger and more frequent.Ecoscientists and engineers are working desperately to find a way to stabilizethe immense quantities of methane hydrate covering the seabed, but so farwithout any success.

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Hurricanes and Typhoons

These intense tropical storm systems originate in latitudes from10° to 30° in both hemispheres, where the sea surface temperature isgreater than 80° F. In 2100, this means almost every sea area in theappropriate latitude band in which it is currently summer or autumn. Storms arecalled *hurricanes* (Americas), *typhoons* (Asia) or *tropical cyclones* (Australia) depending on local custom *hurricane* is used here to refer to all such storms. SouthAtlantic hurricanes are rare because of upper atmospheric conditions.Hurricanes are characterized by sustained surface wind speeds in excess of 74mph. sustained winds exceed 156 mph in a Category 5 hurricane.

Once formed, hurricanes tend to move toward the west and awayfrom the equator. As they cross latitude 25° , they deflect eastward as theycontinue away from the equator. These are generalities individualhurricane movements are chaotic and predictable only by probabilities. Ingeneral, hurricanes are most likely to hit landmasses in the South–East UnitedStates, Japan, South–East and South Asia, and Northern Australia. Although theycause great destruction to coastlines, hurricanes rapidly moderate into lessdangerous rainstorms as they move inland.

At sea, hurricanes create mountainous waves, which can swamp anddestroy ships. In the northern hemisphere, where hurricane winds circlecounterclockwise, the area to the right of a hurricane's movement track is themost dangerous. Here, the wind speed is combined with the hurricane's motion,producing the strongest winds and roughest seas. Additionally, the wind tendsto draw ships into the path of the storm, and they must battle to avoid thisfate. On the left side of a hurricane, wind speed and wave height aresubstantially less, and ships can run with the wind to be taken out the rear ofthe storm. These directions are reversed in the southern hemisphere.

The terrific winds of a hurricane push a mass of sea water aheadof the storm, creating a bulge of water which can be 25 feet or more above meansea level. This *storm surge*, combinedwith rainfalls as heavy as 30 inches in 24 hours, can cause disastrous floodingof coastal areas.

Weather Control

Being able to control the weather has long been a dream ofhumanity. The first tentative steps were taken in the 20th century with cloudseeding experiments designed to induce rainfall with mixed results.Meterorologists began to realize in the 2030s that technology might soon allowthe manipulation of weather patterns on a large scale, which would be moreeffective over the long term than attempting to direct local conditions. Theunveiling of the Ares Conspiracy (p. TS19) in 2041 and the subsequent birth ofthe Preservationist Movement dampened any enthusiasm for weather control forthe next few decades. However, as temperatures and sea levels continued torise, and storms became more frequent and ferocious, pressure mounted for theimplementation of some sort of mitigation system.

Cloud seeding operations proved ineffectual at modifyinghurricanes. In 2089 the first weather control satellite was launched. Operatedby the United States, it used wide−beam microwave lasers to heat air massesnear Hurricane Foster in 2090, successfully turning it away from CapeCanaveral. Since then, a new science of meteorological engineering hasdeveloped, mostly in the hands of AIs running millions of simulation models tohelp predict the outcomes of a particular piece of atmospheric heating.

The legal ramifications of weather control, already mired ininternational politics, were complicated in 2093 when China unilaterally used asimilar satellite to heat parts of the East Pacific Ocean. Some climatologistsclaim this triggered the intense El Niæo of 2093−96, which broughtdisastrous climatic conditions to many TSA and PRA countries. Others refute this,but most political analysts agree on China's intentions. International pressurehas prevented another such incident.

Manipulation of hurricane tracks continues, however. Japan andAustralia launched their own weathersats in 2097 and 2098. Malaysia, althoughnot normally threatened by typhoons, is rumored to be working on a weathersat   conspiracy theorists speculate it will be used offensively rather thandefensively.

The European Union has protested to all nations involved withweather manipulation, but responses, if any, usually allude to the fact thatEurope never experiences hurricanes, making it easy for them to ignore thedamage they cause. In 2095, an attempt to prevent Hurricane Ophelia fromdamaging Miami went awry and caused the storm to hit Nassau, resulting in theloss of 600 lives and $1.3 billion in damage. The Caribbean Union brought alawsuit before the World Court (p. FW55) in 2096, demanding that the UnitedStates use its weathersat only after consultation and agreement with the Union,and to compensate the Bahamas. The United States has so far declined to accepta ruling from the Court, so the case remains in limbo.

El Niæo and La Niæa

El Niæo and La Niæa are the opposite phases of aclimatic cycle known as the El Niæo/Southern Oscillation (ENSO). Thecycle has an irregular period ranging from two to 10 years.

El Niæo phases are characterized by an eastward shift inthe surface heat distribution of the Pacific Ocean, and a linked reduction inatmospheric pressure difference between the East and West Pacific. This weakensthe Pacific's tropical easterly trade winds and can even replace them with mildwesterlies. In turn, this generally causes drier than normal conditions in theWestern Pacific and wet conditions in the Eastern Pacific. Ocean currents arealso disrupted, particularly the cold Peru current which causes upwelling ofnutrients along the South American coast. During El Niæo years, thedisruption to the base of the food chain in the East Pacific wreaks havoc onmarine ecosystems. The effects are not restricted to the Pacific basin   shifts in high altitude jet streams cause unusual weather around the globe. Inparticular, densely populated parts of North America and Europe experience warmweather with heavy rainfall.

La Niæa events usually occur shortly after the end of anEl Niæo, as the Pacific overshoots its equilibrium position. The seasurface temperature and atmospheric pressure differences between the East andWest Pacific are increased, resulting in stronger trade winds. This brings heavyrain and typhoons to the West Pacific, while causing droughts in much of theAmericas.

The warming of the Earth in the 21st century resulted in theproduction of more frequent, longer, and stronger El Niæo events.Slow−moving subsurface waves in the Pacific act to prevent El Niæoevents from being sustained indefinitely, and when one finally ends after threeto five years it is invariably followed by a severe La Niæa. The LaNiæa usually only lasts a year, but causes massive destruction toheavily populated regions of the Pacific and Atlantic before ocean warmingbegins another El Niæo. The last La Niæa was in 2097, and 2100looks like being the first year of the next El Niæo.

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Other Climatic Oscillations

In addition to ENSO, there are several other quasiperiodicclimatic variations. Some, such as the cycle of ice ages and interglacialperiods, are very long term, and will not feature in a ***Transhuman Space*** game without the use ofnanostasis. Two shorter term cycles are:

North Atlantic Oscillation. This is a variation in the prevailing atmospheric pressure systemsover the North Atlantic Ocean. Approximately every 10 years, unusually lowpressure near Iceland produces winds which bring warm, wet winters to Europeand the Eastern United States, and dry conditions to the Mediterranean. In theopposite phase, these conditions are reversed.

Pacific Decadal Oscillation. This cycle varies with a period of 20 to 25 years. In the *warmphase*, sea surface temperatures off thesouthern coast of Alaska are elevated. This brings warm, dry conditions to theNorthwest United States and cold, wet conditions to the Southern United States.It also enhances the effects of an El Niæo on North America andpartially mitigates a La Niæa. The reversed effects of the opposite *coolphase* include enhanced La Niæas.

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Oceanic Resources

Food

The seas have provided a bounty of food since prehistoric times.For most of history, harvesting wild seafood was sufficient. As demand grew andtechnology advanced in the 20th century, natural stocks became depleted andcommercial farming of marine species mostly mollusks profitable. The early 21st century saw the rise of aquaculture, withnon−migratory fish raised in captive habitats supplying increasing fractions ofdemand.

The fishing industry changed forever in 2034 when anenvironmentalist group revealed evidence that the Indonesian company P.T.Payabetung Bioteknologi Terbuka had been releasing gengineered food fish intothe wild, causing the decline of several natural species by competition forfood sources. Over a hundred genemod fish species have now been identified inthe wild, many with unknown origins. Some have prospered and now supportsignificant fisheries. Many have wreaked havoc on natural species. Researcherstry desperately to stabilize the ecosystem, while Preservationists decry whathas happened and try to prevent further genetic pollution.

The development of AI technology and ecoengineering in the 2060sled to improved management of stocks and increased fishing efficiency.Migration and local movements could be predicted and controlled. Much of theeffort was initially focused on preventing the loss of species due to climatechange and the warming of the oceans, but this was a losing battle. Attentionshifted to managing the altered ecosystems and minimizing destructive speciesinteractions. In the ever−changing marine environment, fishery scientists havetheir hands full.

The technology which produced fauxflesh and liberated millions offarm animals from Fifth Wave kitchens is starting to replace some seafoods withfauxfish. The plight of fish, crustaceans, and mollusks as food animals hasnever attracted as much attention as that of mammals and birds, however, andmarket penetration is still small. The engineering problems are greater too.People are used to oysters that look like oysters, not undifferentiated slabsof oyster−meat, and memetic changes to eating habits are meeting growingresistance, led by the Real Food Movement. There is not enough moral differencebetween most natural seafoods and vat−grown versions to sustain research anddevelopment costs.

Fishing Methods

Traditional fishing methods such as trawl nets and long lines arestill in wide use. These are supplemented by new technologies such asintelligent pearlwebs that can swim through the ocean seeking out fish, herdthem into a tight school, then entrap them and signal for a service vessel topick them up.

Ecoengineering also makes fish more abundant and easier to catch.Artificial reefs provide habitat for increasing numbers of shallow−waterspecies. Pelagic fish are attracted to pieces of flotsam, which serve asprotection, markers for food, and reference points for assembling into schools.A small raft of seaweed can support a large community of species covering anarea of a square mile or more. Strategically placed ecoengineered flotsamhabitats can attract vast numbers of fish, making harvesting more efficient.

Fish populations are boosted by manipulating the base of theirfood chain the plankton. In most regions of the sea, plankton growth islimited by the availability of iron as a mineral nutrient. Simply seeding thesurface with soluble iron compounds produces dramatically increased planktongrowth. Following disastrous experiments in the 2030s, the amounts of ironintroduced are strictly controlled to avoid toxic plankton blooms.

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Aquaculture

The alternative to fishing is raising aquatic species incaptivity. Mollusks are the easiest to cultivate and many species can be raisedwith nothing more than wooden frames set up in estuaries and tidal zones, ashas been done for centuries. Crustaceans and fish require considerable spaceand effort to breed, grow, and feed, but the rewards can be worthwhile. Somenatural species are unsuitable for aquaculture because they are difficult tobreed or consume too much feed for the amount of meat they produce, but moreproductive genemod versions are often available. Lobsters, for example, becomecannibalistic in cramped enclosures, but GenTech Pacifica's "SandyClaws" germline grows happily in confined quarters.

In 2100, some 60% of seafood is produced by pennedaquaculture. (Some people argue that, with the active management offree−ranging species in almost all parts of the globe, *all* seafood is now cultured.)

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Bioresources

The oceans contain vast quantities of biomass, includingrepresentatives of every phylum of life on Earth. This abundance and diversityprovides scientists, industrialists, and even artists with a broad range of rawmaterial for many purposes. Gengineers modify species for particular purposes,creating enhanced food animals, pharm animals, and organisms for use inconstruction, transport, ecoengineering, and industrial processing. Somespecies, such as cetaceans and cephalopods, have been subjected to upliftexperiments designed to enhance intelligence and engender sapience (see *CetaceanUplift*, p. 00). Others have provided neworganic compounds usable for drug development.

In 2100, the race is on to catalog and genetically sequence asmany life forms as possible. Many unknown species live in the oceans, andcompanies such as GenTech Pacifica and Atlantec have labs dedicated to studyingspecimens newly discovered in deep and remote habitats. Candidate genes forcommercial use are rushed through the patent process to become potential futuresources of income. The collecting of specimens and subsequent research areprime targets for industrial espionage and subtle sabotage attempts.

Minerals

Historically, the most important oceanic mineral resources havebeen petroleum and natural gas. The development of fusion power in the 2030shas dramatically reduced demand for these commodities, but there are stilloffshore oil platforms drilling for the fossil fuels used in Third Wave regionsand for some specialized purposes. These have steadily dwindled in number overthe latter half of the 21st century, producing a supply of disused floatingplatforms suitable for conversion into habitats. Most of the remaining activeplatforms are in the Persian Gulf, supplying oil for the Islamic Caliphate.

The sea contains many other sources of minerals, which areexploited to various degrees by the mining corporations of 2100.

Manganese Nodules. Theseare potato−shaped lumps of ore from one to eight inches in diameter, denselyscattered across vast regions of the deep sea bed, forming one of the richestsources of industrial metals. Manganese nodules grow slowly by the depositionof metal oxides from the water, catalysed by micro−organisms, and contain up to30% iron and manganese by weight. It is, however, lesser constituents such asnickel, cobalt, and copper half a percent each which makemining the nodules worthwhile. Nodules litter as much as 20% of the sea floor,at an average density of 6,000 tons per square mile. Several companiesspecialize in retrieving nodules, mostly using deep−diving cybershells tocollect and transport them to surface ships.

Metallic Sulfides. Thehot, mineral−laden water around hydrothermal vents reacts with surrounding seawater to produce metal sulfides, which precipitate out of solution. Blacksmoker chimneys are the most visible and fastest growing accumulations, butlarge regions of the sea−floor along the oceanic ridges are covered with olderdeposits of iron, copper, and zinc sulfide.

Cobalt−Rich Crust. Theupper slopes of oceanic islands and seamounts, between depths of 3,000 and8,000 feet, contain cobalt in concentrations twice as high as manganesenodules. This forms a significant resource for small island states such as theFaroe Islands, Cape Verde, the Maldives, and several Pacific island nations.

Abyssal Clay. The abyssalplain north of Cape Verde, is covered with a clay formed from sediment blownoff the Sahara Desert. This clay contains 20% aluminum and is mined simply byscooping it off the bottom at depths of three to four miles.

Volcanic Calderas. In rarecircumstances, submarine volcanoes can form calderas similar to those formed onland. The Izu−Ogasawara Arc of volcanoes, south of Japan, is one such place.Hydrothermal fluids leach heavy metals out of subterranean rock and depositthem in the caldera, creating fields rich in gold and silver. These lodes canmeasure 1,000 feet across and 100 feet thick, and are located at depths of oneto four miles, at the summits of submarine volcanoes. Mining them is lucrative,but dangerous, as the volcanoes are still active.

Hot Brine Pools. The hotbrine pools of the Red Sea (p. 00) accumulate a mud consisting of 40% zinc, aswell as usable quantities of copper, silver, and gold. As former pools werecovered by sediment, they left this ore behind in deposits up to a mile acrossand 300 feet thick, scattered across the Red Sea bed.

Dissolved Minerals. Seawater itself is an important source of industrial chemicals, includinghydrogen, deuterium, chlorine, bromine, ammonia, methanol, magnesium, andaluminum. These are extracted by self−contained processing stations powered byOTEC or other oceanic energy systems (see *Energy*, p. 00). Although sea water contains other valuableelements, notably gold, it is still commercially impractical to extract them.

Energy

A vast amount of renewable energy is collected and stored by theoceans in various forms. Extracting this energy is often easier than directsolar conversion, and has the advantage of power being available around theclock. Even D−He−3 fusion is dependent on the deuterium supply available fromthe oceans. In 2100, fusion supplies just over half the power requirements ofEarth, but much still comes from other sources, with oceanic energy supplying15% of demand.

Ocean Thermal Energy Conversion (OTEC)

Most of the energy stored in the ocean is in the form of heat.The surface waters of the tropics can be 40° F to 50° F warmer than belowthe thermocline. Ocean Thermal Energy Conversion systems use this temperaturedifference to drive a reverse refrigeration cycle in a fluid, usually anammonia−water mixture. Warm surface water boils the fluid, which drivesturbines as it descends to depth, where the cold water condenses it again.

OTEC installations are anchored in deep tropical water. Thelargest measure 600 feet across, have a main shaft descending to a depth of1,500 feet, and weigh over a million tons. A station of this size generates 1GW of power. Many of these facilities have been used as bases for arcologies,housing up to 5,000 people each.

The amount of heat redistributed by an OTEC plant is trivialcompared to the bulk of the oceans. It would take a gigawatt plant half a yearto reduce the temperature of a cubic mile of surface water by 1° F, assumingit wasn't being reheated by the sun. Still, some Preservationists andecophysicists condemn the proliferation of these facilities, arguing that theymay cause subtle changes to the world climate, with unforeseeable results. Thepotential damage an attack on an OTEC plant might cause, spilling millions ofgallons of ammonia into the sea, has been enough to deter ecoterrorists fromany such action, so far.

Other Energy Sources

Waves. After heat, thekinetic energy of waves is the next largest oceanic energy reservoir. The mostefficient power converters use the heavy swells of the mid–latitudes to washwater through fixed turbines. The largest engineering problem is keeping theturbines still, rather than bobbing on the swell. This means wave generatorsare usually fixed to the shallow sea floor not far from shore. Wave powergenerators have an additional benefit, in that they reduce the energy carriedinshore, thus slowing shoreline erosion and protecting fragile coastal areas.Many Fifth Wave nations have barrier formations of wave power generatorsguarding parts of their coastlines, particularly the eastern seaboard of theUnited States, the European nations bordering the North Sea, and Japan.

Currents. Ocean currentscan drive turbines anchored in their flow. Swift currents such as the GulfStream are a significant power resource. An array of generators off thesouth–eastern coast of Florida generated up to 20 GW at its peak in the 2070s,but began falling into disrepair when NAHGI (p. TS20) started shipping cheapHe–3 back to the United States. Japan operates a more modest facility in theKuroshio Current off its south coast.

Tides. Although tidalmotion carries relatively little energy, tidal power generators are easy tobuild and common in places with large tides, including Rangoon, Shanghai,Auckland, the Gulf of California, the Bay of Fundy (Newfoundland), Sao Luis(Brazil), and La Rance River (France). Most are barriers built across bays or estuaries,with turbines driven by the tidal motion of water. These facilities eachgenerate a few gigawatts, but power output is variable according to the stateof the tidal cycle. Tidal power stations can also convert exceptional tides andstorm surges into usable power, such as at the City of Angels arcology near LosAngeles (see p. BD00).

Living in the Ocean

We've made the investment needed to venture into the skies,and it has paid off mightily. We've neglected the oceans, and it has cost usdearly. This is the time to do for the oceans in the 21st century what ourpredecessors did for space.

Sylvia Earle, Chief Scientistof U.S. National Oceanic and Atmospheric Administration, 1995.

Kirby sat in the decompression quarters, idly flipping InVidchannels. A day in and he was already bored. He could barely wait to get out ofhere, board the transport sub, and get back to the surface. The air was in theprocess of being switched from hydrox back to the real stuff. The only way totell was by the effect of the gas on the voicebox, but Kirby reckoned he couldsmell the difference. He wanted to feel a breeze that didn't come from a duct.The evening sea breeze, wafting in off the ocean, with its tangy scent of salt,and of life. The air down here was . . . too clean. Sterile.

The bioroids didn't help either. They made his skin crawl. Fewjobs in Elandra needed the expertise of a human, but when one did, there was nooption but to endure the compression and live amongst the 'roids for a while.The other down side was five days of decomp. But at least he was being paid forit.

The job had required some outside work as well. The Octosaphe'd been partnered with had peppered him with questions about what life waslike on Fiji, but somehow he could relate to that more easily than to thebioroids who'd been built to look like humans. They were adapted to thepressure down here, of course, which was why there were so many of them, andrelatively few humans. The suffrage decision of '95 hadn't caused enough changeto affect the '97 council, but a lot of people were nervous about this year'simpending election.

Kirby found a news channel. Some riot somewhere. He turned onthe InVid information stream. A Biodroiden Befreiungsfront protest in SaoPaulo, turned violent. Well, at least the revolution here was taking placepeacefully. So far.

Elandra

Elandra was the first major ocean−floor settlement and is stillthe largest. It is located at a depth of 380 feet on a seamount at latitude22.34° S, longitude 173.12° E, some 350 miles south−west of Fiji. Thisis in the Hunter Ridge, a chain of volcanically formed seamounts stretching inan arc from Fiji to Vanuatu. The nearest land to Elandra is Vanuatu's remoteHunter Island a tiny uninhabited volcano poking 970 feet above theocean, 130 miles to the west.

History

Following the election of a conservative government with anaggressive territorial agenda in 2068, Australia adopted a policy of vigorouslydefending its interests in the Asia−Pacific region. This resulted in adiplomatic showdown with Indonesia in 2069 over the autonomy of ex−Indonesianmicrostates, and the initiation in 2070 of the Whaleshark Project.

This was to involve the construction of a large underwaterhabitat operated by the Australian government as a colony, a base for sea−floormining operations, and a naval support depot. GenTech Pacifica won theconstruction contract early in 2071 and began drawing up plans for the intendedTimor Sea petroleum fields location. Moderate elements in Australia denouncedthe chosen site as dangerously provocative to Indonesia politicalanalysts now consider this to have been a major factor in the defeat of thegovernment in the 2071 election.

Unable to cancel the project without an enormous damages paymentto GenTech, the incoming government decided to move the facility to a moreneutral location. It chose the remote Hunter Ridge between the friendly statesof Fiji, Vanuatu, and the Kanaky Republic. This location provided close accessto workable copper and gold deposits on the seabed, industrial metals andsulfur from nearby hydrothermal vents, and a bounty of unique biology forstudy. The project's name was changed to Elandra, meaning "home by thesea" in the language of a coastal Australian Aboriginal tribe.

Finally given the green light, GenTech Pacifica beganconstruction late in 2072. The initial base expanded slowly with simpleprefabricated habitats populated by air−breathing humans and genetic upgrades.The introduction of water−adapted parahumans and bioroids, such as Aquamorphsin 2075 and Sea Shepherds in 2080 (p. TS116), greatly sped up the constructionprocess. They also facilitated mining of the nearby resources, creating a boomin the settlement. In 2081, GenTech's new heavy mining division moved in andadded significantly to the base. The mineral wealth of the colony, and theburgeoning population, led to the formation of a special interest politicalcommunity (see p. FW40). With the help and promotion of GenTech, Elandra waseventually granted a seat in the Australian Parliament in 2089.

Blue Shadow activists staged a major raid on Elandra's surface aquaculturefacilities in 2092. Unable to mount an effective defense, Elandra lost itsstock of genemod food fish before the Australian Navy could respond. GenTechPacifica increased security and used the Elandran's dissatisfaction to begin acampaign for independence, which rapidly built momentum. The company had muchto gain by removing Elandra from Australia's laws, and its memetic engineerslaunched devastating attacks against the Australian government's credibility asa competent administrator of the facility. In 2094 Elandra formally applied forfree city status as a member of the PRA. Under pressure on a range of otherdomestic issues, the government granted the request in an ultimately futileattempt to win back support.

The next Australian government quickly re−established cordialrelations with Elandra, including a mutual defense treaty which wasobviously to the benefit of Elandra. What Australia gained was an additionalfriendly voice in the PRA, which helped it and the Union of Alberta and BritishColumbia to exert more influence over the three Asian first−tier PRA members.

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The Elandran Environment

Elandra contains three distinct environments. Most internalareas contain *hydrox* a mixtureof 96% hydrogen and 4% oxygen pressurized to just over 12 atmospheresto match external water pressure. This mixture allows humans to breathe withoutdangerous effects (see *Breathing*,p. 00), but makes their voices squeaky (like breathing helium, but worse). Thelow−oxygen atmosphere actually smothers flame, but attempting to light a fireis banned. The gas mixture is generated by electrolysis of water, with excessoxygen removed and used to produce other breathing gases. The air−conditioningsystem injects oxygen to keep the level at 4% and scrubs carbon dioxide fromthe air.

The pressurization allows access to the water through moonpools holes in the floor open to the external water which canbe covered with simple hatches, rather than bulky airlocks. Inhabitants ofthese areas can enter the water and work at depth without changing pressures.An inhabitant wishing to move to a one−atmosphere environment must decompressfor up to five days to avoid suffering the bends, unless he has the PressureSupport or Resistant to Poison (Dissolved Gases) (p. 00) advantage.

About 20% of Elandra contains air at one atmosphere, drawndirectly from the surface. This is mostly in older sections of the habitat,including the old control center, submarine dock, and many of GenTechPacifica's labs. Half the administration complex is also at one atmosphere.Transit tubes at this pressure run parallel to pressurized hydrox tubes fromthe dock to administration. These areas are connected to the rest of Elandravia airlocks. Some locks contain fully equipped accommodation for multiplepeople undergoing decompression. Others are small chambers for the rapidcompression or decompression of bioroids and shells who do not need todecompress slowly.

Lastly, some individual rooms and buildings in Elandra areflooded with sea water. These are either living quarters for uplifted animalsor research environments.

Outside the Habitat

The tropical waters above Elandra are warmed by the sun andthe thermocline is well below the settlement. At Elandra's depth the watertemperature averages 59° F, varying by 2° to 3° seasonally and up to5° during El Niæo or La Niæa events. There is no significantdaily temperature variation. A full−body wetsuit will keep a baseline humancomfortable in the water.

Sunlight reaching Elandra has all colors but blue and alittle green filtered out of it by the mass of water above. What light remainsis about as bright as a moonlit night (−5 to Vision). It is impossible todistinguish colors in the ghostly blue dimness without artificial light. Atnight, the water is pitch black except for the glow of bioluminescent creaturesand artificial lighting (−8 to Vision).

The peak of the Elandra seamount sits near the depth limitfor photosynthetic organisms. The highest points are covered with severalspecies of algae, which support a sparse community of animals mostlysponges, worms, sea urchins, crabs, and a few types of mollusk. Pelagic fishare drawn to the food source and in turn attract the occasional shark. Theselife forms are generally left alone, providing some park space for thesettlement.

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Physical Description

(((INSERT MAP: ELANDRA)))

Elandra has grown to become a medium−sized town, with apopulation of just over 14,000 humans, parahumans, bioroids, infomorphs, andsapient uplifted animals. It is not a monolithic structure, but rather acollection of separate habitats ranging in size from houses for single familiesto the central administration complex that is home to 2,000 people and containsworkspace for hundreds more. These sprawl over the summit of the Elandraseamount, which has a relatively flat top, shaped in a rough wedge coveringthree square miles. East and west of the summit area the sea floor slopesgently downward before rising to the adjoining seamounts 15 miles away, whileto the north and south the bottom falls away alarmingly to the abyssal plainsome 10,000 feet below.

Most habitats are mid–sized and contain apartments for 10 to 30families. Many of the larger apartment structures are connected to each otherand the administration complex by transit tubes, either laid on the seabed orburrowed through it. Transit tubes range from narrow walkways nine feet indiameter to mass transit corridors with slidewalks and lanes for personalscooters.

A typical habitat is sited on or next to a mass transit corridor,with access doors on the lowest level. On each of the two to four levels areseveral apartments, linked by hallways. Most buildings have a communal moonpool, allowing direct access to the water. These moon pools are all at the samedepth because they must be placed where internal pressure matches the waterpressure so lower–set buildings have them on upper floors, while somebuildings are not at the right level to have one at all. The oldest habitatsare sturdy designs made of stainless steel, with porthole style windows.Slightly newer ones are made of titanium steel, with windows of high–tensileglass. Windows in the pressurized sections can be surprisingly large becausethere is little pressure difference to withstand. Metal structures are linedinternally with biopolymer to prevent hydrogen diffusing through the metal andleaking into the sea. Most new habitats are aquacrete (p. 00), having beengrown in place and then lined with nanocomposite these resemble giantbarnacles or coral formations from the outside. Some older habitats have beenovergrown with algae or aquacrete to make them look more organic, while othersare kept scrupulously clean.

Flooded apartments, preferred by uplifted aquatic animals, aremostly grouped on the eastern side of the seamount, where the inhabitants haveformed a cultural enclave. Some have a single air–filled room for air–breathingvisitors, accessed through a moon pool.

Toward the edges of the town are more isolated habitats, connectedonly by walktubes or not at all. Large vehicles are berthed on the outskirts,where a submarine dock connected to the central complex by a wet rail system(with both air–filled and open cars) handles any high volume traffic.

Industrial facilities are mostly located on the southern edge oftown. These include a fusion power plant, water desalinization plant, and wasteprocessing and recycling installation. Three large buildings contain hydroponicfarms growing fruit and vegetables, as well as fauxflesh vats. Floating aboveElandra proper are bubble fence aquaculture cages, in which fish, shellfish,and crustaceans are grown for food. These are tethered to the seamount withcables, which double as communications conduits to floating satellite dishes,giving Elandra access to the global communications network.

Organization

Political

Elandra is an autonomous free city and a full member of thePacific Rim Alliance. Upon its independence in 2094, it adopted a complexconstitution drafted by a committee of several citizens and approved by ageneral referendum.

The city is administrated by an executive council of sevenmembers, each of whom is directly elected by eligible citizens for a three–yearterm. The council elects one of their number as the Mayor, which is mostly aceremonial title. A 30–member legislative parliament is selected bycyberdemocratic random choice (see p. TS89) from volunteer citizens.Legislators serve four–year terms. With AI assistance, the members of theparliament draft laws often based on citizen initiatives debatethem, and vote on them. Those passed by a two–thirds majority are sent to theexecutive council for approval. Judiciary members are selected by the executivecouncil, and must be approved by a two–thirds majority of the parliament.

Citizens become eligible to vote for the executive council bypaying a poll tax at each election. This sidesteps the problems of determiningsuitable voting ages and sapience levels for various parahumans and upliftedanimals. Any resident capable of earning money and wishing to vote can do so. Ajudiciary decision in 2095 established that unindentured bioroids may also voteif they pay the poll tax. Since then the number of free bioroids taking theopportunity to do so has risen dramatically, and there are concerns among thehuman residents and other members of the PRA that Elandra maybe turning into a "bioroid state."

The current Mayor is Hiram Farrell, a conservative capitalistseen by many as being a puppet of GenTech Pacifica. Farrell has severalinvestments in various GenTech projects being undertaken at Elandra andpromotes policies which are sympathetic with the transnational's goals,sometimes at the expense of the citizenry. Although popular when elected, hissupport has waned as his term has progressed.

Civic

The Elandran administration has drawn up a list of civic duties,each of different value to the community. All residents includingminors are required to fulfil a certain quota of civic duty each year.Serving in a public office fulfils all civic requirements for the term ofoffice. Jobs paid by the government, such as city security or medical practice,also fulfil civic responsibility. Learning from a kindercomp (p. FW34) ortaking higher education courses count too, being the primary way in whichminors serve their duty. Casual work on tasks such as building maintenance,litter collection, or fish farming accumulates partial credits. Volunteeringfor selection in the Parliament also grants credit. Citizens who do not meet theirquota by performing public service may make up the remainder in taxes minors too young to be educated may accumulate it or have it paid by guardians.

This arrangement allows for agreements between citizens to poolresources and make their duties easier. "Marriage" in Elandra is asocial contract between any number of people, under which the members agree toshare responsibility for the civic duties of all the others.

The system of civic responsibilities makes Elandra an egalitariansociety with respect to social services. Health care and education are free topermanent residents of Elandra. Citizens who do not earn a minimum income aresupported by the state at a basic subsistence level, but must perform communityservice to cover their duties. Enterprise and capitalism are encouraged by themeans of discharging duty by paying a fixed tax rather than performing service.

The poll tax and civic duty tax raise enough revenue to cover athird of government expenditure. The remainder is made up from corporate taxescharged to companies operating in Elandra. GenTech Pacifica contributes themost, as it is by far the largest corporate presence in the city.

Social

Humans with no aquatic adaptations were the first inhabitants ofElandra. They built reinforced structures enclosing habitat space at oneatmosphere of pressure, where people could work without needing to decompressto return to the surface. External work required the use of hydrox breathinggear and lengthy decompression. The difficulties of working at Elandra's depthencouraged the rapid development of parahumans and bioroids with adaptations toallow them to work in the water for extended periods. Once such inhabitantswere available, it became convenient to pressurize parts of the town to theambient water pressure. People living in these areas could live at ambientpressure permanently and enter and leave the water at will.

The number of bioroids, bioshells, and cybershells in Elandra hasgrown much more rapidly than the human population. Most new residents live inpressurized habitats, so the fraction of Elandra that remains at one atmospherehas slowly dwindled to its present level. Humans are now a minority amidst thecosmopolitan mix of biogenetic, infomorphic, and uplifted sapients. Thenon–humans are officially encouraged to participate fully in Elandra'spolitical system, but there are interspecific tensions driven by subtlebiochauvinism on the part of some of the humans.

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Elandra's Population, 2100

Humans Baseline 1,692

Genetic upgrade 749

Parahumans Aquamorph 2,171

Other 387

Free Bioroids Sea Shepherd 1,246

Nemo 9

Other 434

Indentured Bioroids* Sea Shepherd (1,865)

Nemo (2,391)

Gillmorph (28)

Other (483)

Infomorphs Ghost 170

SAI 1,318

Uplifted animals Doolittle Dolphin 235

Delphí s 137

Octosap II 739

Other 81

Total population 14,135

* Not eligible to vote.

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Security

Elandra has a small civic police force for internal lawenforcement. Crime is relatively rare, with petty theft the most commonoffense. Occasionally a personal disagreement escalates into an assault, brawl,or even murder. Criminals convicted of minor crimes are assigned additionalcivic duty quotas, which can either be worked or paid off. Dangerous criminalsare deported to Australia for imprisonment under a mutual agreement.

Police are generally unarmored, and armed with a truncheon and apolice armgun. Rooms with moon pools in them qualify as humid, giving a −2penalty to hit with the electrolaser of an armgun (see p. TS155). Airconditioning systems keep the rest of Elandra's air dry enough forelectrolasers to work with no penalty.

External security is taken seriously, following the Blue Shadowraid in 2092. Some citizens perform external security duties but the bulk ofthe force is made up of members of GenTech Pacifica's Security Project (p. 00)in a commercial arrangement with the Elandran administration. GenTech has avested interest in protecting Elandra from external threats because of thenumber of important facilities it has there, and the legal freedoms it receiveson genetic research which cannot be found in most jurisdictions.

GenTech's security personnel are well−trained and lethally armed.In the absence of an actual navy, they are the next best thing. Permanentlyattached to Elandra are a *Flinders*−classdefense boat with standard armament, two *Alopias*−class combat submarines, five *Kasatka* light submersibles (p. 00), and several smallsupport vessels. This fleet carries 34 human and parahuman troops, and 26submarine RATS cybershells (p. 00). Based in Elandra proper are a War−Dop squad(p. 00) and a squad of Seawolf bioroids (p. 00). If needed, GenTech can assignlarger armed vessels and more combat cybershells.

Activities

Mining

The bulk of Elandra's income is derived from sea−floor mining.The abyssal plains on either side of the Hunter Ridge seamount chain containsignificant deposits of copper and gold. These are at depths of 10,000 to12,000 feet, far below routine operating depths for biological sapients. Almostall the mining work is carried out by cybershells.

Mining begins with the erection of a containment barrier coveringthe seabed. This prevents disturbed sediment from escaping and clouding thewater. Although not a great inconvenience to the mining shells, a disturbance likethis would severely disrupt the benthic ecosystem within a wide radius.

At any time there are approximately five separate sites beingworked, each typically taking a year before being exhausted. AI cybershellsspend weeks at a time at a mining site, removing ore and loading it into cargosubmarines for transport back to Elandra. At least one cybershell is relievedeach day to return to Elandra carrying news and for servicing. This is the onlycommunication line with the deep mining facilities. Their isolation and lack ofinstant communication back to base make them vulnerable to hostile actions, sothe outposts are patrolled by GenTech Pacifica's submarine RATS.

Hydrothermal vents are located along a fault system whichapproaches to within 30 miles of Elandra. Cybershell expeditions visit these togather black smoker chimneys, which are rich in metallic sulfides. The chimneysgrow at fantastic rates and can be harvested from the same vent every fewmonths.

Biotechnology

GenTech Pacifica's major underwater laboratories and factoriesare located in and around Elandra. Several other companies also operate smallerfacilities. The labs perform research and development on genetic modificationsdesigned for aquatic adaptation, uplift of marine animals, and biologicalproducts such as aquacrete. Researchers also tinker with species such as tunaand deep sea clams, to maximize productivity of food resources.

The biotech companies collect specimens of species living nearElandra and study them for useful organic compounds and gene sequences.Organisms of particular interest include algae, sponges, deep sea corals, seaurchins, starfish, squid, and fish. Many species are being fully geneticallysequenced for the first time, giving Elandran companies a valuable resource inthe development of new drugs, genemods, and bioproducts.

Biological Research

The waters around Elandra are home to a wide diversity ofspecies. Plots on other seamounts in the Hunter chain are used as biologicallaboratories to study interactions between benthic organisms in relativeisolation. Some have been seeded with particular species, including manygenetically modified ones for environmental testing. Ecoengineers monitor theseexperiments carefully, ready to step in and shut down any that looks likegetting out of control. One deep site near a newly erupted hydrothermal vent isalso being used to test gengineered chemosynthetic organisms.

Behavioral science studies take place amongst several species inthe waters around Elandra. Swift cybershells and bioshells chase pelagic fish,dolphins, and squid, observing and recording migration, feeding, mating, andother behaviors. The numerous spinner and bottlenose dolphins in Elandran andFijian waters are the subjects of intense research activity. Most of thedolphins are baselines, but there are two small colonies of Doolittle upliftsin the area, who keep mostly to themselves. These are monitored closely byGenTech Pacifica. Blue Shadow activists claim GenTech is performing experimentson the uplifts, capturing individuals for surgical and psychologicaltreatments, then releasing them back into the wild to study behavioralmodifications and interactions with fellows.

Humpback whales migrate from the Antarctic Ocean in the southernwinter to calve in waters near Fiji, passing close by Elandra as they traveland spending several months in the vicinity. Whale activity includes sucklingnew calves and mating, before departure for the Antarctic feeding grounds latein the year. Infomorphs using bioshells and cybershells observe whale socialbehavior and record whale songs. Humpbacks most commonly sing during thebreeding season, so Elandra is a popular base for cetanists and whalesingers(p. 00). Several other species can be found in Elandran waters, including minke,pilot, killer, and Bryde's whales, which live in the region year−round, andsperm and southern right whales, which migrate through the area.

Oceanography and Climatology

Elandra operates oceanographic and climatological observation andresearch programs, affiliated with the Global Ocean Institute (GOI, see p. 00)and collaborating with many other research groups around the world.Observations made by Elandran scientists are valuable in establishing baselinesfor global studies of ocean physics, chemistry, and biology, and climatepatterns and change. A major international oceanographic conference, sponsoredby the GOI, is scheduled to be held in Elandra in April, 2100.

A small group of researchers is study the deep ocean trenches andhydrothermal vents in the Elandra area, analyzing aspects of plate tectonicsand vulcanology. They use some of the deep−sea cybershells to visit theseremote locations, record data, and set up continuous monitoring equipment.

Conflicts

Internal Factions

Like most sizable towns, Elandra has competing political, social,and corporate factions. These create subtle undercurrents of competitiveness,snobbery, and discrimination between various groups, although for the most partthe expression of these is at a low−key level. The city appears peaceful enoughto most casual visitors   it is only with familiarity that the internalfrictions become noticeable.

Although GenTech Pacifica has a long history of supportingElandra's infrastructure and autonomy, there are a growing number of voiceswithin the community who feel that the transnational's influence on the city istoo great. Three of the current executive council members are of this group andhave been encouraging local investment by other companies in an effort to waterdown GenTech's dominance. Mayor Farrell's term expires in October, 2100, andmany pundits are predicting a fourth anti−GenTech council member will beelected, changing the balance of power. GenTech's Memetics Project is workingovertime to develop a campaign designed to install its preferred councillor.

Almost all other companies with a stake in Elandra are more orless united in efforts to undermine GenTech's position in the city. Most stickto standard economic and memetic tactics to build their positions, but therehave been a few incidents at GenTech facilities in the past few years. In 2098,GenTech security personnel arrested and charged two Aquamorphs with sabotagingan algae processing plant under orders from Reef Systems Pty. Ltd. TheAquamorphs were found guilty and deported to Australia, and Reef Systems wasforced to pay damages and ordered to cease operations in Elandra. A few voiceson the local Web continue to speculate that the entire affair was a set−up,while others claim it proved that desperate competitors would use any tacticsto usurp GenTech's position. Only a few minor cases of mysterious damage havebeen reported since, but many people assume there is more industrial espionageoccurring than the public knows.

Socially, the various parahumans, bioroids, and informorphs inElandra tend to interact amongst themselves and with uplifted animals, whilethe humans form their own social groups. There are some elements of rivalrybetween the groups, which occasionally escalate into interspecific tensions andviolence, but for the most part the city is a collection of people who justprefer to associate with "their own kind." The greatest socialtension is from a small group of humans who are alarmed that Elandra is turninginto a "bioroid state," and who engage in memetic engineering on theWeb to raise international ire. This group has had little success at anythingother than increasing social disharmony in the town.

The Atlantean Society (p. 00) boasts some 500 members amongstElandra's residents. Most of these are non−aquatic humans and parahumans, butthere are a few Octosap and uplifted dolphin members. The Atlanteans arefiercely devoted to defending Elandra's position as a sovereign free city and aviable, self−sufficient habitat. On the international stage, this aligns themwith GenTech Pacifica, but within Elandra the Atlanteans are behind adetermined drive to decorporatize the government and put policy decisionsfirmly in the hands of the citizens. Atlanteans all volunteer for parliamentaryselection and there are usually two or three in the parliament, where they areamong the most active members.

External Threats

The greatest external threat to Elandra is the possibility ofsabotage or outright attack by militant terrorist groups such as Blue Shadowand Irukandji. Some of the biological research projects being carried out inthe town and its surroundings are prime targets for Preservationist actions.The Blue Shadow attack in 2092 highlighted the dangers and prompted theformation of a significant deterrent and strike force to handle any futureraids.

With overt attacks against Elandra's defenses now being risky,the fear is that activists may plan sabotage from inside the facility. In asense, this is an even more dangerous prospect, since a well−placed explosivedevice in a critical power or environmental system could cripple much ofElandra and require a mass evacuation, with the attendant complication ofdecompressing thousands of people for removal to the surface.

Being a member of the PRA, Elandra is also wary of attention fromthe TSA. Elandra's security forces would be no match for a full military strikeby TSA forces, so considerable effort is put into surveillance of thesurrounding ocean. Satellite observations keep an eye on any suspicious TSAmovements in the Pacific Ocean, and Elandra shares intelligence with Australia,Japan, and other PRA members in the region. At any sign of a threat, PRA forceswould be quick to respond. In the current age of remote warfare, however, it islikely that Elandra could be destroyed and its PRA allies left to exactretribution on the attackers. The main defense against full−scale militaryattack is therefore the deterrent power of Elandra's allies.

Other Aquatic Habitats

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Sea−floor Habitats

Dhamchos Thupten Khusu Monastery: A Buddhist monastery, built into the vertical cliffface of a seamount in the Laccadive Islands off Southwest India, at a depth of110 feet. The 400 resident monks claim the tranquillity of the site isunmatched.

Franklin City: A largeU.S. settlement, in 80 feet of water, nine miles north of Puerto Rico.Population 12,000.

Kuratani: The deepestsite permanently inhabited by humans, this Japanese research station is aheavily reinforced one–atmosphere facility at a depth of 31,200 feet in theNankai Trench. Thirty scientists and support staff work in shifts, relieved bya weekly supply submarine.

Floating Habitats

Al–Dhahalab: Acorporate island in the Red Sea, operated by the Saudi company Isam AlizeraBiotech. Used as a mobile ocean research laboratory studying coral reefecosystems.

Dao Duac–Pho and *Cam–Duong*: Two ex–Vietnamese floating island arcologies moored200 miles north of New Guinea. Declared independence after the Pacific War andnow associate members of the PRA. Population 9,000 each.

¸ les de LumiŁre: Three large and luxuriously appointed floating cities moored off thecoast of Monaco. About half residential and half hotel accommodation.

Isla Santa Fe Córdoba: A floating corporate base in the South Atlantic Ocean operated by theArgentine company Agua Negra Profunda to support deep–sea mining operations.Home to 12,000 people: workers, families, and infomorphs.

Jazireh–Ye Fahrum: Asmall Iranian arcology in the Persian Gulf, used as a prison island and apsychoneural treatment facility for political and religious dissidents.

Schuyville: A curiousmixture of high and low technology, this is a sail–propelled floating townpopulated by a religious sect which prohibits the use of electrical and nuclearenergy. It sails slowly back and forth between Europe and North America.

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Wilhelmsburg

Wilhelmsburg is a drifter (p. 00) arcology built on a platformsupported by multiple catamaran–style hulls. The habitat was originallycommissioned in 2065 and occupied by a group of drifters who wanted a placewhere they could be free to pursue various artistic endeavors. The conceptworked and within a few years Wilhelmsburg had become known as a hotbed forperforming and visual arts. In 2100, the arcology has a permanent population of3,100 people, and lodging and amenities for 400 transients.

Wilhelmsburg has state–of–the art InVid and slinky productionfacilities, as well as equipment and materials for various other artistic formsand media. The arcology is famous for its music recording and mixing studios,and artists from around Earth (and even off–planet) visit to record songs andpromotional InVids. Painters, sculptors, and dancers also come to be inspiredby the surroundings and the social atmosphere provided by the drift community.

Although many of the residents have artistic occupations, thereis a slowly growing segment of the population who simply find Wilhelmsburg agood place to live. It is a high–profile drift habitat, well–connected to theWeb, with the most modern amenities available and a peaceably minded community.Thus it appeals to people who enjoy the drifting lifestyle without having tomake any particular political statement or rejection of Fifth Wave society.

Wilhelmsburg is registered as a ship with the German government.Many of its residents retain citizenship of their original home nations, whilea few have transferred to Jamaican PNCs (see p. 00). The mixture ofnationalities on board is complicated by the fact that third−generationresidents are now being born and some parents are not bothering to sort out thebureaucratic details of citizenship for their children. Some of thesecond−generation residents are unlisted in any global databases and the nextgeneration promises to be even more anonymous. Among such a group of people, itmay not be surprising to find a few who know people like Manuel, the "Kingof Vrijstad" (p. FW102) . . .

The anonymity of a few of the residents and the readyavailability of the latest computer hardware have produced an ideal environmentfor the emergence of a group of Web data pirates. Calling themselves *DieWilhelmsburgbefreier*, this group of justfour humans and one ghost has contacts on the ground in several major worldcities. They utilize these contacts to plant devices such as emissions nanobugsor surveillance dust (p. TS54) in systems they wish to access. Web viruseswritten by the group then access the systems and store information ondistributed data havens in multiple locations for later retrieval. The informationDie Wilhelmsburgbefreier gathers is sold to various companies or postedanonymously to the Free Net (p. FW31). Die Wilhelmsburgbefreier has so farmanaged to avoid being traced to Wilhelmsburg through an elaborate series ofcovers and double−blind contacts by everyone but the German government.When it discovered what the group of hackers was capable of in 2094, theBundesnachrichtendienst (the German federal intelligence service, p. FW38) madean offer they could not refuse: work for it. Today, Die Wilhelmsburgbefreier isa curious mix of anarchic data pirates who continue cracking systems for profitand political statements, but who also form the most effective computerintelligence arm of the Bundesnachrichtendienst.

Physical Description

Physically, Wilhelmsburg is a flat platform, 290 feet wide by 840feet long, supported 35 feet above water level by its multiple hulls. Most ofthe area is covered by separate structures, up to nine stories high. There areexposed walkways running the length and breadth of the platform and a plazanear the center. Many of the individual buildings are connected at higherlevels by bridge tubes. Structural components are largely metal, but theexposed surfaces have been covered with a variety of other materials such asplaster, stone, wood, and polymers, to produce a more aesthetically pleasingenvironment. There are small gardens on the tops of the buildings and the plazais paved with Italian granite cobblestones.

Below platform level, the multiple hulls are filled withengineering plant and machinery, including fusion generators and motors whichcan drive the miniature city at speeds up to 30 mph. There is also someresidential space in this area, inhabited by the mechanics and engineers whokeep the arcology functioning.

Wilhelmsburg cruises the Pacific, Indian, and Atlantic Oceans,plying back and forth around the Cape of Good Hope once every few years. At thebeginning of 2100 it is in the mid−Atlantic, heading north−east toward Europe.

Faridganj

Faridganj is one of the burgeoning set of sea−floor settlementsunder construction in the shallow Bay of Bengal (see p. FW69). It is a projectof the Bangladeshi government, which is investing heavily in aquatic habitatand parahuman technology in order to establish a population base lesssusceptible to climatological disasters. The settlement is in 55 feet of water,two miles off the coast, northwest of Chittagong. Currently, Faridganj houses9,300 humans and parahumans, but the population is growing rapidly and isprojected to surpass Elandra's by 2105.

The majority of Faridganj's inhabitants are aquatic−adaptedparahumans Aquamorphs, Purushagor (p. 00), and variants withgene sequences copied or created by Bhuiyan Genetics (p. 00). There are 1,400non−aquatic humans and parahumans, and 250 uplifted animals, mostly Octosaps.

Similar settlements are spaced every 10 miles or so along theBangladesh coast and in the Ganges delta, at various stages of completion.Faridganj was the first to be begun, in 2077, and is planned to be the largest.Some smaller sites are already considered complete. Faridganj also has foursatellite "suburbs" small habitats a few miles from the cityproper, where Aquamorphs and Purushagor live and can commute in to work.

The main activities in Faridganj are construction, aquaculture,and biotech research. Fully a third of the inhabitants are employed in thephysical expansion of the city infrastructure, from heavy construction towiring, plumbing, and interior decorating. The region for miles aroundFaridganj is used as a vast aquatic farm, with pens for fish, prawns, andcrabs, as well as large oyster and mussel beds. The fields also producecommercially useful quantities of seagrass and various algae. As a modelcommunity for the Bangladeshi government, there is a strong emphasis onapplying new techniques to demonstrate improvements in productivity. The farmsproduce far more food and other organic products than are required by the cityitself, and much of it is exported to Chittagong and further afield.

Bhuiyan Genetics has its main submarine research facility locatedin Faridganj. Several teams of gengineers work on projects as varied asimproving cultivated shellfish growth rates and adapting pirated gene sequencesto create new species of parahumans. These include species with legs fused intoa muscular tail−like structure, making them efficient swimmers but clumsy onland (see *Purushagor*, p. 00). The mostexciting project, and one which is shrouded in secrecy, is the research beingdone on parahumans with gills (see *Gilled Humans?*, p. 00). The intention is to produce a Bangladeshiparahuman species that can survive underwater permanently without requiringtechnological assistance.

Despite the advanced work taking place in the laboratories, the inhabitantsof Faridganj make relatively limited use of high technology for an emergingFifth Wave culture, operating on an almost subsistence economy. This is becauseof a conscious choice by the Bangladeshi government to make its aquaticsettlements self−reliant and to foster further colonization of the sea by itsparahuman citizens. It is thus difficult to find connections to the Web inFaridganj outside of the biotech labs, and augmented reality is not availablein most of the settlement. Much of the equipment used in Faridganj does nothave inbuilt computing capability and v−tags are entirely absent. For visitorsused to augmented reality, Faridganj seems either hopelessly primitive oractively disturbing. One advantage for visitors bent on mischief is thatsecurity systems are also relatively low−tech.

Physical Description

Faridganj is a collection of dome and cylinder habitats anchoredto the seabed. The domes range in size from two−story buildings 45 feet indiameter to massive structures 120 feet in diameter that poke above the seasurface. There are almost 200 domes, sprawled over half a square mile, andconnected by tubes running along the sea floor. More are being added every fewweeks.

The domes are prefabricated on the Bangladesh mainland and towedout to sea on pontoons, then sunk in place and connected up to the rest of thesettlement. They are made of multilayered polymer reinforced with carbonnanofibers, and have a uniform bland appearance on the outside. The suburbhabitats are constructed from the same domes.

All of Faridganj's air−filled space is at one atmosphere ofpressure. Some of the largest domes are often open to the air above sea level they are battened down during storms. Fresh air is circulatedthroughout the settlement by integral air conditioning units in each dome.

The water is accessed through airlocks able to be pressurized tomatch the water depth before the external hatch is opened. Each dome has atleast one airlock. The external hatches are in the floor, so the airlock chamberscan function as moon pools and do not have to be flooded. The airlocks arecapable of rapid pressure change, to allow Aquamorphs to hold their breathswhile being compressed, so they can enter the water and swim to the surfacewith no danger of the bends.

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Gilled Humans?

OCEAN, n. A body of water occupying about two−thirds of aworld made for man who has no gills.

*Ambrose Bierce, **TheDevil's Dictionary**.*

The ultimate adaptation to aquatic life is being able toextract oxygen from water. So far, the established method of allowingparahumans to operate in water is to gengineer traits similar to those ofcetacans and other aquatic air−breathers. This means enhancing the ability ofthe blood and muscle tissue to store oxygen, giving muscles the ability tooperate anaerobically, and creating a ribcage and set of lungs capable ofcollapsing under pressure without injury. Given that these adaptations allexist in mammal species, it was relatively straightforward to transfer them toa human genome. The first Aquamorph parahumans, designed on this model, wereréleased by GenTech Pacifica in 2075.

Producing a parahuman with functional gills is much moredifficult. GenTech has been working on the problem for over 30 years. It hasproduced some bioroids capable of absorbing oxygen from water via gill−likestructures on the torso, but only under controlled conditions of watertemperature, salinity, oxygenation, and flow.

As difficult as it is, giving a human−based bioroid gills isactually the *easy* part of the task.Having a large surface area of blood−rich tissue in contact with cooler watermeans that heat is lost from the body rapidly. The gills cannot be insulatedbecause the need to interchange oxygen precludes the existence of anyintervening material. And sufficiently oxygenated water must be run over thegills *rapidly* in order to extractenough oxygen to support a mammalian metabolism which increases therate of heat loss. A second problem is caused by the physical process ofosmosis, in which water tends to diffuse through membranes (such as gilllinings) toward regions of higher salinity. Body tissues are less saline thansea water but more saline than fresh water, so gilled mammals would rapidlydehydrate in the ocean and bloat in fresh water. So producing a gilled bioroidcapable of surviving in open water requires changes in physiology beyond 21stcentury biotech.

Despite the problems, GenTech continues to experimenthalf−heartedly. Bhuiyan Genetics gained copies of some of GenTech's gilledbioroid designs in 2089 and has been pursuing the concept vigorously sincethen. Unknown to GenTech and the biotech industry at large, Bhuiyan's gilledparahuman program is now the most advanced in the world. It has produced the *Purushmachh* series gilled bioroid design, which is capable ofexcursions of up to 20 minutes in the warm waters of the Bay of Bengal, beforehaving to shut its gills down and breathe air to avoid hypothermia anddehydration. There are six Purushmachh bioroids undergoing intensive tests inFaridganj. Bhuiyan believes it is close to producing a viable gilled parahumangermline, although with the same activity restrictions as the Purushmachhbioroids.

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Ondala

Ondala is a small city occupying a floating arcology moored inthe Caribbean Sea, home to 21,000 individuals. The structure was originally aset of five heavy rigs used in the Gulf of Mexico for petroleum drilling in the2020s. They were decommissioned in 2047 and bought for a bargain price by aconsortium of 12 wealthy eccentrics, who set about turning them into theirideal retreat from the politics of the world. They arranged for the rigs to betowed south and moored together 80 miles north of western Panama, away frompotential hurricane tracks.

The owners declared Ondala an independent state and invitedlike−minded individuals to settle. The initial inhabitants were the familiesand some friends of the owners, but word of mouth spread and soon Ondalaboasted a cosmopolitan population. In 2059 the owners began constructing anOTEC power generator to supply growing energy needs, causing the Panamaniangovernment to realize that they had no intention of ever moving Ondala from itslocation. Panama initiated legal action in the World Court to have thestructure removed, but the owners used their influence with several U.S.senators to arrange a strong legal defense team. They argued that Ondala, stillregistered as mobile rigs with the U.S. Shipping Board, had the right of freepassage and anchorage provided it took no biological or mineral resources anddumped no pollution. This became a landmark test case for the existence ofsimilar settlements around the world, and was decided in Ondala's favor, tomuch celebration.

Ondala's sovereignty, however, remained unresolved. Externalcommentators took the appeal to the United States as an admission that trueindependence could not be attained, while for the inhabitants it provided theimpetus needed to mount a campaign for recognized independent status. Theowners hired memeticists to develop a strategy, and soon political activistsacross the world were promoting the cause. Ondala achieved fame in this way,but no serious momentum was ever gained amidst the numerous global politicalupheavals of the 2060s and 2070s. In 2086, Ondala applied for membership of theCaribbean Union as a free city. The request was granted, mostly out of a desireto bolster the Union's power and promote the cause of microstates, but no othernation has yet recognized Ondala as a free city.

Five of the 12 original owners, plus a clone of a sixth, stilladminister Ondala as a semi−anarchist benign dictatorship. The original fiveare grooming clones of themselves as replacement leaders, but have no intentionof dying just yet and make use of the best life−extension technology they canafford. Their fortunes are invested in U.S. companies, so they haveconsiderable income with minimal effort. Most other inhabitants of Ondala areknown by the owners, either personally or by mutual associates at most stepremoved, so the city has the feel of a tightly−knit community. The leadersgenerally allow any activity which doesn't interfere with the personal rightsof fellow Ondalans all transgressions attract the same punishment:permanent exile.

Citizens of Ondala earn their keep by participating in the worldeconomy, performing work which doesn't require them to leave the city. Many arepolitically active, either organizing or participating in numerous campaigns tosecure the rights of anarchists, secessionists, or free independence movementsaround the globe. Ondala is building a reputation as a haven for politicaldissent of an anarchic or libertarian nature, and it may not be long before apowerful government takes a more active interest in the city.

Physical Description

Additional floating rigs have been added to Ondala over the yearsto cope with increasing population. In its current configuration, the city ismade of 13 decommissioned rigs of various sizes, the OTEC facility, and twocustom−built floating aquaculture farms covering several acres each. Thevarious structures are connected by flexible bridges, some stretching 400 feetacross open water. The bridges are exposed, but have safety rails and arestable in all but the worst weather, so there is little danger of falling.

The rigs and the OTEC structure bristle with multi−storyapartment buildings which are more functional than aesthetically pleasing. Theinhabitants like to maintain a pseudo−industrial appearance out of respect forthe city's history. There are exposed catwalks, ladders, and gangways to befound everywhere. Inside the buildings, the maze−like quality is even moreapparent, caused by the constant unplanned construction and rearrangement ofrooms, walls, corridors, and stairs. Visitors without VIIs to read thenavigational v−tags are certain to get lost.

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Neutrino Telescopes

The colonization of space has provided ideal locations formassive optical and radio telescope facilities such as the Tsiolkovsky FarsideObservatory (p. ITW00) and the Sahasara Chaksu interferometer (p. DB00). Theonly remaining field of astronomy in which Earth−based observatories have anadvantage is neutrino astronomy.

Neutrinos are extremely light particles which travel atnearly the speed of light. They are emitted by stars, and in bursts by violentevents such as supernova explosions or black holes accreting matter. Theybarely interact with matter at all, and most which reach Earth pass through itunnoticed. In order to detect neutrinos, a large mass of transparent materialmust be surrounded by light detectors these detect the faint flashes ofthe few neutrinos which interact with the material. In order to prevent cosmicrays producing false signals, this material must be shielded. The more mattersurrounding it, the better.

This makes the ideal location for neutrino telescopes thebottom of the ocean. Water itself is transparent enough to serve as thedetection material, and no place in the solar system surrounded by so muchmatter is as easily accessible. An underwater neutrino telescope is simply anarray of sensitive light detectors, placed at precise positions near theseabed, and linked to a computer to process the signals.

Some initial experiments in the deep ocean in the 2020s werecorrupted by unexpected bioluminescent organisms. Since then, a few locationshave been found with no such organisms, but most telescopes are simply coveredwith opaque sheeting. Major neutrino telescopes are operated on the floors ofthe Ionian Sea, the Japan Trench, the Puerto Rico Trench, and Lake Baikal.

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New Lands

Humans, or most of them anyway, like to live on *terra firma*. One solution to the problems of not enough land orno land in a convenient location is to make more. Various methods of doing sohave been used throughout history, culminating in newly developed Fifth Wavetechniques.

Coastal Reclamation

The rising sea level throughout the 21st century threatened toinundate low−lying regions such as parts of the Netherlands, Bangladesh, and manyPacific islands. With high technology and a centuries−long tradition of holdingback the sea, the Netherlands not only withstood the onslaught, but reclaimedadditional land. The Dutch are now experts in coastal reclamation and leadsimilar projects around the world.

The biggest advances in coastal reclamation came from theecoengineering field. With new understanding of the actions of wind, waves, andcurrents, ecoengineers were able to design dyke systems supported bybiologically−stabilized terrain on both sides. Instead of eating away atseawalls and producing a need for continuous maintenance, the sea now assistedby depositing sediment and strengthening the barriers holding it back.

After the disaster in Venice in 2033, when the city wastemporarily evacuated and much of its priceless artwork damaged or destroyed bysea water, the lagoon city adopted an aggressive strategy to prevent any futureoccurrence. A broad dyke system was constructed, joining the islands of Lidoand Pellestrina to the mainland to wall off Venice Lagoon from the AdriaticSea. Despite the loss of traditional tourist beaches, the newly createdshoreline has now become as much an attraction as the old, and the lagoon ismaintained at a water level preserving the unique charms of the city.

Land reclamation technology can also be applied to shallow wateratolls or between existing islands. This has been done with some low−lyingisland nations such as Kiribati, the Marshall Islands, Nauru, and the Maldives.India is undertaking major reclamation work in the Maldives in exchange for therights to sea−floor resources in the Maldives' EEZ. This provides jobs and aboost to the local economy, but the work is being done crudely and theresulting land needs serious work before it resembles anything more than aconcrete moonscape.

Kiribati has a more modern approach to island reclamation.Corporate interest in using the nation's scattered territory for aquacultureand deep−sea mining has allowed the government to bargain from a position of strength,securing the latest ecoengineering design principles and biotechnology to allowthe extension and raising of its land in a natural fashion. Gengineered coralsnow grow on Kiribati's reefs, rapidly adding limestone structure to theislands, while seagrasses, mangroves, and terrestrial plants stabilize thecoastal margins and produce arable land.

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Any emergent land must initially take the form of an island,so the island stands as the archetype of land.

James Hamilton−Paterson, *Seven−Tenths*.

(((END QUOTE)))

New Islands

More ambitious than extending the margins of existing land iscreating wholly new land at sea. One approach is to construct artificialislands from high−tech materials. People have been doing this since the 20thcentury, when oil platforms fixed to the seabed and floating oil rigs were theprime examples. Some decommissioned oil platforms have in fact been convertedinto settlements, either sold by the owning companies or inhabited bysquatters.

Corporations wanting convenient bases for deep−sea explorationand resource exploitation have used the oil rig model to produce floatingarcologies, which are anchored in place by multiple mooring lines stretching tothe seabed. Some of these "new islands" are massive structures arcologies housing tens of thousands of people while others aretiny research bases populated by only a few scientists and infomorphs.

Such deep water floating islands are held stable in the swell byheavy pontoon keels, which lie submerged below the turbulent surface layer ofthe sea. The thick steel mooring cables of the past have been made obsolete bylight nanofiber cables which are a tenth the diameter and twice as strong. Afloating island typically has from eight to 12 cables, spread radially anddescending to the seabed at a steep angle. The weight of the cables themselvescauses them to sag slightly, but the tensions are balanced and keep the islandstill to within just a few feet. Most islands are permanently anchored, but afew are occasionally moved to new locations to provide temporary bases.

The new islands are mostly corporate facilities, serving as basesfor deep−sea operations. As such they house workers and their families, expertinfomorphs, and various vehicles, bioshells, and cybershells used to probe thebriny depths. Being corporate−controlled, and in many cases outside nationaljurisdictional zones, some of these islands have evolved into more than simpleworker habitats. Many have lively communities made up of family members who donot work for the sponsoring company, making them seem like extranationalcolonies. Some are run as "tight ships" by the owning company, ableto demand slave−like labor from the inhabitants far from the scrutiny ofgovernments. Others become political or data havens, where people can seekseclusion from the world for any number of reasons.

A few groups of people have banded together to commission theirown floating islands, or purchase decommissioned corporate ones. There are thussome large arcology islands in the hands of nanarchists, political idealists,and those just wishing to get away from it all. Occasionally a corporate islandwill suddenly find itself without a sponsoring company, in the wake of acorporate collapse or war. A handful of these, such as Dao Duac−Pho andCam−Duong north of New Guinea, have ended up as free colonies populated byex−workers and new immigrants.

Atoll Towers

The final method of producing new land is to build directly fromthe ocean bottom until construction breaks the surface. This was not practicalfor water depths greater than 30 feet until the development of aquacrete in2058. Prior to then, only a few halting projects were undertaken using clumsydumping of material on to shallow atolls, causing massive disruption to nearbyecosystems. With seacrete and aquacrete (p. 00) it is possible to accumulatelarger structures in a more ecofriendly way, in water up to 300 feet deep.

Initially, companies used aquacrete to add height to shallowcoral atolls, making it a form of land reclamation as used in

Kiribati.In 2069, GenTech Pacifica began using aquacrete on seacrete foundations tobuild new coral atolls on the flat, shallow seabed of the Gulf of Carpentariaoff Northern Australia. Success led to programs of constructing new islands inthe Coral, Java, South China, Red, and Caribbean Seas, and off the north coastof South America. The technique has also been used in several Pacific islandnations to create new land for burgeoning populations. Islands built from aflat seabed by this process are known as *atoll towers* because of their tower–like formation under thewater.

According to the Law of the Sea (see *Maritime Law*, p. 00), artificial islands are not considered landand do not extend a nation's jurisdictional or economic rights. What is"artificial" is not defined, however, and the line between artificialand natural is now blurred by atoll tower technology, which producesnatural–looking coral islands by organic processes. China has built atolltowers on several submerged reefs in the Spratly Islands in order to pressclaims for extending its territorial rights to the South China Sea betweenVietnam, the Philippines, and Sarawak and Sabah. Other nations have madesimilar claims, but none have been resolved satisfactorily yet.

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Aquatic Habitats in Space

It is possible to fill, or partially fill, a space habitatwith water, although seldom practical. O'Neill cylinders and Stanford toruses(p. TS75) are usually landscaped on the inner surface, and small lakes andstreams are possible. Water may need to be circulated by pumping and spingravity may be different to Earth gravity, but otherwise the lakes can makefine homes for aquatic–adapted sapients. Islandia (p. HF00) has enough waterthat it maintains a hydrological cycle, and houses a small community ofAquamorphs and some Octosaps. When underwater maintenance work is required itis carried out by these groups.

Smaller habitats often contain large water tanks for storageof this valuable commodity, but the tanks are seldom accessible for swimming orliving purposes. Any pools are likely to be narrow lanes for swimming laps, andunusable as living space. One L–4 station operated by GenTech Pacifica islargely full of water. It is used to research microgravity effects on aquaticcreatures and develop microgravity adaptation biomods for them. This seems tobe pure research, though the GenTech scientists may be planning some unusualuse for such creatures.

A few dolphin uplifts have been curious enough to travel intospace. Launch is distinctly uncomfortable for them and they require breathingassistance for the process, but once in microgravity they adapt easily.Dolphins in microgravity do not need water to support their bodies but mustkeep their skin moist with a suit. Biotech Euphrates is working on germlinedolphin modifications to produce a paradolphin species capable of surviving inmicrogravity air without desiccating.

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Maritime Law

One thing is sure: "freedom of the seas" is nolonger an acceptable doctrine. Freedom works and everyone wins if everyonetakes care, but clearly, all lose if even one misbehaves.

*Sylvia Earle, **Sea Change**.*

Technically, maritime law is still governed by the Law of theSea. This treaty originated in a United Nations Conference in 1958, though theoriginal never took effect. A revised version was drawn up in 1982 andeventually ratified by enough nations to come into force in 1994. Severalnations never ratified it however, including Canada, Denmark, Israel, Peru, andthe United States. The treaty established the International Tribunal for theLaw of the Sea to administer and resolve disputes. Like most U.N. commissions,the Tribunal's power was eroded in the 2030s when nations increasingly ignoredits rulings, and it was abandoned in 2045. In 2100, the Law of the Sea isunenforceable, but it still serves as a traditional guide to acceptableactivities and a moral high ground for disputes resolved by other means.

Territorial Rights

According to the Law of the Sea, sovereign territory of coastalnations extends 12 nautical miles (13.9 miles) beyond its shores. Foreign shipswithin this territorial zone are entitled to free passage and a presumption ofinnocence unless engaged in activities hostile to the controlling nation'sinterests, although submarine vessels must travel on the surface. An ExclusiveEconomic Zone (EEZ) extends out to 200 nautical miles (231 miles). If thecontinental shelf is broader than this, a nation can claim an extended EEZ overit to a maximum of 350 nautical miles (405 miles) from shore. Within its EEZ, anation has jurisdiction over mineral and biological resources, and theprosecution of pollution. Regions outside any nation's EEZ are termed the *highseas*, and are available for the peacefuluse of any nation.

In practice, these concepts apply only as far as a nationclaiming such rights can enforce them. Nations have disputed maritime bordersfor as long as they have been sailing ships. With technology allowing theexploitation of marine resources at unprecedented levels, both nations andcorporations are eager to press claims for ownership of as much territory asthey can manage.

Generally, the traditional territorial zone and EEZ are respectedby foreign powers. Fifth Wave and most Fourth Wave nations are able to defendtheir interests and few people want to deliberately instigate wars. As in manythings, however, Third Wave nations sometimes bear the brunt of aggression frommore developed neighbors. Fifth Wave bullying has shrunk the marine territoriesof Third Wave nations without recourse to any form of justice, particularly inregions with significant resources.

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Territory is not something that exists naturally. It must beobtained by a country's efforts.

Soji Yamamoto, InternationalLaw of the Sea Tribunal Judge 1996–2002.

(((END QUOTE)))

Squatting

The Law of the Sea provides no guidelines for the legal status ofindividuals or corporations who take up residence on or under the high seas.Individuals may renounce citizenship of all nations and live free of anyjurisdiction. Nations like to hold on to their citizens, but the cost ofadministration and the difficulty of keeping track of them on the high seasmakes it uneconomical.

The Law states that the high seas cannot be claimed, but inpractice settlers can lay claim to as much territory as they are able todefend. Such people could not stand against the naval forces of a nation, butgovernments are generally not interested in squatters unless larger issues areat stake. There are thousands of free settlements scattered around the globe.Some of the larger ones have sought and received free city status (p. TS84)from a number of administrations, which accords them some of the diplomaticrecognition of nation−states.

The situation is more complex for companies. It *is* possible for a company to move its headquarters toneutral territory and inform its former country that it is no longerincorporated there. Most nations would rather maintain their tax revenue,however, so may not let them go so easily. Having the navy knock on your doorto collect taxes is a large disincentive. Even if they don't pursue thiscourse, nations often place heavy tariffs on goods imported from offshorecompanies, reducing their competitiveness while generating revenue. Companiescan also set up from scratch on the high seas. Such endeavors are oftentraceable to sponsoring onshore companies, so attract the same punishment ascompanies which move. In most cases, a better (and cheaper) option for the companyis simply to move to a "flag of convenience" nation usually aless−developed Third Wave state with lax corporate laws (see pp. BD00−00).

The advantages of operating a company outside any jurisdictionare tempting, however. Workers can be virtual slaves, working long hours forlittle pay, under atrocious conditions. The savings in operating costs can morethan offset any losses due to tariffs, so unscrupulous companies can find themove profitable. Research and experimentation can also be carried out withoutregard for regulations. Biotech Euphrates was one of the first companies totake advantage of these benefits.

Mining

Legally, nations may exploit mineral resources as they wishwithin their EEZ. Government−backed operations can mine freely, and corporationsmay mine with the permission of the nation controlling the territory. Mostcompanies do not have the might to operate illicitly in waters patrolled byFifth Wave navies, but some Third Wave countries do not project enough militaryforce to dissuade clandestine mining operations.

Nations or companies may also mine in international waters. Underthe provisions of the Law of the Sea, however, profits from such mining must besplit with the United Nations, which will redistribute its share among developingcountries. With the United Nations fallen into irrelevance, the developingcountries can only protest ineffectually as Fifth Wave technologies strip thehigh seas of wealth.

In this climate, mining rights go to whoever has the equipmentand capital to stake a claim. Since sea−floor mining requires a largeinvestment, anyone engaged in it is likely to have the capability to defendtheir interests.

Fishing

The Law of the Sea goes into great detail about the rights andresponsibilities of nations in harvesting fish and other organisms. Briefly,nations may specify fishing laws within their own EEZ under the followingrestrictions: Quotas and size limits must be set to ensure maximallysustainable harvests and prevention of damage to populations of ecologicallyinterdependent species; limits for migratory species must be set inconsultation with all nations whose territory they cross; and nearbyland–locked nations must be granted access to fishing in an equitable manner.On the high seas, all nations have a right to fish, subject to cooperativeagreement on quotas to prevent depletion of stocks and ecological damage.

These terms have never proved satisfactory. There aredisagreements over what constitutes a sustainable yield, what causes ecologicalharm, and what is equitable sharing. The international disputes and illicitfishing practices of the 20th century continued throughout the 21st, causingseveral diplomatic incidents. A particularly problematical practice is"quota hopping"   the purchase of fishing vessels registered inone country by companies registered in another. Such a ship can operate freelywithin the waters of its country of registration, but sail to a foreign port toland its catch in the country of the owner.

A major diplomatic incident erupted in 2031 when a Canadian navyfrigate opened fire on Canadian–registered but Spanish– and Portuguese–ownedvessels fishing in the Grand Banks (see p. 00). Since then there have beenshots fired at fishing vessels in the North Sea, Sea of Japan, South China Sea,Timor Sea, and Red Sea by various military forces.

With many commercially valuable species being depleted or drivento extinction by climate change, pollution, ecological disruption, or simpleoverfishing, tensions remain high between fleets and the governments who wishto limit their activities. What little law that was ever effective has fallenby the wayside.

Salvage and Recovery

There are long–standing conventions and laws governing rights andresponsibilities in cases of salvage and recovery. *Salvage* is the voluntary assistance and saving of imperiledvessels or cargo. In such cases, the salvor is permitted to retain possessionof salvaged property until such time as a compensatory award is settled andpaid by the owner. The amount of the award is usually decided by a court, andmay range from 10% to 50% of the value of salvaged property, depending on thedifficulties and risks faced by the salvor. While holding the salvagedproperty, the salvor is required to make it available for inspection andmaintenance by the owner, and to release it on the posting of securitysufficient to cover any potential award.

Recovery is the retrievalof property which has rested in a geographically inaccessible place, usually ashipwreck. If the owner can be determined, still exists, and has not declaredthe property abandoned, this becomes a case of salvage although if thesalvor makes a claim of abandonment the owner may have to defend against thisin court. If nobody can successfully claim ownership, the salvor gainsownership of recovered property. Military or other property owned by sovereignstates is never considered to be abandoned. Some nations have also passed lawswhich grant them ownership of otherwise unowned wrecks within their territorialwaters.

The recovery of historically significant archaeological materialis limited by the Law of the Sea. It states that such objects must be preservedand disposed of in a manner beneficial to all mankind. This dictum is wide opento interpretation, particularly by treasure hunters, but it is used withimpunity by governments who care about such things.

Gengineering

The Law of the Sea specifically prohibits the introduction of"alien and new" species to any part of the marine environment wherethey might cause ecological harm, and requires that nations act to reverse anysuch damage. The Law was drafted prior to anyone creating genemod aquaticspecies, and its applicability to such species is hotly debated between biotechconcerns and Preservationists.

Ethically concerned companies study and test their creations incontrolled conditions before authorizing general release, build in inhibitor ordependency genes to cripple organisms which go feral, and take otherprecautions to prevent release of genemod species to the wild. Companies moreconcerned with profit than ethics, such as GenTech Pacifica, cut corners ordeliberately release organisms without precautions. Proving such negligence isdifficult, but Blue Shadow and other Preservationist groups are masters at collecting or fabricating evidence. Finding a jurisdiction willing andable to prosecute a case of criminally ecohostile gengineering is anothermatter, however, and such disputes are often addressed through less officialchannels . . .

Adventuring Underwater

The underwater environment poses several special problems forbeings not adapted to it. Some creatures possess adaptations that allow a moreor less normal existence in water. In ***GURPS*** terms, a character is *aquatic−adapted* if he possesses either the Amphibious advantage orthe Aquatic disadvantage. Characters without either of these are *non−aquatic*.

The following rules extend those for underwater environmentsgiven on pp. B91, TS59.

(((START BOX)))

Calculating Pressure

Pressure in a liquid on any world can be calculated with thefollowing formula:

Pressure (atmospheres) = Atmosphere + (Depth ¥ Gravity ¥ Density) / 34

Atmosphere is the pressure of the"atmosphere" above the liquid.

Depth is the depth in feet.

Gravity is the gravityof the world, in Gs.

Density is the densityof the liquid relative to fresh water.

On Earth, Atmosphere and Gravity are 1. On Mars, Atmosphereis 0.4 and Gravity is 0.38. On Titan, Atmosphere is 1.5 and Gravity is 0.14. OnEuropa, Atmosphere is 260 (from the weight of the ice shell) and Gravity is0.14. For fresh water Density is 1, for Earth's oceans Density is 1.025, forMars Density is 1.130, for Titan's ethane seas Density is 0.565, for EuropaDensity is 1.074 in the Mesocean and 1.202 in the Tropocean.

Note that on Europa gravity increases with depth in theocean, so the figure quoted is higher than that given for the surface on p.TS44.

Partial Pressures of Gases

The *partial pressure*of a particular gas in a mixture is equal to the pressure of the mixturemultiplied by the fraction made up of the gas in question. Most commonly, thepartial pressure of nitrogen in breathing gas is of concern. Nitrogen comprises78% of a standard air mixture. For example, air at 2.6 atmospheres contains anitrogen partial pressure of:

2.6 ¥ 78% =2.0 atmospheres,

which is enoughto cause nitrogen narcosis.

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Breathing

Air−breathing characters without the Gills advantage (p. CI56)are restricted to the following three approaches to venturing underwater:holding their breath, riding in a submersible vehicle, or diving with scubagear or similar equipment. Holding breath uses the rules on p. B91. Theadvantages Breath−Holding (p. CI21) and Oxygen Storage (p. 00) increase thetime a character can hold his breath. Riding in a vehicle which maintains airat one atmosphere of pressure requires no special rules for the character(although see p. 00 for rules regarding the vehicle). Using any equipment whichsubjects the body to the pressure of the water requires air to be supplied at amatching pressure.

If air must be sucked from Earth's atmosphere via a snorkel to adepth of 3' or more, the pressure of water on the diver's lungs will make thisalmost impossible roll vs. ST every second, at −1 for every 1' over 3'of depth, to draw breath; on a failure apply the suffocation rules on p. B122.

Using air compressed to the ambient pressure avoids any breathingdifficulties, but can cause several physiological problems, described below.Some of these problems can be eliminated or mitigated by breathing differentcombinations of gases. For pressures up to 11 atm., a mixture of helium andoxygen (*heliox*) is effective. Up to 18atm., a carefully balanced *trimix*of helium, nitrogen, and oxygen can prevent problems. A cheaper and safersolution is to use *hydrox*, amixture of hydrogen with less than 4% oxygen there is no danger ofcombustion or explosion because of the low oxygen content. Genetic orbiological modifications can also prevent some of the problems of breathingpressurized gases.

The Bends

The blood and body tissues of a human breathing compressed airabsorb nitrogen gas via the lungs. This nitrogen escapes from solution when theperson returns to lower pressure. If the highest pressure experienced isgreater than 2 atm. or 33 feet deep in Earth's oceans theamount of nitrogen escaping on decompression can be too great to be expelledthrough the lungs. Small bubbles of the gas form in the blood and muscletissue, causing sharp pains in the joints and body, dizzy spells, and breathingdifficulties. In severe cases, blood flow to the heart or brain can be stopped,leading to unconsciousness or death.

The solution to this problem is to decompress slowly, spendingtime at certain intermediate pressures to allow the nitrogen to escape harmlessly.The decompression time required rises sharply with maximum pressure (i.e.diving depth) and time spent under pressure. Decompression can either takeplace at the appropriate water depth, or in a decompression chamber.

At a certain point, the body tissues can absorb no more nitrogen they become *saturated*. Once thispoint is reached, the required decompression time does not increase further. Atechnique for maximizing the amount of useful time spent at depth is to operateat this saturation level for days, weeks, or longer. When returning to thesurface, the same decompression time is required. This technique is called *saturationdiving*.

If a character decompresses too quickly, he must make a rollversus HT:

Critical success means noill effects occur.

Success means thecharacter suffers severe joint pains. He is at −2 to DX and IQ for at least anhour. Roll vs. HT each hour thereafter to recover. There are no lastingeffects.

Failure means thecharacter is completely incapacitated he faints or is paralyzed for atleast an hour. Roll vs. HT each hour to revive; each failed HT roll inflicts 1ddamage. Once conscious, the victim is at −2 to DX and HT for at least anotherhour. Roll hourly vs. HT to recover; if the first such roll fails it indicatesa permanent loss of 1 point of DX.

Critical failure indicatesthe character suffers a sudden and painful death, although brainpeeling toproduce a ghost may succeed if the procedure is begun quickly.

If an afflicted character is recompressed to the highest pressurehe experienced, he rolls vs. HT+4 every five minutes to recover from alleffects short of death.

(((START BOX)))

Decompression Table

This table gives some of the salient decompression times fordiving with compressed air (78% nitrogen).

This is a highly simplified table for game purposes andnot a substitute for professional dive tables this table must not beused to plan real life dives.

Depth	35	50	75	100	125	150	200	400	1000
Pressure	2.0	2.5	3.3	4.0	4.8	5.5	7.1	13.1	31.3
No Decompression Time	Unlimited	80	40	22	10	0	0	0	0
Saturation Time		2.5	5?	8?	12?	18?	24	24	24
Maximum Decompression		16?	21	28?	38?	51?	66	96	240

Depth is in feet, onEarth.

Pressure is the waterpressure in atmospheres. Use this instead of Depth if calculating dive times onother worlds.

*No Decompression Time*is the maximum time in minutes that can be spent at that pressure withoutrequiring a decompression routine.

Saturation Time is thetime in hours after which the body is saturated with nitrogen.

*Maximum Decompression*is the length of decompression required for a saturated diver, in hours.

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Nitrogen Narcosis

At high pressures, nitrogen binds to fatty myelin tissue in thebrain and inhibits normal mental processes. This causes symptoms similar toalcohol intoxication: heightened feelings of either euphoria or paranoiadepending on emotional state, impaired judgment, and inability to performsimple mental tasks. If the condition progresses with further compression, itleads to fatigue, drowsiness, and loss of consciousness. Unlike alcoholintoxication, nitrogen narcosis occurs immediately, as soon as the pressurereaches certain levels.

Nitrogen narcosis vanishes quickly with no aftereffects if thevictim returns to lower pressure. Unfortunately, people are usually unawarethey are suffering from it, and often actively resist any attempt to force themto safety.

If the partial pressure of nitrogen (see p. 00) is over 2 atm.,any character susceptible to nitrogen narcosis has −1 to all IQ−based rolls,loses the Common Sense advantage (if he has it), and gains Impulsiveness. Healso requires IQ rolls to perform even the simplest tasks, such as rememberingto keep track of time or air supply. For each additional atmosphere of nitrogenpartial pressure, an affected character acquires an additional −1 to IQ, and −2to ST, to an effective minimum of IQ 6 and ST 3. Attribute penalties andacquired Impulsiveness caused by nitrogen narcosis are lost immediately if thenitrogen partial pressure falls below 2 atm., and lost Common Sense isregained.

Nitrogen narcosis can be prevented by using heliox instead ofair. This has two drawbacks, however. Firstly, helium dissolves more readily intissue than nitrogen, and decompression times must be increased up to twice aslong. Secondly, helium can cause a new problem . . .

High Pressure Nervous Syndrome

This occurs at partial pressures of helium above 10 atm. The gasdiffuses into nerve tissue, causing muscle tremors, dizziness, nausea,drowsiness, difficulty concentrating, and visual hallucinations. These effectscan be mitigated by using trimix instead of heliox, or by compressing slowly instages, but can only be eliminated by switching to hydrox.

A character breathing helium at 10 atm. or more partial pressuremust roll vs. HT, with a +1 bonus for either of the mitigating proceduresmentioned above:

Critical success meansminor muscle tremors, with no game effect.

Success indicates obvioustremors, causing −2 to all DX−based rolls.

Failure indicates tremors,dizziness, and nausea, causing −4 to DX and −2 to IQ.

Critical failure means thecharacter suffers all the listed symptoms, causing −4 to DX and IQ. He maybecome paranoid and belligerent, or fall unconscious at the GM's option.

These effects last until the character is removed from the highpressure helium atmosphere, at which point he recovers immediately, but maystay asleep if already unconscious.

Oxygen Toxicity

At partial pressures above 0.6 atm., oxygen itself becomesdangerous. Exposure for an hour or more can cause pulmonary edema acondition in which the lungs fill with fluid. At higher pressures, oxygentoxicity can be lethal. The only way to prevent danger is to avoid high partialpressures of oxygen. This means switching to gas mixtures with smallerproportions of oxygen during compression. As long as the partial pressure ofoxygen is in the range 0.15 to 0.6 atm., mammals can extract enough to survivesafely.

If a character is exposed to high oxygen partial pressures formore than HT¥6 minutes, apply the following rules. Attribute penalties arenot cumulative with increased pressures, but symptoms are.

0.6−1.1 atm. partial pressure of oxygen: The character finds breathing painful and is besetby wracking coughs, causing a −2 penalty to DX, and must make a successful rollvs. HT every 10 minutes or take 1 point of damage.

1.1−1.6 atm. partial pressure of oxygen: The character suffers muscle twitches, dizziness,and nausea, causing −4 DX and −2 IQ penalties; roll vs. HT every five minutesto avoid 1 damage.

1.6−2.1 atm. partial pressure of oxygen: Vision and hearing become impaired; the charactersuffers −4 DX, −4 IQ, and an additional −2 on sense rolls; roll vs. HT everyminute:

Critical success indicatesno further effect until the next HT roll.

Success indicates 1 pointof damage from coughing.

Failure indicates thecharacter goes into convulsions and automatically takes 1d−3 damage per minute.Convulsions do not stop until medical treatment is given do notcontinue to roll vs. HT. If using scuba gear, make a DX roll every minute toavoid dislodging the mouthpiece and drowning.

Critical failure means thecharacter dies.

Greater than 2.1 atm. partial pressure of oxygen: The onset time for the most severe symptoms aboveis reduced to *one minute*.

A character can only recover if removed to a lower oxygenenvironment and given medical attention. A successful Physician roll will stopconvulsions and reduce attribute penalties to −2 on DX. Lost hit points arerecovered as per recovery from disease (p. B133), with a +4 bonus on any HTrolls for appropriate nanodrug treatment. The −2 DX penalty is removed onlywhen recovery is complete.

(((START QUOTE)))

The change−over was automatic, and the demand regulator alsoadjusted the oxygen flow so that the mixture ratio was correct at any depth. Ascorrect as it could be, that is, for a region in which man was never intendedto live . . .

Arthur C. Clarke, *TheDeep Range*.

(((END QUOTE)))

Pressure

High pressure is not intrinsically dangerous to humans over shorttime scales. If compressed slowly (taking 10 minutes per atmosphere), the humanbody can withstand pressures up to 100 atm. without physical damage. Theproblems associated with pressure have to do with the process of changingpressures, the toxic effects of gases absorbed through the lungs (see *Breathing*, p. 00), and long−term exposure. The PressureSupport advantage (p. 00) will help prevent these effects.

Characters who are compressed by more than 10 atm. without enoughtime for their bodies to adjust are subject to crushing damage as per p. TS58.If a character is exposed to high pressure *suddenly*, such as in a breached vehicle, the result isgenerally instantly fatal. Characters with blocked sinuses or other aircavities such as decayed teeth will feel increasing discomfort and pain whencompressed, even slowly, as the cavities are squeezed. Such pain causes a −1penalty to DX and IQ−based rolls until it is relieved. The only solutions areto vent the cavities or to return to lower pressure.

Pressure can also cause problems when it is lowered. Bodily aircavities cause pain similar to that caused when pressure increases. A worseproblem is that expanding gas can rupture body tissues or penetrate bloodvessels and form bubbles in the blood, conditions known as *embolisms*. This causes symptoms similar to the bends GMs who assess a chance of gas embolism should apply the rules for the bends(p. 00), including treatment and recovery. The greatest risk of gas embolismcomes from holding breath while ascending during a dive in which compressed gashas been breathed. As the gas in the lungs expands it must be exhaled or severeembolism is inevitable (treat HT roll results as one category worse, so anyfailure results in death). Panicked characters may forget this cardinal rule(IQ or Scuba roll to remember if mental state is agitated).

Prolonged exposure to high pressure causes stress to thecardiovascular and musculoskeletal systems. Characters living in environmentsmore than 10 atm. higher than their native pressure must make annual rolls vs.HT+2. Failure permanently reduces HT by 1.

Aseptic Bone Necrosis

This is a long−term problem caused by the effects ofdecompression on capillaries in the bones. Tiny bubbles of gas coming out ofsolution can damage these blood vessels, weakening the bone. It most commonlyoccurs in the hip, shoulder, and knee joints, and leads to increased likelihoodof fractures. The only cures are joint replacement surgery or nanodrugtreatment to rebuild the capillaries.

The GM may require an annual HT roll for any character engagingin frequent compression. A failure indicates onset of this condition, causing apermanent −1 to HT, unless treated surgically.

Cold and Heat

The rules for cold and heat on p. B130 are for exposure to air.Water has a much higher heat capacity than air and conducts heat away from thebody rapidly. It also penetrates clothing, destroying any insulating effect.Warm water prevents the body from losing heat by sweating, making it worse thanhot air. The result is that a character's temperature "comfort zone"(see *Temperature Tolerance*, p. CI30) ismarkedly reduced when in water. A baseline human, with a comfort zone in air of35° F to 90° F (assuming suitable "everyday" clothing), has acomfort zone of only 75° F to 85° F in water. Diving suits can extendthese zones see p. 00. Aquatic−adapted characters have a defaultcomfort zone of 50° F to 85° F in water many animals have thiszone shifted upward or downward to some extent.

Any character immersed in water at a temperature below his comfortzone must roll vs. HT once per minute, taking 1 point of fatigue on a failure.This represents fatigue caused by shivering if the character isactively swimming he stays warm, but takes fatigue according to the swimmingrules on p. B91. If the water temperature is more than 20 degrees below thecomfort zone, a successful HT roll causes 1 point of fatigue, while a failedroll causes the number of points equal to the amount by which the roll failed.Once unconscious due to fatigue, the character loses hit points instead.

Immersion in water close to freezing can also cause thermalshock. Any character plunged into water with a temperature more than 20 degreesbelow his comfort zone and also below 35° F takes 1d−3 cold damage perminute, in addition to any fatigue. He must also roll vs. HT. A failure reducesDX and DX−based skills by −3 until he is warmed up. Critical failure indicatescardiac shock and stoppage of the heart, which reduces hit points to 0 ifcurrently positive and causes death in HT/3 minutes unless CPR is givensuccessfully (First Aid−4 or Physician roll). If a character is unfortunateenough to be immersed in a cryogenic liquid such as Titan's ethane seas, applythe cryogenic atmosphere rules from p. TS58.

A character in water *hotter*than his comfort zone also rolls vs. HT once per minute, taking 1 point offatigue on a failure. If the water is more than 40 degrees above the comfortzone, the character also takes 1d−4 burn damage per minute. At 50 degrees abovethe comfort zone, the water is dangerously hot and causes 1d−4 burn damage persecond.

Movement

Non−aquatic characters use the swimming rules on p. B91 to swimon the surface. Aquatic−adapted characters do not need Swimming skill. Theyautomatically swim at their base Move without needing to roll (see *Aquatic*, p. 00).

Underwater, non−aquatic characters with an air supply must rollagainst Scuba skill (p. B48) every half hour, and need no Swimming rolls. Theyswim underwater at the same speed as on the surface, rolling for fatigue as perp. B91. Swim−fins give swimming Move bonuses (see p. 00). Non−aquaticcharacters may swim very long distances at a slow speed to minimize fatigue speed is two times Swimming skill yards per minute, or three times ifswim−fins are worn. Distance swimmers fatigue at the same rate as if marchingon land (p. B134).

Aquatic−adapted characters move freely underwater at their fullMove score. They swim long distances according to the marching rules on p.B187. Aquatic−adapted characters generally cannot make use of simple swim−fins,since their limbs and propulsion method are already optimized for pushing theirbodies through water.

Senses

Non−aquatic characters have their senses adversely affected inthe underwater environment. Similarly, characters with the Aquatic disadvantagesuffer poorer sensing ability in air. Characters with the 10−point version ofthe Amphibious advantage do not suffer any penalties in either environment.

Light. Sunlight penetrateswater poorly. For each 75' of depth, assess a −1 darkness penalty, to a maximumof −10. Add this to any penalty for night illumination at the surface. Waterpreferentially absorbs red light; below 20' everything takes on a greenish−bluecast and colors cannot be distinguished without an artificial light source.

Vision. The absorption oflight by water gives a −1 penalty on Vision rolls per 15' of range, *inaddition* to any low light penalties, for *allcharacters*. Non−aquatic characters have afurther −4 to Vision rolls and suffer a −4 penalty on manual tasks requiringvision (such as Mechanic rolls) if their eyes are directly exposed to water goggles or a mask will prevent this problem. Aquatic characters suffersimilarly if their eyes are exposed directly to air. The refractive index ofwater relative to air means that objects viewed through a flat window appear tobe 25% larger and closer than they really are this effect can becorrected by using a variable−thickness or spherical window, which is standardfor diving masks and most submarine viewports in ***Transhuman Space***.

Hearing. The increasedspeed and carrying distance of sound in water distorts sounds and makes itdifficult to tell where a sound originates. Non−aquatic creatures will alsousually underestimate the distance a sound has travelled. Non−aquatic orAquatic characters in their non−native environment roll normally to *hear* a sound, but must succeed by 4 or more to localizeor recognize it.

*Taste and Smell.*Non−aquatic characters cannot effectively taste or smell when underwater, evenif they are not wearing masks.

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The Psychology of Diving

Panic

The underwater environment can quickly cause panic incharacters dependent on a constant air supply. Any unexpected event,particularly one interfering with air supply, can require a Fright Check (p.B93). Examples include: becoming entangled in seaweed or a net or line; thesudden, close appearance of a shark; having a facemask knocked off; or failureof breathing gear. Divers may substitute Scuba skill for IQ when calculatingWill for such Fright Checks.

An air−breathing character who fails a Fright Checkunderwater must make a roll vs. HT. Failure indicates the character beginshyperventilating if no air supply is available the character must makea Will−4 roll to prevent inhaling water and roll an additional Fright Check ata −3 penalty. A hyperventilating character is unable to perform any rationalaction except make a Will−2 roll every 10 seconds to recover. They may behaveerratically, bolting for the surface or flailing wildly the GM mayrequire DX rolls to avoid dislodging or damaging equipment, including breathinggear.

Long−Term Effects

In some cases, living underwater can be as lonely asexistence anywhere in the solar system. The limited utility of radio forkeeping in contact with the outside world means people can be truly isolated.Confinement to a cramped vehicle or habitat with limited social interaction isa recipe for stress. Some people handle stress well. Some become antisocial andaggressive, while others become withdrawn and suffer feelings of inadequacy andlow self−esteem. Forcing players to roleplay these effects may not suit somegamers, but the GM can use them to give life to NPCs and create dramaticincidents.

Seasonal Affective Disorder (SAD). This is a form of clinical depression caused by abiochemical imbalance of the hypothalamus gland due to a lack of sunlight. Itaffects surface−dwelling humans during winter months, and can be a permanentproblem for underwater dwellers. The most effective treatment is exposure tobright light for several hours per day. Most underwater habitats have stronglighting installed in commonly used areas, with a brightness approaching fulldaylight. The latest aquatic parahumans have a genemod which prevents SAD, butlighting systems are cheap and common, so there is little incentive to removethem.

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Combat

The ***GURPS Basic Set*** has rules for underwater combat on p. B91. Those areappropriate for non−aquatic characters. Aquatic−adapted characters follow therules given here.

Firstly, such characters are efficient fighters underwater. Theystill have to work against the resistance of the water, but they are used tothis. Rather than periodically rolling against Swimming skill in a fight, theyroll against HT+3 every 10 seconds, taking 1 fatigue if they fail. They stillsuffer fatigue based on Encumbrance at the end of long fights (see p. B134).

Aquatic−adapted characters also use weapons effectively. Closeweapons (including fists) are used at no penalty, 1−hex weapons at −1, andlonger weapons at an additional −2 per hex. (Thus, an Aquamorph uses a 3−hexweapon at −5 underwater, rather than the baseline human's −12.) They alsosuffer only −1 to damage with Close weapons underwater, rather than halving it,though they halve damage from other weapons just like anyone else.

Hand−to−Hand Combat

Thrusting, impaling weapons are more effective underwater thanswung weapons they meet relatively little water resistance, whereas afull arm−swing meets a lot. To reflect this, damage from such weapons should bereduced by only one−third, rather than one−half, while damage from anydrag−prone weapon requiring a roundhouse swing should be reduced by two−thirds.GMs may have to rule which weapons and attacks fall into which category on acase−by−case basis. Most commonly carried melee weapons underwater will bethrusting, such as knives and spears. Knives are particularly useful, sinceattacks targeted at the diving equipment of an air−breather can achieve lethalresults without even touching the victim's skin.

Note that underwater combat is three−dimensional, with fightersable to pass over, under, and around each other. Aquatic−adapted beings can use their Athletic andCombat/Weapon skills normally when rolls against such skills are required tomaneuver in combat. Non−aquatic characters must roll against the lower of theskill in question and Swimming skill to perform such actions. Characterswith 3−D Spatial Sense (p. CI31) have a +2 bonus to such rolls.

Ranged Attacks

The following rules apply to ranged weapons underwater:

Thrown weapons have 1/10their usual 1/2 Damage and Maximum ranges, and do half their normal damage.(This means they do 1/4 listed damage between their reduced 1/2 Damage andMaximum ranges.) If this reduces the maximum range to 1 hex or less, theycannot be effectively thrown. This rule also applies to mechanically poweredprojectile weapons, such as spearguns or high−tech crossbows.

Guns and missiles have1/20 their usual 1/2 Damage and Maximum ranges (1/30 for soft−nosed bullets),but suffer no further damage reduction. Torpedoes suffer no penalties. Modernguns are relatively safe to fire underwater or immediately after immersion.Older guns will malfunction and become unusable on a skill roll of 16 orhigher; on a critical failure they explode.

Lasers have half theirusual 1/2 Damage and Maximum ranges in clear water. Turbid water will blockthem completely. This assumes tunable rainbow lasers, which are the default in ***TranshumanSpace***. Obsolete orcheap lasers without the ability to emit blue−green beams have only 1/10 their1/2 Damage and Maximum ranges underwater.

Electrolasers do not workat all underwater. Attempting to fire one in water will simply trip acircuit−breaker designed to prevent shock to the user.

Explosions are moredangerous underwater because water transmits the concussive pressure waves muchmore readily than air. Triple all distance increments for concussion damage(see p. B121).

Radiation is attenuated bywater. A yard of water has a radiation PF of 8 (see p. TS60). Note this ismultiplicative; two yards of water has PF 64, and so on.

Any ranged attack which passes from air to water, or vice versa,should have the underwater part of its range reduced as above. For example, abullet fired from air into water treats each hex after it enters the water asequivalent to 20 hexes in air. Refraction at the air−water boundary makesaiming across it difficult. Ranged attacks made from air into water or viceversa are at a −4 penalty.

Extraterrestrial Oceans

There is no effective way for this heat, accumulated overbillions of years, to reach the surface and be lost to space, and theradioactivity inside Ganymede and Callisto must melt their icy interiors. Weanticipate underground oceans of slush and water in these moons, a hint, beforewe have ever seen the surfaces of the Galilean satellites close up, that theymay be very different . . . When we do look closely . . . this prediction isconfirmed. They do not resemble each other. They are different from any worldswe have seen before.

*Carl Sagan, **Cosmos**, 1981.*

Earth is not the only world with oceans. Some of the icy moons inthe Deep Beyond contain more liquid water than all of Earth's oceans combined,kept liquid by radiogenic or tidal heating. One satellite Titan has oceans of liquid hydrocarbons. And Mars has seas newly created by the handof humanity. The extraterrestrial oceans may sometimes appear similar to thoseof Earth, but they are even more alien and dangerous places.

Mars

The oceans of Mars are described in ***Transhuman Space: InThe Well***, in termsof their relationships to settlement and terraforming. The following sectionsdescribe their physical and oceanographic characteristics.

The Borealis Sea

The high salt and mineral content (15% salinity) of the BorealisSea lowers its freezing temperature to 14° F. This helps to keep the oceanliquid during the summer months, but in the long winter the temperatures dropbelow 0° F all the way down to the low latitudes, and the surface of theocean completely freezes over. Since the impurities in the water are locked outas it freezes, the white sea ice that forms is a stark contrast to the silty,coffee–coloured water on which it floats. A system of thermal boreholes coupledwith a network of pumps and heat distributors on the sea floor keep the deeperparts of the ocean liquid all year round.

Despite this, the ancient north polar ice cap extends to latitude80° N and the sea ice cap extends further to latitude 60° N all yearround. This means that while the Borealis Sea is circumplanetary at depth, thepermanent sea ice cap covers the surface of the ocean and forms an isthmuslinking the north pole to Tempe and Xanthe Terra.

Ocean circulation on Mars is similar to that on Earth. Althoughthere are thermal boreholes and an extensive heat distribution system on thesea floor, the temperatures there are not very high only around25° F, just enough to keep the water liquid below the surface. Cold watersinks from below the permanent sea ice cap and flows southward and westward(due to Coriolis force) toward the southern shores of the ocean and the waternot covered by ice, if any is present. This means that when icebergs calve fromthe sea ice shelf north of the Marineris Sea, they are funnelled by currentstoward its mouth, causing a major shipping hazard there.

The deepest points of the Borealis Sea are located in Utopia andAcidalia Planitia, where the water depth reaches 1.25 miles. The pressure atthe deepest point in the Borealis Sea is 84 atm.; freezing point there isslightly lower at 12° F.

The Marineris Sea

This body of water is kept liquid all year round by orbitalmirrors. Ideally, cold water would flow into its depths for its whole lengthfrom the Borealis Sea while warmer water would flow from Marineris into theBorealis Sea. However, the system of giant locks in the Valles Marineris (seep. ITW00) only allows the easternmost part of the Marineris Sea to circulatewith the Borealis Sea as a result, the western part of the MarinerisSea is much warmer than the other oceans on Mars. Although the locks are farapart enough to allow some circulation to occur within each segment, a pumpsystem extends along the entire Marineris sea floor to bring at least some coldwater into the western end to help equalize the heat balance.

The Hellas Sea

The Hellas Sea is isolated from the other oceans on Mars. Thedeepest point on Mars is in the Hellas basin, at a depth of over three miles inthe northwestern corner the pressure on the sea floor here is 210 atm.A permanent sea−ice shelf extends into the sea from the southern shore, and thesea surface freezes completely during the winter. At other times, the liquidsurface is filled with icebergs, which circulate counterclockwise around the centerof the sea because of Coriolis force.

Europa

Europa is the sixth major moon of Jupiter, and the smallest ofthe Galilean satellites. Its surface is bright water ice, with brown and yellowbands and irregular patches of varying size. The colors are the result of saltcontamination, primarily magnesium sulfate. Different rates of radiationbombardment color the salts yellow in the leading hemisphere of Europa, whereasin the trailing hemisphere they are brown.

Beneath Europa's icy surface is a vast salt−water ocean that ishome to the only native extraterrestrial life so far discovered. Studying theselife forms is the *Centre de Recherche AstroBiologique d'Europa* (CRABE), a science foundation funded by the EuropeanUnion. A Duncanite corporation Avatar Klusterkorp arrivedlater, secretly initiating a pantropist plan to colonize Europa with adaptedlife forms and modified humans. CRABE recently discovered this project'sexistence, leading to outrage among Preservationists. A radical group the Europa Defense Force (EDF, p. TS44), led by former Negative Growthterrorist Torsten Rademacher (see p. DB00) has arrived on Europa tostop Avatar's research. A low−intensity conflict has broken out between the twofactions as a result a small but fierce "war under the ice,"with CRABE attempting to remain neutral.

Europa and the organizations present on it are introduced in pp.TS43−44 and DB00−00.

The Surface of Europa

"The distant sun hangs low in the western sky and eveningslowly draws on. I'm on my way to ManannÆn Station for an exclusiveinterview with the leader of the Europa Defense Force, those self−styledcrusaders for the preservation of the indigenous Europan ecosystem. I've beentravelling for hours now, picking my way over the broken landscape, wishingthey'd picked a better method of transport than the Landstrider I've ended upin. I'm tired, hungry, and more than a little nervous.

"Around me is a world of shadows. That's what you getwhen the sun's low and there's barely an inch of flat ground to walk on. Quiteappropriate given all the conspiracies and secrets that are hidden beneath theicy surface secrets I'm going to reveal, assuming I can get there inone piece."

Copernicus Jones, ***War In Europa****(TEN: 2099).*

Europa is covered at a variety of scales by a network ofoverlapping cracks and ridge systems. Very few parts of the surface areactually flat and level ground slopes usually range between 5° and20° from the horizontal. Despite this, Europa is smooth at large scales the greatest elevations on Europa are rarely more than 1,500 feet abovethe average satellite radius.

Travel over the Europan surface is problematic at best. The slopechanges every few hundred yards, and the large cracks that are encounteredevery few miles have to be jumped or flown over simply travellingaround them is not an option when they often continue for hundreds or thousandsof miles.

Ridges and Cracks. Themost common type of Europan ridge system is the double ridge twotriangular ridges next to each other, occasionally with a deep fissure severaldozen feet wide between them. The ridges are usually symmetric in section, butsometimes the center–facing slopes are steeper than the outer slopes. Othertypes include bare cracks (deep crevasses dozens to hundreds of yards across),lipped cracks with rims that slope upward before they drop steeply into thecrack itself, and complex ridges with wide bumpy plateaus at the top. Doubleridge systems are typically 1,000 to 3,000 feet across, and a tenth as high. Ridgesare often crossed or cut by other ridges and cracks which can deform and upwarpthem.

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Tides and Surface Travel

Tidal forces on Europa are caused by orbital motion and varywith location. A full tidal cycle is equal to the orbital period: 3.55 Earthdays. These forces can act to open or close existing cracks in the ground, orcreate new ones. Millions of years ago, when the ice shell was thinner, thetides forced small amounts of water up the cracks toward the surface. If thewater reached the surface, it froze to form a small mound on either side of thecrevasse. Over thousands of years, these mounds built up to form the doubleridges that crisscross the surface. If the water did not reach the surface, itfroze underground and propped the crack open. Today the ice shell is thickerbecause of global cooling, and the water can no longer reach the surface.Cracks still open and close over the tidal cycle, but they no longer penetrateto the base of the ice shell. As a result, double ridges are no longer formedtoday, except under extraordinary circumstances.

The tide acts on entire regions, pulling double ridges apartby a few yards, opening existing cracks further sometimes even creatingnew cracks that stretch for hundreds of miles, cutting straight through everytype of terrain then bringing them back together to their originalconfiguration. At high latitudes the tides can also cause *snapback*, which occurs as stresses build up in cracks whilethey are closed during the tidal cycle. When they are opened later, theyrelease the built–up shear stresses, causing one side to move suddenly to theleft or right by a few yards. This is rarely troublesome, but can causedistress for travellers unfamiliar with the phenomenon of what CRABE personnelrefer to as "The Lurches."

Cracks do not open and close quickly enough to trap vehicles,but the tides do cause problems when vehicles find cracks in their path thatare too wide to traverse. The only solutions are to either find a way aroundthe crack (if it is short enough) or wait 18 to 22 hours for the tidal forcesto close it. As a result of the tidal effects, surface travel over Europa israre and only done when absolutely necessary, over short distances.

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Chaos Terrain. These arelarge areas where plumes of warm ice have broken through the surface (e.g.Thera Macula). "Warm" is a relative term   the plume is only afew degrees warmer than the surrounding ice. Chaos is the dominant terrain typebeing formed today, though the timescale for its formation is tens of thousandsof years. Chaos areas consist of rafts of ridged terrain separated by ahummocky, salt−rich matrix, bearing a striking resemblance to enormous icebergsin a frozen choppy sea. The edges of the rafts are steep cliffs which rise afew hundred yards above the matrix. Sometimes the rafts are tilted into thematrix, with the opposite end rising high above the surface.

Lenticulae. Sometimesknown as *micro−chaos*, lenticulaeare irregularly−shaped pits, spots, and domes that punctuate the landscape.They can be up to 10 miles across, and usually form around larger chaos areas.The depressions have broad floors, often containing hummocky, disrupted terrainthat is troublesome to negotiate. Domes upwarp the existing terrain, and cancontain hummocky terrain at their summits. Lenticulae are formed when smallplumes of water or warm ice penetrate the ice shell all the way to the surface,but at a smaller scale than the larger chaos terrains.

*Secondary Impact Craters.*Primary impact craters such as Pwyll and ManannÆn are few and farbetween. Falling ejecta from such impacts causes smaller secondary craters,which occur in clumps across Europa (particularly around the Pwyll impact,which scattered ejecta up to 1,000 miles). These are bowl−shaped, from tens ofyards to half a mile in diameter.

Under the Ice   The Oceanus Noctis

"The standard joke around here is that we work under themost pressure in the solar system, but in the end it's not much different toworking in any deep underwater rig on Earth, or in a space station. Whether thepressure outside is non−existent or 1,500 atmospheres, either way we'd be deadif the hull was catastrophically breached. So you tend to forget about it.Sure, it can get claustrophobic at times, but if you want to have a break thenhead up to the surface and enjoy the view. There's nothing like watchingJupiter looming over the horizon with a few moons in tow to blow away thecobwebs."

Kurt Brzinski,CRABE/Vosper−Babbage Engineering Chief.

Europa's ice shell is 13.5 miles thick. Beneath it lies the *OceanusNoctis*   The Ocean of Night   avast ocean of salty water extending 51 miles further to the geologicallyactive, rocky surface below. The rocky body is 1,820 miles in diameter, with asolid metallic core 915 miles in diameter.

The Oceanus Noctis is so named because there is no natural light,apart from the occasional dim red glow visible at active volcanic vents on thesea floor. Its volume is almost twice that of all of Earth's oceans combined,and it is 7.5 times as deep as the Marianas Trench.

The Oceanus Noctis is about as deep as Earth's atmosphere, andunsurprisingly the most interesting part is the bottom of it. The structure isdifferent to that of Earth's oceans, since Europa has no atmosphere andeffectively no solar heating at the top of the water to drive circulation. TheOceanus Noctis is divided into two separate layers the upper *Mesocean*, and the lower *Tropocean* separated by a compositional boundary knownas the *Hydropause*.

The Sea Floor

Only 15% of the Europan sea floor has been mapped at resolutionsgreater than 3,000 feet much of it is "Europa Incognita."Most of the floor consists of clays and muds formed by the *in situ* chemical breakdown of the basaltic lava flows thatmake up most of the sea bed. Nearer the many eruption sites, the recentlyerupted volcanic rock is exposed and largely unaltered.

Europan silicate geology is similar to that of Venus plate tectonism does not occur in the same way as it does on Earth. Instead,active rifting jostles plates against each other to form long fold belts andshear zones, and crust is recycled by thickening and melting. The dominant formof heat loss is hotspot volcanism, with the largest volcanic centers locatedunder Conamara Chaos, Thrace, and Thera Maculae, at 5° S, 140° W (nearMorvran crater) and at 10° S, 50° W. There are many recent but extincthotspots and vent fields scattered across the sea floor, indicating that heatflow within the past ten million years was greater than it is today. This wasmost likely due to a period of increased tidal heating, which may also havebeen responsible for the complete resurfacing of Europa's ice shell. Volcanicactivity appears to have died down considerably since this peak, with currentlevels slightly lower than that of Earth. Ongoing volcanic and hydrothermalactivity is focused along rift zones and around isolated active hotspots.

*Mineral Resources.*Metalliferous sediments including iron, zinc, and manganese sulfidesand oxides can be found around active black smoker vents. The largestfields, however, are found around extinct vents, where the sediment has hadtime to be chemically weathered. Avatar Klusterkorp has set up a few automatedmining stations to exploit these resources.

The Basal Seas

The bottom of the Oceanus Noctis is dominated by the effects ofsubmarine topography. Trenches, ridges, basins, and hills can restrict the freeflow and mixing of water at the sea floor, separating the bottom water intolocal *basal seas* with different salinity,temperature, and density to the rest of the ocean. Turbidity currents andvolcanic eruptions can destroy the physical barriers between a basal sea andthe rest of the ocean, causing the basal sea to mix with other water and loseits separate chemical identity.

Local variation in the hydrothermal vent chemistry determines thecharacteristics of the various basal seas. Some of the more isolated seas havetheir own divergently evolving vent ecosystems.

The Tropocean

Hydrothermal vents erupt into the *Tropocean* the lower of the two major layers of theOceanus Noctis. The Tropocean extends just over four miles above the sea−floordatum level (64.5 miles below the ice surface), above the basal seas and mostof the topography. It consists of salt−rich hydrothermal fluids that haveerupted from vents and are not constrained by topography to form basal seas.Its waters are generally well−mixed. The top of the Tropocean contains materialfrom small to medium−sized volcanic eruptions that has risen above the denserhydrothermal fluids. These *megaplumes* do not have the buoyancy to penetrate the Hydropause and rise to thetop of the Oceanus Noctis, and thus remain at the top of the Tropocean. Theysupply heat that drives the circulation in the Mesocean above. Currents withinthe Tropocean driven by Coriolis force distribute material over large areas ofthe sea floor. Most of the sea−floor topography is contained within theTropocean. There are a few large hotspot volcanoes however, similar to Earth'sHawaiian Islands, which rise above the Tropocean and penetrate into the layerabove.

The Hydropause

The boundary between the Tropocean and the Mesocean is called the*Hydropause*. Since the Tropocean is muchmore saline than the Mesocean above it, the strong density contrast between thetwo layers prevents material from mixing between the oceans. In oceanographicterms, the Hydropause is a very strong *halocline* and *pycnocline* (change of salinity and density, respectively) that separates the twolayers.

The Hydropause is not a distinct layer *per se*, but is a very effective barrier to convectionbetween the layers. This barrier is up to 200 feet thick, and varies by a fewhundred feet in height above the sea−floor depending on the topography andactivity below. Sea−floor topography can penetrate this layer   theThrace Rise, Mount Thera, and the Conamara Rise are examples of large volcanicedifices that rise above the Hydropause and can erupt material directly intothe Mesocean.

The Mesocean

The *Mesocean* is much moreextensive than the Tropocean, extending 47 miles from the Hydropause up to thebase of the ice shell, comprising the vast bulk of the water on Europa. It iswell−mixed by convection, with upwellings where warm plumes from the Tropoceanimpinge on the Hydropause, and so has a fairly uniform composition. It is alsowhere most of the weak Europan magnetic field is induced by passage through thejovian field.

Hydrothermal plumes can occur in the Mesocean if they erupt fromvolcanoes that rise above the Hydropause, or occasionally from powerfuleruptions which penetrate into the Mesocean from below. Since the Mesocean isnot internally stratified, such *hyperplumes*can rise all the way to the base of the ice shell and create thermalinstabilities there, driving ice shell convection and ultimately creating chaosterrain on the surface. If the plume is long−lived and powerful enough, it maymelt through the ice layer completely, though this is very rare.

Material erupted by hyperplumes stays entrained in the plume asit rises, and disperses laterally when the plume hits the ice shell. Thematerial is then convected down, or settles back into the depths.

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Ocean Circulation

On Earth, water temperature varies depending on depth andgeographic location, generally being warmer at the surface. On Europa however,the top of the ocean is always colder than the base. The water density ishigher at the top of the ocean than at the bottom, so convection cells span theentire Mesocean, carrying cold water into the depths and warmer water up fromits base. The Hydropause usually prevents water from the Tropocean mixing withthe less saline water above it. Lateral currents also exist, caused by Corioliseffects.

In the Tropocean, volcanic eruptions and topographic effectsproduce complex lateral and vertical currents. Although the ocean currents aresimilar to atmospheric weather systems, they have so far not been powerfulenough to affect facilities there.

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Europan Oceanography

Pressure. The weight ofthe miles of ice above the water means that even at the top of the OceanusNoctis the pressure is 260 atm., equivalent to a depth of 8,600 feet below thesurface of Earth's oceans.

Pressure increases by one atmosphere per 226 feet of depth in theMesocean (cf. per 33 feet on Earth) up to 1,360 atm. at the base of theMesocean. It then increases more rapidly (one atmosphere per 198 feet) withinthe Tropocean because of the greater water density, to a crushing maximum of1,470 atm. at the sea–floor datum. Pressures this great do not exist in Earth'soceans they would be found at a depth of 48,800 feet under the sea,over a third again as deep as the Marianas Trench.

Salinity. The salinity ofthe Mesocean is 5% (cf. 3.5% on Earth). The bulk of the salt content ismagnesium sulfate rather than sodium chloride. The Tropocean salinity is muchgreater than the water above it, averaging 10% saline.

The basal seas are always more saline than the Tropocean, sincethe hydrothermal output is trapped there by the topography and the saline fluidcannot circulate. Many basal seas are between 10% and 20% saline. The mostsaline basal sea known is located in the Kargel–Zolotov Channel, which has asalinity of nearly 30%.

Temperature. The uppermostpart of the ocean is stable at 25° F just above the freezing pointgiven the salinity and pressure. At the base of the Mesocean, heating due tocompression of the water raises the temperature to 40° F.

Temperatures in the Tropocean increase from 40° F near the topto 50° F toward the sea floor. Near hydrothermal and volcanic vents,temperatures range up to hundreds of degrees Fahrenheit depending on how farthe water is from a heat source. The temperature gradient is very steep aroundthe vent chimneys, going from 650° F to 50° F over a few inches. Thevertical temperature gradient is less extreme, dropping a similar amount overseveral yards. Hydrothermal life can be found in the region around the vents,where the temperature range is 50° F to 175° F.

Density. Europan sea waterincreases in density until its freezing point, and decreases in density as itgets warmer. This means that water at the top of the column is denser thanwater below it the convection cells that result from this keep theMesocean well–mixed and chemically uniform. The Tropocean has a higher densitybecause of its greater salinity the large density difference definesthe Hydropause.

Acidity. The OceanusNoctis is very slightly acidic because of the hydrothermal gases left over fromreactions with the rocks on the sea floor. Acidity tends to be higherimmediately around some hydrothermal vents and in some basal seas. The acidityis not significant enough to cause problems for life or equipment however.

The War Under the Ice

"We are the Europa Defense Force. We exist to defend thevirgin Europan ecosystem from the intrusions of those who have no regard forthe sanctity of indigenous life. Today's actions are but the start of ourrighteous struggle to liberate Europa from pantropic pollution and we vow tocontinue until all the artificial forms the Duncanites have released into theenvironment have been destroyed, and the pantropists are ousted from thisworld. Know that nothing is of higher priority to us than the preservation ofthe Europan ecosystem and that we shall give our lives to defend and protectit, so that our sacrifice may ensure its continuing and natural evolution intoa bright future."

Press statement, EuropaDefense Force, 2098.

Three recent events have significantly shaken the peaceful statusquo on Europa the discovery of the Europa project in 2096, the arrivalof the EDF in 2098, and the escape of Copernicus Jones from ManannÆn Station in late 2099.

Oceanographers analyzing data from Chyba Station had noted aslight increase in sea−floor oxygen levels in early 2096 and had been puzzlingover its significance when they made the shock discovery of distinctlyterrestrial thiotrophic spores. As more evidence was collected and the originof the spores rapidly became clear, Giovanni Montaldo the fiery Italianmicrobiologist who became Chief Scientist in the facility at the start of 2096 flew over to Genesis Station with a contingent of scientists andconfronted Station Commander Judith Sigurdsson in person. Previously, relationsbetween CRABE and Avatar had been good the two groups had even pooledtheir resources and data concerning the Europan biosphere. When he discoveredthat the spores had been deliberately released and that Avatar had beensecretly working on the Europa Project for 15 years without once consultingCRABE personnel, Montaldo felt betrayed and became extremely angry, immediatelycondemning Avatar's "irresponsible tinkering with a virginecosystem." Avatar personnel could say little to defend themselves, andinstead argued from a pantropist view their priorities were the futurehuman colonization of Europa, and the indigenous ecosystem was to be exploitedto that end. The discussions rapidly descended into a heated and acrimoniousargument, at the end of which the CRABE contingent stormed out, with Montaldoordering an immediate data embargo on all CRABE research material to Avatar andforbidding further interaction between the two groups. Montaldo's superiors inthe ESA supported his decision, and since then relations between the two groupshave remained extremely frosty and contact has been minimal. Although bothgroups are obliged to respond to emergency communications, none have been madeby either side.

While CRABE frantically rallied its resources in an attempt todocument and even protect the Europan ecosphere from Avatar's contamination, aprivate group called XERG (Xenological Ecology Research Group) bought the oldESA base at ManannÆn crater in 2098. CRABE personnel were initiallyheartened (if a little wary, given their previous experience) at the prospectof a new scientific group with whom they could exchange information. Theiroptimism rapidly turned to horror as hostilities erupted between Avatar and thenewly−revealed Europa Defense Force.

Although Montaldo sympathized with the Preservationist view, hecould not condone the EDF's violent approach. As a result, he attempted to keepCRABE out of the conflict. The only official communication between the twogroups came not long after the arrival of the EDF, when Montaldo riskedcontacting them to declare CRABE's neutrality and non−involvement in the War.The EDF accepted this, stating that their argument was with Avatar, not withthe E.U. base. So far, the EDF has not approached CRABE facilities, and CRABEhas stayed out of their way. However, these reassurances have not been enoughfor some sponsors of the scientific facility, and nearly 50 researchers havebeen relocated from CRABE since the War was declared. In addition, there are asignificant number of more enthusiastic supporters of the EDF within CRABE.While they cannot do any more than redirect supplies to the EDF and providesome limited intelligence, their support has made a difference.

The Escape of Copernicus Jones

Lonely System reporter Copernicus Jones arrived atManannÆn Station in late 2099 with the promise of an exclusive interviewwith the previously unknown leader of the EDF. After the interview wascomplete, Rademacher had second thoughts and decided that the information Jonesnow knew was too dangerous to release, and held the reporter as a hostage,albeit a well−treated one.

The first the outside world knew of this was when Jones' recoverycraft was shot at by EDF defenses when it attempted to return toManannÆn at the pre−arranged time to pick up the journalist. The craftsurvived the encounter, headed for neutral ground at CRABE for repairs, andwaited.

Amy Wilson was a young ecoactivist who had arrived atManannÆn a few weeks earlier. However, her enthusiasm for the cause hadfaded since her arrival at ManannÆn Station, particularly after she sawthe glee with which the staff showed off their kills to Copernicus Jones. Shedecided that she wanted to get out of the base and escape from the EDF, and sawin Jones a chance to do so. After a couple of weeks of his incarceration, shemanaged to talk to the journalist in his cell and persuaded him that she couldget him out of the base so long as she came with him. He agreed, andthey secretly planned their escape.

The chance came while most of the EDF personnel were listening toone of Rademacher's "pep talks." Wilson managed to steal the key toJones' cell and set him free, and together they overpowered the guard. The cellwas located in the underwater portion of the base, so they made their way tothe submarine dock, hoping to get there before anyone noticed Jones wasmissing. After a few narrow escapes, they made it to the dock, stole the EDF'sonly manned minisub an aging *Asterius* and struck out toward CRABE. By the time the EDF members foundout, there wasn't much they could do about it. Despite nearly getting lost,almost encountering some EDF cryobot patrols on the way, and nearly running outof life−support, they managed to get to CRABE. Although there were asignificant number of EDF sympathizers at CRABE, there was nothing they coulddo to stop Wilson and Jones from leaving Europa in the recovery vehicle withoutblowing their cover. After their escape, Wilson placed herself in the custodyof E.U. security forces on Earth, spilling the beans on what she knew of ManannÆnStation and the EDF, and Jones published his story, blowing the lid off"The War Under the Ice."

The escape of Copernicus Jones has considerably changed thepolitical situation on Europa. The only reason the EDF did not take any kind ofpunitive action against CRABE is that they cannot afford to make yet anotherenemy. Rademacher himself is now a lot more paranoid justifiably sogiven that one of his crew has escaped with a lot of information about the EDFand its activities on Europa and the EDF is growing more and moredesperate in its actions. Tensions at CRABE are also high, as they are not surewhether some kind of retaliatory action is going to be aimed at them, if theEDF blames them for allowing the two "fugitives" to escape from theirjurisdiction.

The Current Situation

Currently, the situation is very tense on Europa. The dramaticescape of Copernicus Jones from ManannÆn Station and the revelations ofhis "War In Europa" TEN report, the defection of Amy Wilson, and theRoyal Navy's interception of a shipment of combat bioroids destined for the EDFhave put a lot of pressure on the terrorists, and their actions are becomingmore desperate and violent. The European Union has already sent an SDV toEuropa, ostensibly to negotiate with the EDF and Avatar and to attempt to bringthe conflict to a peaceful end. However, rumors have recently surfaced thatChina has dispatched a fully−loaded warcraft to Europa in a bid to apprehend or kill Torsten Rademacher and several other members of the EDFin retaliation for their involvement in the attempt to destroy the MartianSpace Elevator in 2094. If this is true, a bloody end to the War Under the Icecould be imminent depending on whether the E.U. or Chinese contingentarrives at Europa first. There is a feeling that the EDF is under siege and itcould try to pull off one last desperate, major attack. Meanwhile, CRABE has anew Facilities Chief in the shape of French exobiologist Dr Manu Marron. DrMarron is somewhat less volatile than Giovanni Montaldo, whose eventful threeyear tour of duty finished in 2099.

Marron was endeavoring to keep CRABE outside the War Under theIce, but this was jeopardized by the sudden arrival of Jones and Wilson at thebase Marron could certainly not deny them entry. Those events alsoincreased his suspicion that there are some active supporters of the EDF inCRABE, and it is possible that he will take some action against thesympathizers soon.

Communications and Operations on Europa

Sonar in the Oceanus Noctis works about as well as in the Earth'soceans, although terrestrial sonar equipment must be recalibrated on Europa toaccount for the different sound speeds. The presence of a denser water layernear the Europan sea floor significantly affects sonar properties however.Sound from sources in the Mesocean can be reflected at the Hydropause, causingconfusing signals and false echoes.

Submersibles that do not travel far from their base of operationson the sea floor use a combination of sonar landmark tracking, sonar navigationbeacons, and inertial tracking to fix their location.

The keystone of global navigation in the Oceanus Noctis is theSonar Navigation System a network of sonar buoys suspended on cablesabove the sea floor and below the base of the ice shell. To be useful on thesea floor, SNS buoys must be located below the Hydropause. If they are withinthe Mesocean their signals will be reflected at the Hydropause, making themuseless in the Tropocean and confusing in the Mesocean. Therefore, they areusually placed either directly on the sea floor or on short tethers (up to amile long) anchored there.

SNS buoys emit a low frequency sonar ping every second, and canbe detected from 12 miles. Buoys are arranged in grid networks on the sea floornear established facilities, so that vessels are always within range of atleast three of them. Exploratory routes away from the bases are temporarilydelineated by buoys, which may eventually become permanently emplaced.Navigation in the Oceanus Noctis does not use latitudes and longitudes vehicles navigate by reference to specific SNS beacons, each of which transmitsa unique, identifiable ping structure.

A similar arrangement exists on the base of the ice shell, wherethe SNS buoys are suspended a mile or so below the ice. The areas around themain facilities are covered by the SNS Ice buoys, which transmit on a differentfrequency to the sea−floor buoys to identify them more easily.

While the system is well established around the bases, it isstill easy to get lost in the Europan ocean. If the sonar signal is lost it maybe difficult to reaquire, particularly if travelling through the Mesocean. Iflarge distances must be travelled, it is usually more practical to go to theice surface and travel using an OTV.

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Sonar on Europa

The speed of sound in the Oceanus Noctis is greater than inEarth's oceans. It increases constantly with depth in the Mesocean sincetemperature increases gradually and salinity remains uniform. Sound speedranges from 3,340 mph at the top to 3,850 mph at the base of the Mesocean. Thesharp density contrast of the Hydropause produces a sudden change in soundspeed over the few dozen feet of the boundary. At the top of the Tropocean, thespeed of sound jumps by 90 mph to 3,940 mph, and then increases further withdepth, up to a maximum of 4,010 mph at the sea−floor datum. (cf. the speed ofsound in Earth's oceans, which ranges from 3,130 to 3,510 mph.)

The speed of sound increases rapidly with the rise intemperature around hydrothermal vents and volcanic hotspots, reaching values ofup to 4,500 mph.

The temperature variation with pressure is the opposite tothat which generates deep sound layers (p. 00) on Earth these aretherefore not found on Europa.

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Life on Europa

Europa's native life consists largely of thermophilic microbes,concentrated around vents and hotspots in the basal seas and the Tropocean. TheEuropan biosphere is less abundant and less diverse than Earth's, because theenergy and mass of material available to sustain an ecosystem is much smaller.Some Europan life forms are relatively advanced simple invertebratessuch as the nematode−like vent worms (up to an inch long) but these arerare. The hydrothermal ecosystems are generally similar to those found onEarth, though they largely consist of microbial mats, rather than more complexcreatures.

The Mesocean is largely lifeless; there is insufficient heat andnutrient flux to support life. Some psychrophilic (cold−loving) microbes haveevolved there however, from thermophiles that were entrained in hyperplumes.The psychrophiles lie dormant until they encounter another hyperplume (orsettling material derived from one), then wake up, feed and rapidly reproduce,and then enter a state of stasis again until they float into another warmplume. Because of the state of total shutdown while dormant, some individualpsychrophiles may be many thousands of years old.

Vent Life

The dominant indigenous life forms on Europa are bacteria. Of the30 known active vent fields, all have some bacterial activity around them.There are two types: methanogens, which anaerobically metabolize carbon dioxideand hydrogen emitted from the vents, producing methane as a byproduct; andrarer photosynthetic bacteria, which metabolize carbon dioxide byphotosynthesizing infrared radiation emitted by the hydrothermal vents andproduce oxygen as a waste gas. Methanogens live around all the life−bearingvents discovered so far. Thiotrophs and methanotrophs that are commonly foundaround vents on Earth (see *Unusual Ocean Environments*, p. 00) are not present on Europa, since theirmetabolisms require free oxygen that is not available in sufficient quantities.

Individual vents have limited lifespans, from years to decades.When they shut down, everything around them dies from lack of nutrients if thecessation of activity is sudden enough. Bacteria spread between vents by beingentrained in erupting plumes. The microbes usually enter a dormant spore stateuntil they drift into a suitable zone of habitability around another vent. Mostspores do not make it that far, however, and eventually die in the cold,uninhabitable water between vents.

The Europa Project

The Europan submarine environment is not naturally conducive toterrestrial life. The indigenous photosynthetic bacteria can only survive in alimited range around the vents (as far as the infrared light they require tosurvive can penetrate), and do not produce enough oxygen to significantlyoxygenate the water. Because of this, unmodified gills are useless in Europanwater. This presents significant difficulties for bioroids and terrestrial lifeforms, which cannot survive without oxygen.

Avatar realized that the Europan environment was potentiallyhabitable, and began the Europa Project (see p. DB00). The aim of the Projectis to increase the satellite's biomass by enhancing the indigenous life formsand adding adapted terrestrial forms the ultimate goal is to createparahumans that can survive there. So far, Avatar has modified the gill structuresof its Europan bioroids so that they are full of highly efficient symbioticmethanotrophic and thiotrophic bacteria enhanced versions of the onesfound in the gills of worms and bivalves around vents on Earth. In addition,Avatar has set up automated oxygen−cracking stations (see p. 00) in theKargel−Zolotov Channel, which produce large amounts of oxygen to enrich thelocal environment of its basal sea. Many of these have been placed around thevents in the Channel, along with imported thiotrophs and methanotrophs. Theoxygen crackers produce just enough oxygen to sustain the imported life inclose proximity to them, but so far have not significantly increased the amountof dissolved oxygen in the Tropocean as a whole. Even with modified gills, Europanbioroids can currently survive only in areas around the oxygen crackers. Thesestations are key targets for EDF raids.

Avatar has been performing extensive terraforming around MountThera and in the K−Z Channel installing oxygen crackers, introducingnew bacteria, and setting aside large areas of the sea floor as farms ofmodified mussels for the Europans to harvest. The imported life has survivedreasonably well in the Europan environment, despite the high salinities and lowconcentrations of oxygen. The War Under the Ice and protests from CRABE have significantly slowed progress in recent years.

While the Europan biosphere appears to be largely intact, the EDFclaims that indigenous life near the Avatar farms has been adversely affectedby increased oxygen toxicity in the water and competition from imported Avatarbacteria. Avatar strenuously denies this, but this is enough justification forthe EDF to step up their offensive.

LOCATIONS

(((INSERT MAP: EUROPA)))

(((START BOX)))

Distances onEuropa

	Pwyll	ManannÆn	Thera	Thrace	Conamara	Callanish	Tyre	Murias	K–Z	Greenberg
Pwyll	0	698	1,211	1,323	606	998	2,233	2,938	958	515
ManannÆn	698	0	1,215	1,313	578	1,597	1,558	2,490	700	682
TheraMacula	1,211	1,215	0	114	1,679	1,902	1,448	1,889	531	714
Thrace Macula	1,323	1,313	114	0	1,791	1,964	1,384	1,776	618	828
ConamaraChaos	606	578	1,679	1,791	0	1,102	1,944	2,499	1,231	984
Callanish	998	1,597	1,902	1,964	1,102	0	2,779	1,951	1,921	1,436
Tyre	2,233	1,558	1,448	1,384	1,944	2,779	0	957	1,384	1,866
Murias Chaos	2,938	2,490	1,889	1,776	2,499	1,951	957	0	2,198	2,603
K–Z Channel(mid)	958	700	531	618	1,231	1,921	1,384	2,198	0	486
GreenbergBasin (mid)	515	682	714	828	984	1,436	1,866	2,603	486	0

Distances are in miles on the surface. To find distancesbetween these locations at the base of the ice shell, multiply by 0.986. Tofind distances on the sea floor, multiply by 0.934.

(((END BOX)))

ManannÆn and ManannÆn Station (2° N,240° W)

ManannÆn Station was built in 2061 but abandoned in 2072due to CRABE budget cuts in the early 2070s. It was reoccupied by the EDF whenthey arrived in 2098. Much to the consternation of the EDF, the station liesover a cold spot; there are no active vents or hydrothermal communities within100 miles. Below ManannÆn lies a lifeless desert, and a gently slopingabyssal plain. The surface component of ManannÆn Station is described onp. DB00.

The EDF sea dock is a hemispherical structure anchored to thebase of the ice shell. Since the base was originally designed for a smallercrew, the dock facility is not very large. It originally only had the capacityto launch one small manned submersible, and the EDF only has cryobots, ROVminisubs, and cybershells. The dock is extremely cluttered with supplies,boxes, parts, and robotic vehicles.

The EDF maintains a small network of SNS buoys on the barren seafloor below ManannÆn Station. The location of the

Avatar base was wellknown, and the EDF's first activity on Europa (while still under the cover ofXERG) was the creation of an SNS corridor extending toward the western end ofthe K–Z Channel.

Avatar was suspicious of the new group, and noticed its covertattempts to approach Genesis Station. More investigation revealed the trueidentity of XERG, and Avatar immediately dispatched its MAD forces to deal withthem, hoping to destroy or cripple ManannÆn Station from space. Whilethe surface installation was badly damaged, the submarine portion of the basewas unharmed and the attack did little to dissuade the EDF from continuing itsactivities. Furthermore, the crash of the USV Chesapeake Bay during the battleprovided an unexpected bonus of arms and supplies to the EDF.

The ecoterrorists retaliated by launching cryobot carriers armedwith Lamprey devourer nanobot hives (p. 00), targeting Avatar's facilities inthe K–Z Channel. The attack succeeded, resulting in the complete destruction oftwo bases and the deaths of 80 Europans. The EDF announced its presence to TENfollowing the attack.

Since then, Avatar has tightened up security along the K–Z Channel,as the EDF continues to send cryobots on automated patrols in and around theChannel. It programs them to target and destroy anything not of indigenousEuropan origin with their Lampreys modified mussels, bacteria,Europans, oxygen crackers, bases . . . Each unit patrols for a couple of weeksand then returns to base, where the records of its kills are downloaded.Recently, some heavily armed cryobots have been sent on patrols near MountThera most have been destroyed by Avatar defenses that have stepped upconsiderably in recent months, but some have inflicted significant damage tothe facilities there.

The EDF currently holds a siege mentality. Its leadership especially Torsten Rademacher is growing more and more paranoid,particularly since Copernicus Jones escaped from captivity at ManannÆn.The less fanatical members are starting to worry that the leadership isbecoming dangerously unstable, and see the E.U. negotiating mission as theirlast chance to get out of the situation alive. The more experienced membersthink that Chinese forces are coming with the E.U. mission to destroy the baseand kill them all, and so feel they have nothing to lose by performing moredamaging attacks. Tensions at the base are very high, and could reach breakingpoint soon.

Pwyll and CRABE (26° S, 271° W)

CRABE is the largest and oldest settlement on Europa, and has themost extensive research interests on the satellite. It was built in 2057 in thePwyll impact crater, and expanded in 2092 as a result of increased funding.Like the other facilities on Europa, most of CRABE is under the ice. Theelevator on the surface leads into a two–tiered complex of rooms built into theice shell a 1,000 feet below. The upper rooms are used for surface vehicle andequipment storage, while the lower rooms comprise several laboratories, amedical bay, and accommodation for up to 120 people. An elevator 13 miles longconnects this to the main facility at the base of the ice shell.

Another level of rooms is built into the ice at the base of theshell a reception center is located at the lower end of the elevatorshaft, with self–contained food–production and recycling facilities. CRABEpersonnel refer to the central shaft as "the dumbwaiter," since it iswhere food arrives at the upper section from below. The expanded accommodationand food–production and recycling sections were built with the extra investmentCRABE received in the early 2090s, allowing the base to sustain more people inmore comfortable, less cramped surroundings.

The Consolmagno–Lewis base is a vertical dumbbell–shapedstructure 80 feet across and three stories high, attached to the base of theice shell. Half the uppermost level contains the old habitation section, nowused for storage and to house scientists who need to stay at the underwaterbase to monitor their equipment. The other half contains the Science/Laboratorywing and the Technical wing, which is occupied by large computers that housethe station's infomorphs (including Sinetar, see p. DB00) and data analysisfacilities.

The core of the dumbbell is 40 feet across, and houses thestation's fusion reactor and engineering facilities. Conduits lead up and downinto the wider dumbbells to provide power, heat, and light to the rest of thebase.

Half of the lower dumbbell is taken up by the hangars, whichhouse the station's three *Asterius*mini–subs and various small aquatic cybershells and ROVs. The other half isdivided between the CRABE Mission Control center and a new Vosper–Babbagefacility installed in 2093, which contains extensive minifacturing workshopsthat produce and repair CRABE vehicles and robotics and maintain the base. In2097, this facility completed the construction of the prototype *Zeus*–class Mobile Sea–Floor Rig, along with threestate–of–the–art *Abyss*–classmanned submersibles to accompany it. The *Zeus* was constructed in modules inside the station andassembled outside using cradles and supports, taking two years to complete. The*Zeus* and its crew of 10 arecurrently performing fieldwork on the sea floor along the deep Thomson Riftsouth of the Conamara Rise.

Chyba Station is a small CRABE facility located on the sea floorbeneath the Consolmagno–Lewis base, near the southern end of the Thomson RiftSystem that extends northward toward the Conamara Rise. It provides more roomyaccommodation and laboratory facilities for the *Zeus* crew, who will return here after their currentfieldwork is completed, and serves as the shuttle terminus between the seafloor and the ice shell. It is also the nexus for the CRABE sea–floor SNSnetwork.

Personnel. CRABE is ascience base, studying the Europan biosphere and the surface geology. Most ofthe station's crew of 70 humans and 40 infomorphs are biologists from Europeanuniversities and the International Exobiology Foundation. The rest of thescientific personnel is made up of oceanographers, vulcanologists, andplanetary geologists. There is also a small contingent of engineers fromVosper–Babbage, who moved in after the company provided sponsorship in returnfor a testbed for its heavy–duty submersible designs.

Tyre and Schenk Station (31.7° N, 147° W)

Tyre is a 93–mile–wide impact scar in the northern hemisphere,similar to but larger than Callanish (p. 00). A small CRABE research basecalled Schenk Station is located here. Schenk Station holds the distinction ofbeing the most remote permanently staffed base on Europa the nearestbase is a small outpost located at Murias Chaos (p. 00) on the leadinghemisphere, over 900 miles away. It was established as one of a number of smallCRABE outposts in the early 2090s, to study the surface geology of the area. Inthe past couple of years the base has expanded somewhat its isolatedlocation puts it beyond the scope of the War Under the Ice, so the station nowserves as a refuge for a staff of nearly 20 scientists who want to escape fromthe tensions of the southern hemisphere.

In late 2098, CRABE decided to drill through the ice andestablish a small outpost at the base of the ice shell below Tyre. The basicdesign of the station is similar to CRABE a ring of galleries builtnear the top and the base of the ice shell, surrounding a reinforced centralelevator shaft. Currently, the submarine part of Schenk Station is little morethan a submarine dock extending from the ice shell.

Preliminary exploration of the sea floor has revealed that Tyreis located above a large plateau a mile above the sea–floor datum. A surprisediscovery was that the plateau contains some of the oldest rocks on Europa,dated at nearly two billion years old. The region appears to be a preservedchunk of ancient crust that has somehow escaped tectonic recycling. Althoughthere are no hydrothermal vents in the area, there is still enough geologicalwork to occupy the personnel at Schenk Station.

Conamara Chaos and Spaun Station (9.5° N, 273.3° W)

A small abandoned CRABE surface facility called Spaun Station islocated among the ice rafts of Conamara Chaos. It was constructed in 2060 inorder to study the geology of the Chaos, but was evacuated as a safetyprecaution in 2098 after the EDF launched its attacks on Avatar, due to itsrelative proximity to ManannÆn, less than 600 miles to the east.Sympathizers at CRABE informed the EDF of the location of the station, and in2099 they gleefully plundered the base of the few supplies that were leftthere; little remains of the station now apart from an empty shell. The CRABEleadership is aware of the looting and is not happy about the situation. Thiswas one of the first signs that the EDF had active sympathizers in CRABE it is unlikely that the EDF could have located the station or knownthat it was abandoned without inside help from CRABE.

The Conamara Rise is the huge volcanic bulge on the sea floorthat is the progenitor for the extensive chaos above. While its highest pointspenetrate the Hydropause, most of the Rise lies just below it, nearly 4 milesabove the sea−floor datum. CRABE's prototype Zeus Mobile Sea−floor Explorer rigis currently exploring the Thomson Rift zone that extends up to a mile below thesea−floor datum just south of the Rise. Although this is quite close toManannÆn Station, CRABE feels that it is very unlikely that the EDFshould chance upon it, because it is operating on its own, beyond any SNSnetworks, slowly following the deep rift northward from Chyba Station towardthe Rise.

Greenberg Basin (Midpoint: 38° S, 238° W)

One of the most extensively studied areas on the Europan seafloor is the Greenberg Basin, a 600−mile−wide basin lying 170 miles to the eastof CRABE. The base itself is located not far beyond the northwest corner of thebasin, which contains two sizeable vent fields and many extinct hotspots andvolcanic shield fields. This has given CRABE personnel plenty to study.

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The Echo

The vast majority of evidence suggests that there is noindigenous life on Europa larger than the tiny vent worms, yet for the past 25years there have been scattered reports of an object shadowing vehicles at theedge of sonar range. The object referred to simply as "theEcho" has been reported by CRABE researchers and Avatar convoystravelling through the Greenberg Basin. A few aquabots and cryobots from CRABE(and later Avatar too) have disappeared since the late 2070s in mysteriouscircumstances in the Basin; some people attribute these losses to the Echo.Since the War Under the Ice began, it has been difficult to separate suchlosses from those caused by armed EDF cryobots, but it is possible that the EDFhas suffered unusual losses too.

Very little is known about the Echo; it is elusive anddifficult to track, indicating some form of intelligence may be behind it. Allthat is known for certain is that it is about eight feet long and roughlycylindrical in shape. Current theories range from a hitherto unknown indigenouslife form (deemed unlikely by CRABE and Avatar, but seized on by the EDF), toan errant aquabot or cryobot.

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Thera Macula and Genesis Station (47.7° S, 180.9° W)

Genesis Station   the Avatar Klusterkorp facility locatedat Thera Macula   is located above an ancient volcanic hotspot, believedto have formed the chaos terrain within which the station is locatedapproximately a million years ago. The volcano itself   Mount Thera   is still active and there is ongoing hydrothermal activity around theedifice. To the east lies the Thrace Rise, a large volcanic bulge that was theprogenitor of the more extensive Thrace Macula chaos. The Thrace Rise isbelieved to be extinct, as the most recent flows around it are tens ofthousands of years old and there are no active vents around it.

Prior to the War Under the Ice, the surface component of theAvatar base was little more than a few access shafts and a maintenance shack.Recently however, the EDF has launched several attacks that have necessitated aradical improvement of base defenses. Hidden laser turrets cover the approachesto the base, and new missile (AKV) turrets are being installed by the MADforces who have recently arrived to reinforce the base (see p. DB00).

The MAD garrison is housed in insulated tunnels and rooms meltedinto ice near the surface. Twenty combat bioroids are stationed at the surfacegarrison, while two MAD *Nestor Makhno*SPVs patrol the space around the base.

Genesis Station. GenesisStation itself is a marvel of bioengineering. It is a huge organic structureattached to the base of the ice shell underneath Thera Macula. It looks like across between an anemone and a plant, with roots extending deep into the iceshell above it to anchor the facility. It gets its energy from the fusion reactorbuilt into its core. Submarine docks, residential blocks, and sciencefacilities hang off the branches of the structure like decorations from aChristmas tree. Genesis Station is home to 50 human Avatar scientists and 30sapient infomorphs. Ten MAD soldiers specializing in underwater piloting havealso been moved (along with some armed subfighters) to Genesis Station to serveas rapid response teams in case of a direct assault on the base. A toruslocated around the base of the structure serves as the surface elevator accesspoint. This torus contains guarded reception facilities and a docking bay forthe submarine bus that shuttles visitors between the inhabited modules.

Avatar operates three sea−floor facilities at vents around MountThera, and four along the Kargel−Zolotov Channel. Two more facilities on thewestern end of the rift were destroyed in the attack by the EDF in 2098. Allthese facilities are populated by Europan bioroids   40 are housed ateach of the Theran vents, and 20 are located at each of the K−Z Rift bases.

Base Commander Judith Sigurdsson has been in charge of thefacility since it was established in 2079. She has weathered many of thepolitical changes that have occurred on Europa, and is a hardened and stubbornwoman. She has maintained a sense of dogged persistence among the crew ofGenesis Station, and refuses to allow the EDF to wear her down or get in theway of Avatar's work. She has lost many friends at CRABE because of the EuropaProject but is universally admired by the staff of Genesis Station. She isdetermined to see the Europa Project succeed, and is almost ready to advance itthe next stage   *parahuman*Europans.

However, recent events have put Avatar's projects on hold.Sigurdsson's contacts in the Gypsy Angels Collective (p. DB00) have heardrumors that the Chinese have mobilized a *Xingzhai*–class SDV (p. SSS35) to deal with the EDF once and for all, and shehas taken the unusual step of spreading these rumours to CRABE, and via them tothe EDF. She is hoping that the E.U. and Chinese forces *en route* to Europa will remove the problem of the EDF onceand for all, but she is playing a dangerous game the EDF is now moredesperate than ever as a result of the rumors and the events of the past year,and more likely to mount a desperate last–ditch attack on Genesis Station.

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Europan Parahumans and Bioroids

The current Europan bioroids are but the second phase ofAvatar's plans for the pantropic colonization of Europa; the first wasmicrobial and animal colonization. Phase III is scheduled to commence withinthe next year colonization using Europan *parahumans*. The existence of Europan parahumans is currentlyone of Avatar's most closely guarded secrets, and word has not passed beyondthe walls of Genesis Station. Although EDF leaders suspect that this wouldhappen eventually, if they were to discover that the project was advancedenough to start almost immediately it could push the current tense situationover the edge.

Europans can theoretically survive up to the top of theTropocean (1,360 atm.) and down to 1,600 atm. There are not enough chemicals inthe Mesocean for their symbiotic bacteria to survive, and there is certainlynot enough oxygen though this is actually a problem at any significantdistance from an oxygen cracker and a hydrothermal vent.

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Kargel–Zolotov Channel (Midpoint: 25° S, 208° W)

The K–Z Channel is a 370–mile–long rift that extends westwardfrom a point 430 miles northwest of Mount Thera. The rift is seven miles wideand three miles deep relative to the surrounding plateau on average; itsdeepest point lies 1.5 miles below the sea–floor datum. The rift trapshydrothermal fluids from vents and eruptive fissures that run along its floor,forming a basal sea with a salinity of nearly 30%. The Kargel–Zolotov Channelcontains some uniquely adapted hypersaline vent biota and is extensivelystudied by Avatar bioengineers. Four small Europa Project test farms arelocated on the sea floor near the eastern end of the rift. Two more farms usedto exist further west along the rift; their destruction by the EDF in theattack that signalled the start of the War Under the Ice in mid–2098. Much ofthe War has taken place in and around the Kargel–Zolotov Channel since then, asthe EDF tries to eradicate the altered communities in the rift.

Thrace Macula and Thrace Rise (46.6° S, 171.2° W)

Thrace Macula is a large, relatively young chaos located justover 100 miles east of Thera. Large pockets of liquid brine were entrained inthe rising ice plume that formed it, creating dark flow–like features aroundthe chaos.

The sea–floor progenitor for the chaos is a large volcanicstructure known as the Thrace Rise, most of which rises above the Hydropause.This volcanic bulge consists of a large central volcano (Mount Thrace) and ashallow rift that extends eastward toward Mount Thera. The rise is currentlygeothermally inactive. Seismic measurements indicate that Mounts Thrace andThera are part of a volcanic hotspot chain similar to Hawaii on Earth, and thatthe hotspot is moving westward relative to the crust. The current center ofactivity lies at Mount Thera.

Avatar sent research vessels to the Thrace Rise to study andcollect the fossilized Europan microfauna located among the metalliferoussediments there.

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Surface Outposts

Not all outposts on Europa lie on the sea floor or at thebase of the ice shell some just study the surface geology or observefeatures in space there.

Callanish and Taylor Station (16.0° S, 333.4° W)

An ESA Jupiter Monitoring observatory Taylor Station is located at Callanish. It was chosen for its location near thesub−jovian point, which affords a good view of Jupiter and the surroundingspace (for field and particle measurements). Callanish is an impact scar similarin appearance to Tyre, 62 miles in diameter, consisting of disrupted terrainand multiple concentric rings and scarps. There are no underwater facilitieshere.

Taylor Station was established in 2065 and is crewed by threededicated LAIs named Neberu, Mushtarie, and Brhaspati (the Babylonian, Arabic,and Sanskrit names for Jupiter). They refine the raw data they gather andtransmit the processed data to CRABE for analysis via a small ESA relaysatellite in a 24−hour equatorial orbit (5,290 miles high) around Europa. Ifnecessary, the station can transmit its data directly to Earth or Mars.

Murias Chaos and Murias Station (22.4° N, 83.9° W)

A small CRABE outpost studies the surface geology of MuriasChaos, an unusual mitten−shaped chaos that bulges above the surroundingterrain. Research is coordinated from Schenk Station at Tyre (see p. 00), andoccupancy is temporary. Murias Station is the most remote location on Europathat is occupied by people, lying nearly 3,000 miles from Pwyll.

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Ganymede

Following the revelation of The War Under the Ice, the EuropeanUnion decided to commence work on a new scientific research base on Ganymede,under the direction of former CRABE Facilities Chief Giovanni Montaldo. Thebase is being set up in the Gilgamesh impact basin, a 91−mile−diameter craterlocated at 62° S, 124° W. Gilgamesh is similar to Valhalla on Callistobut much smaller in scale, and was formed when a large asteroid or cometsmashed into Ganymede's thick ice shell.

The goal of this base is to penetrate the ice shell andinvestigate any life forms in the ocean below. Preliminary heat flowmeasurements made on the surface in 2057 suggested that the bottom ofGanymede's 500−mile−deep ocean was volcanically active, to a much greaterextent than Europa. This raised the possibility of yet another extraterrestrialecosystem, assuming it could survive the phenomenal pressures at the sea floor.

Furthermore, Ganymede's ecosystem would not be contaminated byAvatar's experiments, which would allow scientists to continue their studies ofvirgin alien biospheres. The environment is also both physically andpolitically less hostile, and while the engineering problems remain significant(not least, building vehicles that can survive pressures of over 20,000 atm. atthe sea floor), companies including GenTech Pacifica and Vosper−Babbage havealready placed bids on engineering contracts to meet the challenge.

Work started on Gilgamesh using cryobots imported from CRABEStation on Europa in mid−December 2099, and ice drilling is underway. GilgameshBase should be fully operational by 2103. So far neither Avatar nor the EDFhave shown any interest in Ganymede, and scientists involved in the project atCRABE hope they never will.

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Other Worlds, Other Oceans

Two other bodies in the solar system are known to have liquidlayers:

Callisto. Seismicsurveys and geophysical data have revealed an ocean 45 miles deep sandwichedbetween Callisto's 80−mile−thick water ice shell and a 30−mile layer of dense,high−pressure ice at its base. Below this is a mixture of ice and rock, withthe rock proportion increasing down to the surface of a completely rocky coreof radius 420 miles.

Enceladus. A water iceshell 60 miles thick overlies a 20−mile layer of liquid water and a 75−mileradius rock core. The rock surface appears to be volcanically inactive.

Neither moon's ocean has been explored, though attempts havebeen made to send cryobots through the ice shells. No life is believed to existin either satellite, and both oceans are in the process of freezing out. Seepp. DB00 and DB00 for more information on these moons.

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Titan

"Titan's a strange place to be. You look out of thewindow in Port Minos and you can see the cliffs of the valley, the tide comingin on the sea, the surface of the ponds shimmering in the gentle wind, and theorange sky and maybe the odd cloud really high up. It all looks kinda normal .. . until you remember it's cryogenic out there, and that if you steppedoutside without protection you'd freeze in an instant. I knew a guy that wentnuts here he forgot about the cold and decided that all he wanted to dowas run around naked and frolic in the lakes. He didn't last more than a fewseconds of course. It happens from time to time, though the authorities try tocover it up. I guess this place can remind people too much of home . . ."

Titan is one of the most alien and challenging environments inwhich transhumanity has established an outpost. The only satellite with anappreciable atmosphere, Titan is an almost featureless orange globe, althoughin 2100 its southern hemisphere is a very slightly darker shade than thenorthern one. The atmosphere is so deep that the satellite was once thought tobe larger than Ganymede, the largest moon in the solar system. In fact, Titan'svisible atmosphere is nearly 200 miles deep, and the satellite's actualdiameter is 3,220 miles. Beneath the atmosphere is a shell of water ice 90miles thick. Titan has a very deep subsurface layer of water and ammonia stretching450 miles beneath the ice shell. Below this is another 90 miles of dense,high−pressure ice, overlying a 980−mile radius rocky core. Titan does not havea metallic core or an intrinsic magnetic field   neither does it have aninduced field, since its orbit is just outside Saturn's magnetosphere. Theaverage ground temperature is −289° F and varies little across the surface;the minimum recorded temperature on Titan's surface is −296° F at the poles.

Atmosphere. Titan'satmosphere is composed of 93% nitrogen, with 5% methane, 1.8% argon, 0.2%hydrogen, and trace amounts of ethane, carbon monoxide, and hydrocarbon gases.There is no free oxygen, and only trace amounts of water vapor. The atmosphereis very deep; the top of the mesophere   where incoming meteors burn up   is 375 miles above Titan's surface. The top of the visible atmosphereis marked by a detached layer of hydrocarbon haze at 190 miles altitude. Themain haze layer fills the stratosphere down to a height of 40 miles; below thisthe atmosphere is mostly clear. The haze absorbs the shorter wavelengths oflight, allowing only the red end of the spectrum through, resulting in a dimorange light, as bright as a full moon on Earth (−5 Vision penalty),illuminating the surface. Methane exists throughout the atmosphere, with amaximum concentration at a height of 25 miles, where the temperature is lowest(−333° F). Methane clouds form at heights around 15 miles.

Waether. The climate onTitan is mostly dry. What little rain falls is very different to that on Earth.There are no low clouds or fogs on Titan; the only altitudes at which methanemoisture can condense are between 12 and 16 miles. Rain clouds form quickly,dump methane rain in a short downpour, and then disappear rapidly. Raindropsform around a nucleus of ethane droplets or haze particles, growing up to halfan inch in diameter. The methane usually evaporates in the lower troposphere onthe four−hour journey to the ground, leaving only the cores around which thedrops nucleated, called "rain ghosts." Around the Mayan Plateau,where the major settlements are, small showers of rain ghosts occur every fewweeks, although sometimes even the ghosts don't reach the ground. Snow and haildo not occur on Titan; temperatures are never low enough at raincloud−formingaltitudes to freeze methane.

Once every 15 Earth years, around the spring and autumnequinoxes, a particularly large rain storm covers about 10% of the satellite.These storms dump many feet of rain in a very short time, raising the humidityof the lower atmosphere so much that the methane actually makes it to thesurface. Such downpours create short−lived methane floods that can erode riverchannels into the icy ground as they boil away into the atmosphere. The ethanethat remains behind flows into the sea or collects in pools. The next storm isdue sometime in 2100.

Winds on Titan are not very powerful at low altitudes, and areusually no stronger than moderate breezes at the surface. Higher up the windblows predominantly westward, averaging up to 230 mph near the top of thestratosphere and gusting up to 450 mph.

The year 2100 is northern hemisphere spring on Titan; thesummer solstice is due in 2103. There is currently more haze in the upperatmosphere in the southern hemisphere than the north, which causes thathemisphere to look darker when viewed from space.

*Geography and Terrain.*Titan's surface is made of bright water ice tainted by small amounts ofammonia. Small pools of liquid ethane and hydrocarbon sludge can be found allover the surface. Most of Titan's topography is subdued; an area of highlandsand hills known collectively as the Mayan Plateau peaks only a mile above thesurrounding terrain. 18% of

Titan's surface nearly six million squaremiles is covered by liquid ethane. 90% of that is the Minoan Sea, alarge, shallow sea in Titan's western hemisphere. Eight large ethane lakes arelocated in the other hemisphere six east of the Mayan Plateau, and twosoutheast of it.

There are about 2,000 craters on Titan, mostly 6 to 12 milesacross. Smaller craters are rare, since most of the impactors that would haveformed them burned up in the atmosphere. Larger craters are uncommon, rangingfrom 15 miles in diameter to the largest: a basin 90 miles in diameter east ofthe Minoan Sea. While more craters are located on the leading hemisphere, manyare also located beneath the Minoan Sea, and crater rims poke above the liquidethane near its shores. Most craters contain small pools of ethane orhydrocarbons in them some of the larger craters contain ponds in theircentral pits and a ring of liquid near their rims, giving the appearance of abullseye if seen from above.

There are ice volcanoes on Titan, which erupt mixtures of ammoniaand water that rises through cracks in the ice shell. This lava is a cold,partly frozen slush and is very viscous, forming wide domes similar to somevolcanic features on Venus. Volcanic activity on Titan is never violent, thoughmethane geysers do occur in rare circumstances.

The Minoan Sea

The Minoan Sea is a roughly diamond–shaped body of liquid ethaneextending up to 60° latitude on both sides of the equator, with two of itsapices located near the sub–saturnian and anti–saturnian points. It reaches amaximum depth of just over half a mile near its center. Because of the lowdensity of the liquid ethane and the low gravity, the pressure at the sea floorin the deepest part of the sea is just under eight atmospheres. The sea–floortopography is smoother than the surface topography, and is mostly covered in thicklayers of complex hydrocarbon sludge that has settled from the ocean above.Cryovolcanoes are located on the sea floor, erupting ammonia–rich water lavathat freezes to form pillow formations under the liquid ethane.

The eccentricity of Titan's orbit around Saturn means the tidalbulge raised on the satellite oscillates between 3° E and 3° W over anorbit, changing by four yards in height as it does so. This causes considerablecirculation and strong currents in the Minoan Sea within six degrees of the anti–saturnianpoint, and that area has been named the Charybdis Sea as a result. The NubiaChasma (also known as the Nubian Valley) on which Port Minos and Huygens Cityare located, is a linear fault zone 1,000 miles long, and the Minoan Sea fillsmuch of this valley. Tides flow up and down the Chasma over the course of aTitanian day and are focused by the topography high tide at Port Minosis 30 feet higher than low tide. As a result, the island of Labrys becomesabout a mile smaller at high tide than at low tide, and Port Minos is locatedon the higher parts of the island. Huygens City is further inland and liesbeyond the tidal range of the Minoan Sea. The cause of Titan's eccentricity isa mystery the tides raised in the Minoan Sea and in the internal watershell should have circularized the orbit long ago.

A crescent–shaped island called Scylla is located in the easternpart of the sea, surrounding a large flooded crater basin. A hydrocarbon miningfacility is located in this bay, extracting and processing the sludge that isconcentrated in the topographic low of the basin. Other small islands andcrater rims lie above the average sea level, particularly near the coastline.

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Living on the Moons

Gravity on the moons of Jupiter and Titan is lunar–like between 0.1G and 0.2G, a range between microgravity and "lowgravity." This *minigravity* rangepresents some problems to inhabitants. Normal walking is impractical, andrunning is impossible the most efficient way to move around on foot isby bounding. Unlike microgravity, there is a definite down direction, thoughobjects take five to seven times longer to fall than they would on Earth.

Bases are designed with planar floors stacked on top of eachother three–dimensional beehive structures are unsuited to theseconditions. Handholds and rails are often present on walls and ceilings to aidand control movement, but footholds are unnecessary.

Workers based on the Galilean satellites or Titan are usuallyprovided with DNA Repair and Microgravity Biochemistry permanent nanomods (p.TS165) by their employers as perks of the job. The latter is required becauseminigravity still has adverse effects on bone structure and biochemistry.Employment contracts are always at least six Earth months long and can beseveral Earth years in length after a year the employee is said to havepaid off the nanomods. Biomods are rarely used, and Tennin are unnecessary insuch environments.

Living on Titan

Buildings on Titan are pressurized to 1.5 atmospheres the same as the ambient pressure outside. This makes construction and venturingoutside simpler, although airlocks are still necessary to prevent contaminationof breathable air with the external methane atmosphere.

Like any alien environment, life on a base on Titan can bestressful. Sometimes workers crack under the pressure, becoming victim to whatis known as "The Titan Haze." One catalyst for the derangement is thevaguely Earth–like appearance of the external environment. Victims do all they canto get outside the base, wearing no protective clothing or oxygen supplies, andas a result they invariably die quickly in the cryogenic conditions. Thismethod of death is referred to as a "Hazing." However, if the body isrecovered soon enough, it is possible to produce a ghost of the person, andedit out their derangement this has been done a few times in caseswhere the person had important knowledge or experience. It is rumored that someunscrupulous corporations on Titan sometimes do this to ensure that workersstay on for the entire length of their contracts. Some conspiracy theoristseven believe that the ghosts are placed in cloned bioshells and their cryogenicdeaths are edited from their memories completely, so that they carry on theirworking life blissfully unaware of their suicides.

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Organizations

If man could find a way to work there in safety and relativecomfort, he would at once possess the key to more than ten million square milesof sea bed. He could tap the scientific secrets and mineral, animal, andvegetable wealth of those immense submerged plains.

Edwin Link, Johnson−Sea−Linkresearch submersible designer, 1963.

GenTech Pacifica Pty. Ltd.

GenTech Pacifica is the world's largest ocean technologycorporation, involved with every aspect of underwater and sea surface technology.Originally started as a small genetic engineering company by a group ofAustralian scientists in 2031, it has grown to become a transnational employingover 400,000 people, as well as a large number of infomorphs and upliftedanimals. Its major offices are in Sydney and Seoul, but it has a presence inevery Fifth Wave country, several less−developed nations, and most free cityaquatic arcologies and underwater settlements. It also has a few labs in theIslandia space colony and one small L4 station of its own.

GenTech is known for its clashes with environmental andPreservationist groups, particularly Blue Shadow. It aggressively manipulatesthe media and governments to maintain its public image and its legal freedoms.It has been accused of crimes ranging from anti−competitive behavior and fraudthrough slavery of sapients to global pollution and criminal ecologicalmanipulation, but no charges have ever been prosecuted successfully.

Organization

When GenTech Pacifica began to turn a substantial profit from itsearly work in developing genemod fish and mollusks suitable for aquaculture,the idealistic researchers ceded control of the company's finances to a groupof ambitious and foresighted executives. Under their direction, the companydiversified and prospered.

Eight of the original twelve board members are still alive, andmaintain an iron grip on the company. They have access to the bestlife−extension technology and none look likely to pass away soon. A ninthmember, Daren Phuong, is publicly believed to have died in a transport accidentin 2094. His comrades secretly arranged for a ghost upload, and Daren continuedto work for GenTech, monitoring the Web for useful information. In 2097, heleft a suicide note and apparently deleted himself.

Subordinate to the board of directors is a web of administratorsselected for competence and loyalty. The most senior run GenTech's majoroperational divisions and projects. No person has unilateral power over such alarge portion of the company, however, with divisional leadership resting intriumvirates, of which at least one is an SAI reporting directly to the board.In this way, the board maintains ultimate control of company policy.

GenTech's divisions are: Research and Development, PrimaryProduction, Engineering, and Public Relations. Each is split into subdivisionsreferred to as *Projects*. Within aProject, various activities are carried out under management groups, alsoconsisting of at least one infomorph which reports directly to the board. Atthe activity level, these direct reporters may be ghosts as well as SAIs. Veryfew people know that the Board maintains a direct link all the way down tospecific activities.

Activities

Research and Development

Gengineering. GenTechPacifica's signature activities are genetic engineering and biotechnologyresearch and development. It does basic genetic research and applies it toproduce innovative parahuman, animal, and plant genemods. GenTech is famous forproducing radical genemods, but for each Aquamorph there are dozens of minorgermline modifications designed to make fish grow faster or lobsters tastebetter.

The Bioroid Project designs and produces new life forms fromscratch, using existing creatures as templates and raw genetic material. TheUplift Project uses genetic, implant, drug, and psychological processes toraise the intelligence of certain sea species with the goal of producingsapience.

Climate Control. ThisProject has so far concentrated on storm and seismic damage mitigation throughthe use of coastal wave buffers. Project leaders plan to launch oceanic heatinglaser satellites in the near future.

Primary Production

Aquaculture. Much ofEarth's seafood is raised in controlled environments, and GenTech produces mostof the technology which enables it. Nearly all aquaculture farms buy at leastsome of their supplies from GenTech, from water filtration equipment tonutritionally balanced stock feed. GenTech also runs large farms of its own,supplying seafood to consumers in Oceania, eastern Asia, the Union of Albertaand British Columbia, Ecuador, and Chile.

The Space Aquaculture Project operates GenTech's orbitalfacilities, doing research and development into the unique problems of raisingseafood in microgravity and places where every drop of water means excess massto be carried around. The Fauxfish Project is involved with developingcommercially viable vat−grown seafood meat. It has encountered severaldifficulties and has only recently begun to market product. Fauxfish remainsexpensive compared to aquacultured animals, and it doesn't seem to have quitethe right taste or texture yet.

Sea−floor Mining and Mineral Extraction. Sea−floor Mining manufactures underwater miningequipment and cybershells, and operates seabed mines in all the oceans andmajor seas. Mineral Extraction uses processing plants to extract industrialchemicals and metals from sea water.

Engineering

Habitat Construction. Thisis a major Project with several large activities. Researchers develop newconstruction technologies and eco−engineers apply them to underwater andfloating habitat designs. Construction crews assemble new habitats and performexpansions and renovations on existing ones under contract. With the growth inoceanic living, these activities generate a large component of GenTech'srevenue.

*Vehicles and Cybershells.*The Submersible and Ship Projects design, test, and build aquatic vehicles inshipyards located in Australia, Korea, and Japan. Another Project develops andbuilds cybershells designed for aquatic use.

*Power Generation.*GenTech's Power Project produces oceanic power plants of all types (p. 00) fordeployment around the world. It usually includes power systems in aquatichabitat contracts as well.

Public Relations

Media. GenTech's publicrelations division is a ruthless marketing and memetic engineering tool. TheMedia Project operates as a subsidiary company, producing entertainment anddocumentary InVids and slinkies with carefully designed messages supportingGenTech's activities. The popular children's InVid *Captain Salt andthe Deep Rangers* presents heroes who usecutting−edge technology to accomplish goals and to defeat threats which embodyphilosophies antithetical to GenTech's own.

Memetics. The MemeticsProject plans and executes long−term campaigns intended to produce favorableeconomic and legal conditions for company operations. An especially effectiveproject discredited policies of the Australian government, effectively forcingit to grant free city status to Elandra in 2094 and ultimately contributing toits loss of the next election.

Security. The SecurityProject is responsible for protecting GenTech's property and interests. It hasaccess to the latest armor and weaponry, and tends toward a "shoot first,ask questions later" policy when protecting facilities from potentialterrorist attacks. In some cases this is literally true, as Security has beenknown to create shadows of killed terrorists for interrogation purposes.Security is also responsible for certain black operations involving industrial espionageand sabotage. Some people suspect the failures of rival companies to beatGenTech to market with a fauxfish product can be blamed on targeted sabotage.

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GenTech Pacifica's Associations

Avatar Klusterkorp

GenTech is closely associated with Avatar Klusterkorp, thoughGenTech actively denies any link. The company has been helping Avatar with theEuropa Project (p. DB00). GenTech collects and sequences genetic samples fromterrestrial hydrothermal vent life forms and passes on the data to Avatar touse as templates for their modified microbes on Europa. There are rumors thatmodified organisms are tested at some isolated vent communities in the Pacific,and Blue Shadow is actively hunting out such testing grounds.

The Real Food Movement

This movement (p. 00) is in reality the brainchild ofGenTech's Memetics Project. GenTech has far too much invested in aquacultureand fishing technologies to allow fauxfish to become a commercial success.Allowing quality fauxfish to become popular would ruin GenTech's strangleholdon seafood production technology, particularly with nanosocialist−backedcompanies ready to steal fauxfish genetic material and produce piratedversions. Having witnessed the downfall of land−based farming following theintroduction of fauxflesh, GenTech created the Real Food meme and beganpropagating it in much more subtle ways than the more overt engineering carriedout by the Media Project.

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Sakolpok Co. Ltd.

Sakolpok is one of the largest corporations within the TSA. Ithas interests and subsidiaries in aquatic vehicle and habitat construction,nanotechnology, oceanic mineral extraction, power systems, and aquaculture.

Originally based in Thailand, Sakolpok expanded into othernanosocialist countries as the political movement spread in the 2050s. It was amajor supplier of naval and space hardware for TSA states in the build up tothe Pacific War. This was mostly naval vessels, spacecraft, and microbots,although some Sakolpok scientists were involved in the secret programs todevelop nanovirus weapons (see p. FW16) and the *Kupu−Kupu* and *Rajasi*−class AKVs (pp. SSS47 and DB00).

At the end of the war, some of Sakolpok's management fled to itsDjakarta office in Indonesia, leaving behind much of the company's infrastructure.The Indonesian government assisted the company in re−establishing itselfbecause it still had factories throughout the TSA and represented a significantindustrial base. The darker side of Sakolpok was lost in the war, and its newmanagement sought to reshape the company's image. They concentrated on civilianocean technology and dropped the spacecraft construction division, which hadbeen based in Thailand and could not be rebuilt easily.

Sakolpok has diverse facilities throughout the TSA, but littlepresence in other countries because of anti−nanosocialist trade sanctions.Apart from its contempt for international laws regarding intellectual property,Sakolpok is now a relatively benign company, with management and practicesconforming to ethical, safety, and labor standards higher than the norm for TSAcompanies. It is thus one of the more desirable employees in the TSA.

Organization

Sakolpok is controlled by a strict hierarchy of managers led by aChief Executive Officer. The current CEO is Setiawani Dharwiyanti, a bright andenergetic woman who was elected to the position in 2093. Unlike herpredecessor, she has adopted a hands−on approach to running the company, andreceives regular briefings from her cadre of managers. Setiawani has increased thecompany's focus on civilian production and appears to be scaling back militarycontracts with a view to eliminating them.

Sakolpok's managers administrate regional divisions based in eachTSA nation. The largest regional operations are those in Indonesia, Malaysia,Bangladesh, and Peru. Each region engages in a slightly different mix ofactivities, depending on local technology and competition, though the emphasisremains on oceanic industry and nanotechnology.

Activities

Technology Sharing

This is the term Sakolpok uses to refer to the nanosocialistpractice of copying ideas, research, and products created by others. Mostregional offices have a large section constantly scanning the world media fornew innovations, reverse−engineering rivals' products, and producing cheapcopies of established designs. Sakolpok has a ready market for the fruits ofthis work because of the isolation of TSA nations from the world economy.

Anarchists and infosocialist sympathizers in non−TSA nationsoccasionally post pirated software, construction blueprints, and 3D printerprograms to semi−secure Free Net data havens (see p. FW31) where Sakolpok andother nanosocialist companies can access them. The technology sharing sectionsmust be vigilant for such information, because it is frequently deleted or thedata haven shut down within hours by the various network law enforcementagencies of non−TSA states.

Construction

Sakolpok's major industry is the construction of ships,submarines, and aquatic habitats. Relatively little design work is done, withmost vehicles being copies or minor modifications of successful models designedby other companies. There are shipyards in several TSA countries, producingcommercial and private vessels. A few contracts for the TNI−AL (Indonesian Navy,p. 00) remain to be completed, but other military production has ceased.

There are dozens of submarine habitats and hundreds of floatingcities in the seas of the Malaysian and Indonesian archipelago, mostconstructed and maintained by Sakolpok. The Bangladeshi division is the majorcontractor for underwater habitats for the rapidly growing parahumancommunities living offshore.

Nanotechnology

Despite losing many of its best nanotechnologists in the PacificWar, Sakolpok retains its position as a leading nanotech company in the TSA.This is the only business section which does significant original research, andso attracts grants from local nanosocialist governments. Sakolpok specializesin maintenance nanobots for its own products, so these are often aquatic−adapted.Innovative products from the research section include devices such as pearlwebs(p. 00) and Lateral Line nanosymbionts (p. 00). The nanotech section inMalaysia has also recently begun large scale copying of pirated mainstreamconsumer nanotech items.

Other Activites

*Oceanic Mineral Extraction.*Sakolpok builds and operates mineral extraction facilities in the shallowwaters of the South China and Java seas and the Bay of Bengal. These produceindustrial chemicals for the nearby TSA nations.

Power Systems. Theindustrial capacity of the TSA rests heavily on oceanic energy productionbecause of helium−3 embargoes imposed by the United States and China. Sakolpokprovides the expertise and infrastructure for some of the largest oceanic powerprojects on Earth. With almost all TSA nations in tropical regions, theemphasis is largely on OTEC systems (p. 00), but there are significant tidaland monsoonal storm surge power generators in the Gulf of Martaban nearRangoon, Burma, and along the Bangladeshi coast.

*Aquaculture and Ecoscience.*With 1.2 billion people to feed, and relatively little land area, the nationsof the TSA rely heavily on fishing and aquaculture. The coastal shallows ofmost TSA states are dotted with fish and shellfish farms using equipmentsupplied by Sakolpok. The Peruvian regional office also runs a sophisticatedecoscience section, dedicated to study and preservation of the productive wildanchoveta and sardine fisheries in Peru's EEZ. The anchoveta fishery collapseddisastrously in the 1970s because of overfishing it took nearly 100years to recover and the Peruvian government is determined not to let a similarevent occur again.

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Sakolpok's Associations

Bhuiyan Genetics

Sakolpok cooperates closely with Bhuiyan Genetics (p. 00) inBangladesh's Bay of Bengal settlement project. The complementary skills of thecompanies make for an ideal partnership, tempered only by a friendly rivalrybetween engineers and scientists who strive to design and build products eitherwith mechanical engineering or wet technology.

Manfasi

Following the Pacific War, PT Manfasi (p. FW57) has been themajor competitor of Sakolpok in the establishment of a new energyinfrastructure for the Asian TSA states. While Sakolpok developed oceanic powersources, Manfasi concentrated on solar energy. Sakolpok now has the upper handin the long battle, because its technology has been developed using readilyavailable resources, whereas many of Manfasi's installations require hardwarerestricted by trade sanctions against the TSA. Although such items can beacquired, the ongoing expense has made solar power in the TSA uneconomical inthe long term compared to the low running costs of oceanic power. Solar isstill used for some specialized applications, but Manfasi's business has fallendramatically and Sakolpok analysts are watching for any industrial sabotagesponsored by their rival.

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Blue Shadow

*We're not terrorists, we're **ecology advocates**. The rich and powerful have convinced the sheepof the world that the environment is doing great, when in reality they'vebroken the legs of Mother Nature and have given her crutches so she can hobblealong. There may be less chemical pollution and fewer oil slicks these days,but do you think all those genemod fish and bacteria are just going to vanishor that they don't replace or outcompete natural species? Wishful thinking. Themore we screw up the natural order the more we have to work to keep the wholeecology from flying apart by introducing yet more technology. There'snot much "natural" left in the oceans, but we're working on fixingthat one aquafarm and mining platform at a time.*

"Mako," posting tothe Web via an untraced Free Net server.

Blue Shadow is the largest and best organized Preservationistradical group. It is dedicated to the protection of the ocean and the campaignagainst exploitation of sea creatures. Its stated policy is one of limiteddirect action it engages in illegal activities up to propertydestruction but endeavors to minimize casualties. Blue Shadow's brand ofPreservationism is moderated by a dose of pan−sapient rights althoughits members believe that animals should not be uplifted and genemod creaturesmust not breed, they feel that existing sapients have the right to live outtheir lives. The breeding, use, and abuse of captive sapient creatures is thusa prime target for its operations.

Organization

Blue Shadow uses the proven decentralized organizational systemof most successful terrorist groups. Members are organized into discrete cells,with most people having contact with only a handful of fellow members. Eachcell has a leader who reports to a superior in a cell higher up the commandchain, until the group's shadowy leaders are reached.

Blue Shadow has four operational divisions: Intelligence,Memetics, Operations, and Finance. The visible activities of the organizationare carried out by Operations personnel, but most Blue Shadow members have"office" jobs maintaining its large support structure. These divisionsare not formalized Intelligence personnel often take part in actionsmounted by Operations, and high–ranking members oversee work across severaldivisions.

Recruitment

Blue Shadow recruits people for jobs in Memetics or Financeinitially. At this stage they are not aware they are working Blue Shadow. Manypeople remain in this ignorant state their entire careers this isparticularly the case in Finance, where entire front organizations dedicated toraising revenue operate with only a few executives knowing where the profitsgo.

Senior memetics personnel discreetly compile psychologicalprofiles of workers. Promising candidates are manipulated to increase theirsusceptibility to Blue Shadow doctrine. Some are abandoned at this stage aspersonality traits inconsistent with terrorist work come to light. Afterseveral months a candidate might find a pamphlet on his desk, or an anonymouse–mail message memetically designed to catch his attention. If he chooses toact on the contact, he will be taken into a cell and given tasks directlyrelated to Blue Shadow activities.

Once a new recruit has proved himself, he may be reassigned to anarea suiting his particular skills. Most members spend some time inIntelligence before moving on to Operations. Talented memetic engineers oradministrators may remain in their original divisions, eventually rising toleadership ranks.

Equipment

The day–to–day tasks of the Operations Division are acquiring,developing, and maintaining equipment. Blue Shadow operates a fleet of elevenships, three cargo submarines, four helicopters, and numerous small boats.Additionally, there are personal surface scooters, submarine propulsion units,and diving gear. The large vehicles are legally registered and operated byfront organizations, as either mainstream Preservationist, research, orcommercial vessels. For the most part, they engage in legitimate activities. Itis only a few times a year that they are seconded to terrorist missions.

Activities

Intelligence Gathering

Most of Blue Shadow's work is the gathering of information. Theorganization needs to know about potential targets for propaganda and terrorismand it needs to know what defences it has to overcome in its operations.Typical intelligence personnel spend much of their time surfing the Web forleaked information and following it up, infiltrating corporate activities, orengaging in covert surveillance of operational sites. Surveillance ofunderwater bases is perhaps the most glamorous of these activities, but it isstill mostly boring work, punctuated by moments of terror when discovery islikely. Collected intelligence is passed to the memetics division forpropagation and to the operational division for planning.

Memetic Engineering

A significant division of Blue Shadow actively propagatesPreservationist memes and cultivates of new ones. Its memetic engineersspecialize in the creation of subtle free memes (p. FW32) designed to swaypublic opinion in favor of radical Preservationism. Examples might alter InVidentertainment programs so that criminal characters are parahumans while theheroes are baseline humans, or modify financial and news reports of ecohostilecompanies to undermine shareholder confidence.

The memetics division also creates public reports outlining collectedevidence of illegal activities and animal and sapient rights abuses by targetcompanies. While some reports are simply facts, many are engineered toemphasize the abuses, presenting them in ways calculated to promote publicawareness and outrage.

Rescues

The most visible Blue Shadow operation is the rescuing andliberation of uplifted and sapient sea creatures. In fact, many people thinkthis is all Blue Shadow does. Although these operations are risky and only afew are carried out each year, they are often spectacular and well−publicized.Several slinkies of raids, recorded by Blue Shadow personnel and highlightingcruelty to sapients and ruthlessness of defensive tactics, have been"leaked" to the Web.

A rescue is typically a lightning raid on an underwater facility.Perimeter detection equipment is neutralized, any guards incapacitated, andsecurity and containment facilities breached. Often the "liberated"animals are frightened and disoriented and need to be coerced into leavingcaptivity. Previously liberated uplifts work with humans at the front lines tohelp convince the captives. Sometimes it is necessary to forcefully remove someanimals. After being taken to safety and calmed down, most animals appreciatetheir release, or at least do not try to return to their captors, so BlueShadow sees forced removal as a justifiable means.

Rescued uplifts and genemods are sterilized by nanoviraltreatment (usually without their knowledge) and either released or recruitedinto Blue Shadow.

Sabotage

Blue Shadow also sabotages ecohostile activities such as oceanfloor mining, oil drilling, waste dumping, and new land development. Sabotageoperations are designed for maximum disruption of activity, while trying tominimize casualties. Most are relatively subtle, such as burying caltrops insediment which is to be sucked up for processing. The resulting mechanicalfailure of the mining machinery may not even be recognized as sabotage.Sometimes more militant methods are used, such as torpedoes, planted explosives,and bombjacking teleoperating stolen cybershells or bioshells carryingexplosives (see p. BD00). Although these operations produce results, many ofthem are covered up by the victim organization, which is usually eager to avoidnegative publicity.

Fund Raising

Blue Shadow's activities use considerable resources of materiel,manpower, and, ultimately, money. Its annual operational budget is between $300and $400 million, varying from year to year depending on the success offundraising activities.

More than half the budget comes from indirect donation. BlueShadow operates several more mainstream Preservationist groups, researchorganizations, and even a religion (the Church of God's Image, p. 00) as frontswhich simply funnel funds into its coffers. Some of these front groups alsoengage in merchandising and selling advertising space in publications toincrease revenue.

Some donations are made directly to Blue Shadow, by people whoagree with its methods. Most such donations are from wealthy eccentrics orpeople who participate in the group's terrorist activities. In general, suchdonations are made covertly enough to avoid the attention of law enforcementagencies.

The remainder of Blue Shadow's funding is raised by corporatesubsidiaries that develop ecologically sound ocean technology, mostly stealthvehicles usable by the operations division and InVid and slinky documentarieshighlighting the beauty of the pristine sea.

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Blue Shadow's Associations

Front Groups

Most of Blue Shadow's outside associations are through itsvarious front groups. Many of these are legitimate businesses or non−profitorganizations in their own right, with their only link to illegal activitybeing the surreptitious use of funds or equipment by Blue Shadow cells. Thesefronts are incredibly diverse, ranging from mainstream Preservationist groups,through scientific research institutes, to commercial enterprises. Throughthem, Blue Shadow has contacts throughout the social, scientific, and businesscommunities. Most people never know when they deal with Blue Shadow, and nobodysuspects just how far its tentacles reach.

Splinter Groups

An organization as large and decentralized as Blue Shadow isbound to splinter into competing factions, especially when the group as a wholeis based on a moralistic ideology. Several high−ranking cell leaders have gonetheir own ways with their own interpretations of radical Preservationism,creating dozens of more−or−less independent activist groups. Some are moredevoted to pan−sapient or non−sapient rights, while others are skewed to themilitant Preservationist end of the spectrum. Irukandji (p.00) is one of thelargest and most dangerous splinter groups.

Daren Phuong

Unknown to GenTech Pacifica, the ghost of their ex−boardmember Daren Phuong (see p. 00) did not delete himself in 2097, but transmittedhimself to a secure Blue Shadow computer. With the new perspective of being aninfomorph, Daren could no longer appreciate the physical comforts built up over50 years of corporate greed and eventually converted to Christianhyperevolutionism (p. TS89). He vowed to erode the amoral edifice he had helpedbuild, and sought out Blue Shadow contacts. They arranged a secure machine andencryption keys so he could transmit himself to a pre−arranged network addresswithout being noticed.

Information Daren has provided has led to several successfulraids on secret facilities, but Blue Shadow remains extremely cautious and haskept him isolated from the net in case he reports back to GenTech. Blue Shadowhas made several xoxes of Daren; trying to hack them to create a trustworthyinformation source is a major ongoing project. Daren, sincere in his defection,is increasingly frustrated with his captivity and is on the verge of becomingpsychotic.

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Military Forces

(((START QUOTE)))

There's no reason for having a Navy and Marine Corps.General Bradley tells me that amphibious operations are a thing of the past.We'll never have any more amphibious operations. That does away with the MarineCorps. And the Air Force can do anything the Navy can do nowadays, so that doesaway with the Navy.

Louis A. Johnson, U.S.Secretary of Defense, 1949.

(((END QUOTE)))

*I'm counting ten missiles incoming on the **Yongguo** . . . Why don't we have any ELINT assetsavailable? I don't **care**what Lieutenant Spohn said, we have priority. Whoah! Look at that thermalspike! Looks like the **Yongguo** took two hits; get Johnson in on the datalink, he's going to wantto take a look at that. Ha! Yeah, that idiot swore up and down their newanti−missile laser system was 98% effective. File it to Mike too, he's beenrunning simulations for the spooks at NTIC. Bloop, the USS **Clinton** is reporting the Chinese just splashed thelaunch platform with supercavs.*

*Ah hell, it'll be twenty seconds before the missiles getwithin range of **Xiukang**battlegroup's anti−missile systems. No orbital laser assets overhead right now;last TSA strike took out most of their warsats and they aren't launchinganother set for at least a week. Hmm. I'm counting thirty missiles, Russian6K91 designs according to the signature probably just rolled off theproduction line. Here they come; zoom in with the optics. The Chinese arefiring interceptors . . . There goes six missiles, seven . . . ten . . . Theanti−missile lasers are firing. **Wow**, nice shot, there goes another six. Oh there'sno way they'll stop the rest; break out the popcorn.*

*Capt. Michael Glass, as recorded in **Outside,Looking In: The Pacific War**,assembled from declassified U.S. records.*

Compared to the rapid development of ground, air, and spaceforces, change has come with a glacial slowness to the world's navies. Althoughthey adopted new technology directed energy weapons, unmanned aircraft,supercavitating torpedoes they neglected to change their tactics andstrategy because of it. The Pacific War was the first conflict to see extensiveuse of naval forces since World War II, and it came as a serious shock topoliticians who had been draining naval budgets in support of space operationsor coastal defense. The War showed that without a strong ability to engageenemy forces well away from the coasts there was little that could be done toprotect inhabited areas and military targets, even with orbital superiority. Italso showed that even the most forward−thinking forces had based theirstrategies on critically flawed assumptions about the effectiveness of the newgeneration of anti−ship weapons.

Large, heavily armed surface vessels had been the backbone ofnavies for the past century, supported by attack subs and carriers. As theseships had become increasingly complex and expensive there were fewer of them inservice. Incremental upgrades kept them operational for decades many ofthe PLAN and U.S. Navy's warships at the outbreak of the Pacific War had hullsand components over 70 years old. They proved hopelessly vulnerable to massedcruise missile strikes and orbital attack. Naval commanders realized they werestuck in the Third Wave while military strategy and technology had moved on.

Change has come slowly and painfully, except in the case of Chinaand the TSA, which were starting from scratch after the Pacific War. Othernations have massive investments in their current forces or simply don't see aneed to improve what they have. The exceptions are nations that are dependenton control of the seas for their economic survival.

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Operational Environments

Green Water: Over thecontinental shelves, near archipelagos and coasts.

Blue Water: Openocean.

Brown Water: Inshoreestuaries and coastlines.

Red Water: Mars, orany planetary waters other then Earth.

(((END BOX)))

China

China is still committed to fielding the region's, if not theworld's, strongest navy. Although it suffered a setback during the Pacific War,the Chinese military leadership has been quick to adapt the lessons it learnedto its newly rebuilt fleets. China is rapidly working to close the technologygap that the TSA exploited in the war, and has made heavy investments inantisubmarine warfare and its own submersible fleet. Even so, the sea servicesdo not attract the highest–quality officers, and the government is growingincreasingly worried that the massive numbers of bioroids in the PLAN andparamilitary coast guards pose a growing security risk.

People's Liberation Army Navy (PLAN): The PLAN suffered from both crippling losses andreduced prestige following the Pacific War. Although they had successfullycontained and eliminated the TSA's capability to use their naval forcesoffensively, it proved a Pyrrhic victory. The PLAN has spent the last 15 yearsrebuilding, investing heavily in new construction and an ambitious submarineprogram. Bioroids in the PLAN enjoy significant freedoms, and are even allowedto go ashore during port visits (albeit under heavy surveillance).

Customs Service: TheCustoms Service (*Hai Guan*) is aparamilitary police force that protects the Chinese coast and inland watersfrom pirates and TSA infiltrators. In recent years the Customs Service hasacquired a reputation for corruption and even outright banditry with itssouthern detachments; some suspect this is actually done under governmentapproval as a harassing tactic. Most Customs vessels are surface craft,although they maintain a large number of AUVs that can be deployed from aircraftor boats for anti−submarine operations.

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Chinese "Victory" at Sea

The PLAN started the Pacific War with the most advancednavy in the world, and ended it using ships built at the turn of the century,armed with weapons welded on at the last minute.

Admiral Paul Perkins,United States Naval Institute, 2086.

The PLAN suffered massive losses during the Pacific War, andhas yet to recover even half of its total strength 15 years later. Almost allof the losses were early in the war before the establishment of orbitaldominance. Within one month the PLAN had lost the entire East Sea Fleet exceptfor two ships in drydock awaiting repairs and four submersibles still intransit to the region. TSA strikes killed most of the PLAN leadership and allof their best captains and crews; several PLAN−SF staff officers foundthemselves in command of ships during the war due to personnel shortages. Ifthe PLAN−SF had not established orbital superiority so early in the conflict itis likely that the navy would have been crushed under waves of hypersoniccruise missiles, supercavitating torpedoes, and combat divers. As it was, thePLAN had to hurriedly redeploy its reserve fleet assets and bring many shipsscheduled for the scrapyard or mothballs back into active service.

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Pacific Rim Alliance

The PRA as a whole has a small naval force considering the sizeof the territory that it must protect. The decisive defeat of the TSA duringthe Pacific War and the decimation of the PLAN left no regional power in aposition to seriously threaten the PRA control of their waters. This has slowlybegun to change, especially with the resurgent Malaysian and Indonesiansubmarine forces expected to outnumber the PLAN and PRA two−to−one by 2120.Each member nation's fleets are independent, but in practice this means littleas only Japan and Australia have a navy of any significance and capability.

Japanese Maritime Self−Defense Force (JMSDF): Japan maintains the largest, most advanced, and mostprofessional navy in the PRA perhaps the most advanced in the world.The JMSDF conducts frequent cross−training and exercises with the U.S. Navy andRAN and conducts port visits around the world. Within Japan the JMSDF is seenas highly conservative, and attracts recruits unhappy with the rampanttranshumanism of modern society.

*Royal Australian Navy (RAN):*Australia's navy has the largest investment in submersibles of any regionalpower, with 40 in service. The RAN operates almost exclusively in the Pacific,with the bulk of their forces deployed within 1,000 miles of Australia'snorthern coast defending the nation's EEZ and corporate resourceextraction facilities. Australia maintains a world−class demining capability,which was largely responsible for clearing up the thousands of mines that weredeployed by the TSA and PLAN during the Pacific War. Their skills areoccasionally requested by other nations, making their minesweeper force theonly truly expeditionary part of the RAN.

Transpacific Socialist Alliance

The Pacific War validated the TSA's overall maritime strategy using a largely submarine fleet to deny the PLAN free reign of the seaand prevent any large−scale amphibious operations. Unfortunately, the TSAlacked any means to follow−up on its initial successes and never quite managedto prevent the PLAN from keeping them on the defensive. The member nations ofthe TSA are now on the cutting edge of naval strategy and tactics, and theirdevelopments are closely watched by everyone else.

*Tentara Nasional Indonesia−Angkatan Laut (TNI−AL):*The TNI−AL has the largest fleet in the TSA, and has spent a considerable sumof money rebuilding after the Pacific War. The TNI−AL operates the nation'sspace forces, and has been active in re−establishing the TSA presence in orbitto counter the superior Chinese forces. It has funded the *SalahudinSamboja* project in conjunction with theDuncanites (p. SSS44) and has made plans to buy several old USVs possibly to convert them into cheap "missile boats." Groundside, ithas continued to expand the submarine force that almost defeated the PLAN, andhas embarked on at least two extremely secret construction programs at anunderwater dock off Sulawesi.

*Tentera Laut Malaysia:*Most of the Malaysian navy was saved from destruction during the Pacific War,largely because the fleet was conducting a goodwill tour when the war began,and many vessels were confined to port for the duration of the war (and thusprotected from Chinese attacks). The timing of the tour has remained a sorepoint in relations with other TSA nations, but without the intact MalaysianNavy around during the tense period immediately after the war it is possiblethat China would have risked another conflict. Currently the Malaysian navy ismost active in assisting the other Pacific TSA nations in rebuilding andconducting aggressive patrols of Malaysia's EEZ in pursuit of pirates and PLANstealth subs.

United States

The U.S. naval forces are but shadows of their former selves. Nolonger do Navy ships enforce American political will around the world. The lastcarrier battlegroups were dismantled over 30 years ago, and few ships aresighted above the waves. The Coast Guard has stepped in to fill the gap, takingon an important peacekeeping role in U.S. waters and occasionally inpeacekeeping and anti−piracy missions elsewhere. The U.S. military is one ofthe most technically advanced, yet biochauvinistic, in the world. AIs maytechnically hold a rank, but may never receive a warrant, making themineligible to become officers. On the few unmanned arsenal ships, ghosts are incommand.

U.S. Navy: The U.S. Navyhas moved from a surface−based force to one that uses the world's greatestnumber of submarines, including some of the few in the world armed with nuclearweapons. These ultrastealthy "boomers" hide in deep water and waitfor the call to unleash their cargo of long−range cruise missiles. The Navy iscurrently investigating expanding its underwater facilities into full−fledgedbases and Congress has begun to pay attention to the Navy again as moreAmericans move to the seas. It has invested heavily in uplifted and furtherenhanced cetacean troops such as the War−Dop series.

Coast Guard: The CoastGuard's role has expanded dramatically over the past century, as hundreds ofthousands of people have settled in the inviting waters of the United States.Coast Guard vessels routinely patrol up to 400 miles from land, looking forillicit corporate activity everything from poor labor standards tosurreptitious attempts to mine seabed resources and telling drifters to"move along" when they start to look too settled in. The Coast Guardoperates submarines and several squads of submarine cybershells, which help itpolice the increasingly busy U.S. EEZ below the waves as well as above.

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The Decline of Naval Power

Naval power had been in a steep decline for several decadesprior to the Pacific War. The cost of a single naval battlegroup had alreadyreached the point where it was seriously threatening national defense budgets.Ever smaller and smarter anti−ship missiles and stealthy submarines hadrelegated surface fleets into virtual obsolescence long before anyone dared toadmit it.

The Pacific War proved that naval technology forecasts wereincorrect and defensive countermeasures largely ineffective. Too expensive tosimply scrap, but proven to be far too vulnerable to cheap and readilyavailable weapons, battlegroups were marginalized in favor of developing spaceforces and larger coastal forces, which had proved key to the Chinese victory.Large surface fleets for centuries the backbone of naval power disappeared practically overnight as they were transferred to second−line andcoast guard duties. What was left were small, highly mobile forces largely composedof submersibles, which were able to avoid the watchful eyes of orbitalsurveillance platforms.

The remaining surface fleets have taken a "quantity overquality" approach that is reminiscent of the old Soviet Navy. Many smallvessels degrade the effectiveness of large missile strikes by splitting thefire among multiple targets, and each vessel is capable of carrying enoughmissiles on its own to be a threat. With datalinking and AI battle managementtools, dozens of small vessels can work together as a single unit. Smallercraft are also cheaper, faster to construct, and more expendable.

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Other Organizations

Corporations

Agua Negra S.A.

This Argentine mining giant is the largest resource company inSouth America. Agua Negra specializes in ocean floor mining and extraction ofminerals from sea water, but also has conventional mining interests on theSouth American continent. It operates deep−sea cybershells that collectmanganese nodules from the South−East Pacific and Argentine basins, and performsulfur and metal extraction near hydrothermal vents. These activities aresupported by several new islands, the largest of which is Isla Santa FeCórdoba, some 600 miles south−east of Buenos Aires. Santa FeCórdoba and two other floating islands in the South Atlantic are run bythe subsidiary company Agua Negra Profunda S.A.

Recently Agua Negra has begun operating shallow sea−floor mineson the continental shelf around the Antarctic Peninsula, supported bycentralized underwater habitats with parahuman and uplifted animal workersoriginally supplied by GenTech Pacifica. Chile has lodged formal protestsagainst the Antarctic activity, claiming it violates the Revised AntarcticTreaty (p. FW25), but is hesitant to take further action because of morepressing military issues on its northern borders and the United States being ongood terms with Argentina. Blue Shadow activists are convinced Agua Negra'sactivities are disrupting the Antarctic Peninsula ecosystem, as well asemploying gengineered sapients. Unlike the government of Chile, these groupshave no qualms about taking action against the company's bases.

Atlantec Inc.

Atlantec is a U.S. based bioengineering company with a stronglyecoproactive philosophy. It produces animal−based bioroids designed to stabilizeecosystems and clean the environment of pollution. The two main approaches usedby Atlantec are: producing artificial species to replace ecologically importantspecies which are being depleted or lost; and creating new life forms which canactively process and restore some part of the damaged environment. Mostreplacement projects involve unglamorous species such as corals, mollusks,fish, and plants. Environment processor bioroids are more notable, includingthe recently developed leviathan filterers (p.00).

Atlantec also has a small division engaged in archaeobiology. Itsgreatest success to date has been the reintroduction of the Florida panther,which originally became extinct in 2031. Although not as important to thecompany's main goals, this division generates most of Atlantec's publicity andfosters the donations which make up a significant portion of its revenue.

Bhuiyan Genetics Ltd.

Bhuiyan is the largest company in the rapidly growinggengineering industry in Bangladesh. It made its fortune when commissioned bythe Bangladeshi government in 2077 to produce parahuman designs for itsinitiative to populate the waters of the Bay of Bengal (see p. FW69). It wonthe contract because it had recently acquired pirated genetic blueprints forGenTech Pacifica's Aquamorph parahumans. Bhuiyan has since produced severalvariants, other water−adapted parahumans of its own design, and a series ofbiomods and nanoviruses for adapting humans to aquatic life. With thenanosocialist subsidies for research and profits from production of designs,Bhuiyan has built an aquatic gengineering company more influential than GenTechPacifica within the TSA.

Although Bhuiyan's strength lies in human and parahumangengineering, it is rapidly expanding into the fields of animal and plantengineering. It has adopted some pirated food fish designs from non−TSAcompanies and is tweaking genes to develop species more suited to the IndianOcean. Its greatest non−human success to date is a productive red alga whichhas been adapted to thrive in the low−light zone between 300 and 600 feet deep,opening thousands of square miles of the Bay of Bengal to intensive biomassproduction.

Mbungwe Engineering (Pty.) Ltd.

A South African ecoengineering and biotech company, MbungweEngineering acts as a consultant to many projects within Africa and off itsshores. The highest profile projects concern wildlife management in the largeterrestrial preserves of Kenya and Tanzania, and ecological consulting for theOlympus Project (p. BD00). Mbungwe's most important ecoengineering activities,however, are in the areas of coastal stabilization, storm mitigation, arcologydesign, fishery management, and artificial reef habitat construction.

The biotech arm of Mbungwe is active in archaeobiology, geneticpreservation, and gengineering of ecologically important species. Mbungwe hassecretly been developing minestars (p. 00) as a method of collecting ore−richmanganese nodules from the deep seabed. Its recently formed sea−floor miningdivision carried out the first minestar operation in 2096, and it has quietlybeen using processing ships to collect the fruits of their work ever since. Asingle operation scatters a million minestars, about 30% of which are collectedover the next few weeks, yielding approximately 750 tons of high grade ore.

Shimada Umiya

The culturally conservative population of Japan remains one ofthe highest consumers of seafood per capita. Shimada Umiya is one of severallarge fishing and aquaculture companies supplying this huge demand. Catchingfish from wild populations is strictly regulated by the Japanese government toprevent overfishing. Shimada adopted Fifth Wave fishery management technologyearly, giving it an unsurpassable lead in the modern seafood industry.

Most of the people employed by Shimada work in ecoscience andeco−engineering activities, studying and managing marine ecosystems. Aconstruction division creates large artificial reefs in the shallows offJapan's coast and along the Ryukyu island chain, which are seeded with rapid−growinggengineered plankton and iron−rich mineral supplements. These reefs house largefish communities and form a major source of Shimada's catch. The company usespearlwebs and cybershells extensively to herd and catch mature fish.

Victoria Shipping Ltd.

This is a cargo shipping company based in Victoria, in the Unionof Alberta and British Columbia. It operates a fleet of 54 cargo vessels ofover 500 tons displacement and several support vessels. All the ships arecontrolled by infomorphs, either SAIs or ghosts of former captains who enjoythe nautical life. They ply the waters of the Pacific Ocean, shipping goodsbetween Alberta and British Columbia and other major nations of the PRA,especially Japan and Korea. A few ships operate on routes through the PanamaCanal to Buenos Aires or ports in Europe.

Victoria Shipping also services floating arcologies andunderwater settlements in the North Pacific region, using cargo submarines toreach submerged habitats. It has established its own arcology a few miles offVancouver Island, in which it is selling real estate to raise revenue for aplanned expansion into commercial arcology manufacture and management.

International Nongovernmental Organizations

Church of God's Image

This is a high−profile televangelist religion based on the tenetsthat those created in God's image (i.e. baseline humans) can be saved whileother sapients (parahumans, uplifted animals, and infomorphs) are abominations.These beliefs appeal to many religious Preservationists and the church has abroad, if not very deep, following. Its main activities appear to be deliveringpulpit−bashing sermons and soliciting donations.

In reality, the church is a front operated by Blue Shadow for twopurposes. The first is to spread the Preservationist meme, while the second isto raise cash for its operations. On both accounts the church has provedsuccessful beyond expectation. If anything, it may be too successful, becauseit is beginning to attract interest from economic authorities who are wonderingjust how much money it makes and where it goes.

Global Ocean Institute (GOI)

The GOI is a scientific research organization made up ofoceanographers, ecologists, climatologists, and members of associated fieldsfrom around the world. It acts as a loose administrative body and adissemination agency for matters of ocean science. A few executive positionsare filled by members of the oceanographic community by election, and acommittee sits to discuss and arrange liaisons with national governments onmatters of scientific and ecological importance. The GOI also holds a fewconferences each year, attended in person by hundreds of participants andremotely by thousands more.

Mars Oceanographic Group

The 1,500 members of the Mars Oceanographic Group (usually abbreviatedto "The Mars Group") are oceanographers, areologists, and planetaryscientists who study the dynamics and structure of the new Martian oceans. Alarge part of their remit is to monitor and control the oceans' interactionwith the atmosphere and the surface. They are seeding areas of the Borealis andHellas Seas (and ice sheets) with modified Black Plague algae (see p. ITW00) inan attempt to reduce the reflectivity of the planet and prevent temperaturesfrom dropping so much in winter. Large black algal mats are currently growingin Chryse Bay north of the mouth of the Marineris Sea, though it is too earlyto say whether they are having the desired effect or not. The Mars Groupgathers to discuss progress and future strategy at a conference held throughoutthe first week of Virgo every year at the University of Mars.

Servare Historiam

This is a group of professional and amateur archaeologists andhistorians dedicated to the preservation of archaeological and historicalsites. Servare Historiam supports scientifically–conducted archaeologicalresearch, but campaigns against the unnecessary disturbance of sites. Withvirtual presence and slinkies, it argues, there is no need for the removal ofartifacts to museums. The practice it decries most, however, is the recovery ofhistorical artifacts by treasure hunters, and subsequent sales to privatecollectors.

With the majority of known archaeological sites on land alreadyplundered for museum pieces or private collections, Servare Historiamconcentrates on the protection of underwater sites, most of which have onlybecome accessible in the past 100 years. It seeks to protect shipwrecks andcoastal sites submerged by rising sea levels.

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Marine Archaeology

Until the 21st century, almost all archaeology was done ondry land. It was only with the invention of small submersibles designed forscientific work in the 1960s that historic shipwrecks could easily be studied,and it did not become routine until after remote operated vehicles appeared inthe 1990s. As robotic vehicles evolved into cybershells, more researchersgained access to the wealth of archaeological material hidden beneath thewaves.

Over the centuries, hundreds of thousands of ships have sunk.Those which plied ancient trade routes contain valuable clues to unravellingthe history of human civilization, including ship construction techniques,cargo types, and trade quantities. More recent wrecks shed light on historicalexpeditions, military actions, and commercial shipping. A few, such as thewreck of the *Titanic*, fascinate thepublic and continue to be explored by virtual presence as *in situ* museums.

Shipwrecks are not the only archaeological sites underwater.Since the last ice age ended around 10,000 B.C., rising sea levels have submerged10 million square miles of land, inundating countless Neolithic, Bronze Age,and Iron Age sites. Some areas, such as the Black Sea, hide coastal settlementsfrom as late as 1000 A.D. Anoxic water conditions or burial in sediment canpreserve such sites better than those on land.

Finding submerged archaeological sites involves long,exhaustive searches, but once found they are eagerly studied by professionalsand the public alike. Groups such as Servare Historiam campaign to protectthem, while more mercenary ones like Choses Merveilleuses seek to exploit them.A significant find can trigger interest and activity from many corners.

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Weathersense

Weathersense is a well–regarded mainstream ecoproactivist groupdedicated to monitoring Earth's climate and campaigning for initiativesdesigned to halt and reverse climate change. It is a strong supporter of theeffort to restore the ozone layer to preindustrial levels and wants a similarprogram to reverse the global warming and sea level rises of the past 150years. This has been proposed by a few national governments, but the Fifth Wavenations most able to undertake such a task are reluctant to commit the enormouslevels of expenditure necessary to achieve significant results. Unlike the immediatephysical dangers of the ozone crisis of the 2070s (p. FW21), the threats ofglobal warming are longer term and not obvious enough to cause outcry amongstleaders looking no further than the next term of office.

The group is particularly concerned about the possibility ofrunaway methane hydrate release (p. 00). Most members are opposed to theartificial manipulation of weather phenomena by atmospheric–warming lasersatellites, because this injects further energy into the already overactiveglobal climate system. OTEC power generation (p. 00) is another area ofconcern.

Many leading ecoscientists and meteorologists are active membersof Weathersense. They give speeches and produce educational InVids to deliverthe message that the world's weather will continue to worsen unless somethingis done to counteract the changes already cascading through the climate system.The group's philosophy is one of peaceful protest and political lobbying. Thereare no known associations between Weathersense and more militantPreservationist groups, but many agencies harbor suspicions.

Criminal and Terrorist Groups

The Boreal Pirates

Mars is already one of the most interesting and dangerous placesin the solar system. So what does a young disenchanted person do to seek excitementand rebel against society? He runs away to join the Boreal Pirates!

The Pirates are part criminal organization and part historicalrecreation society. They seek to relive the heydays of piracy on Earth in the17th century. Their equipment is more modern, but they still attack shipsplying their way across the Borealis Sea. Most pirate operations are carriedout using hydrofoils and jetskis, attacking by surprise in the remote reachesof the sea. Their main objective is the theft of cargo they try not toinflict unnecessary casualties, lest they prompt a more concerted effort tofind and destroy them.

The Boreal Pirates should be played straight in most ***TranshumanSpace*** campaigns. Incampaigns with a silly or satirical bent, however, they are likely to adoptpirate slang ("Arr! Shiver me timbers!") and the captain is bound tohave a cybernetic leg and a gengineered sentient parrot.

Choses Merveilleuses

This black market enterprise has a very select clientele. ChosesMerveilleuses specializes in acquiring archaeological artifacts, items ofhistorical interest, and treasures unknown or thought lost. It sells theseitems for small fortunes to private collectors, who pay a premium for absolutediscretion. Although a small operation, a large amount of cash flows throughits coffers, and Choses can exercise considerable influence in thearchaeological and treasure–hunting communities.

Choses does not operate artifact recovery expeditions itself. Ithires freelancers for active fieldwork, and sends agents to work on ornegotiate with other expeditions. Agents are skilled psychologists andmemeticists, who determine the best approach for acquiring choice items, eitherby buying, stealing, or blackmail. Freelance treasure–hunters mostly work onunderwater sites, away from easy detection, but some terrestrial expeditions indeveloping nations have been commissioned and rumors abound that NASA'sMars Polar Lander probe lost in 1999 has since found its way into a privatecollection . . .

Irukandji

Irukandji is a recently–formed militant Blue Shadow splintergroup dedicated to the eradication of all marine life genetic–upgrading and,especially, intelligence–enhancing projects and military applications. Namedafter a tiny but deadly jellyfish, the name fits the group's *modus operandi* of striking quickly and with lethal force. UnlikeBlue Shadow, Irukandji terrorists use any means at their disposal and have noqualms about loss of sapient life. They sabotage gengineering laboratories,research vessels, scientific meetings, and any operations making use of genemodspecies such as aquaculture, sea–floor mining, and submarine and coastalhabitat development. They also target Fifth Wave naval vessels and shoreinstallations, whether they are involved with gengineering or not. Bombjackingbioshells and puppeteered uplifts (such as War–Dops) is a particularly favoredterror tactic, though they will bombjack cybershells too (see p. BD00).Operations are designed to kill genemod species, bioroids, and bioshells, andthose who develop or use them, rather than simply disrupting activities.

Rackham Gang

The "Rackham Gang" is the nickname of a well–organizedpiracy group operating in the Celebes Sea region amongst islands of thePhilippines, Indonesia, and Sarawak and Sabah. A lot of PRA cargo trafficpasses through this region, making it a rich hunting ground. The gang operatesmodern biphibian hydrofoil craft from bases hidden amongst the more remoteislands of the archipelagos. They operate submerged near their bases to avoidsatellite detection. PRA patrols managed to find one base in 2097, and theamount of high–tech gear stored there was staggering. Attacks have continued atan average rate of one cargo ship every four months, so the gang obviouslysuffered little from this loss. Cargo shipping and military analysts speculatethat they are backed by the TSA, but the TSA officially denies this.

The favored tactic of the Rackham Gang is to surface in severalbiphibians a few miles away from an unmanned cargo vessel to avoidraising suspicions as close sonar contacts then close and board asquickly as possible. Security experts jam or destroy communications and anyautomated defense systems, allowing cargo subs to surface nearby and receivetransferred cargo. If time and the PRA navies allow, the pirates sail the shipto a TSA port, where it is sold.

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Campaigns and Adventures

The worlds of ***Blue Shadow*** can be used as adventure settingsto bring variety to a ***Transhuman Space*** campaign with broad scope, or asthe focus of entire campaigns. Many of the campaign themes in the ***TranshumanSpace*** core book and ***TranshumanSpace: Fifth Wave***can be explored in aquatic environments. In addition, several new and uniquepossibilities are available.

Living Undersea

The most primal adventure theme is survival. Underwater is ahostile environment, with difficulties at least as great as survival in space.The exotic scenery can be used as a backdrop to a campaign, or it can become anintegral component of an adventure plot. GMs should play up the otherworldlynature of life under the sea there are unique hazards that need to befaced, and danger is close if anything goes wrong.

An undersea campaign can be built around simply making aliving. A group of characters in Elandra might undertake tasks from internalpolitics, to inspecting deep mining facilities, to assisting security infoiling industrial espionage or terrorism. Encounters with cetanist tourists orstrident Atlanteans will add color and spice.

Places like Elandra and Ondala are connected to the Web, somedia junkies and memehackers can indulge in their activities with abandon.Agitators might seek the safety of remote settlements and pursue political orcriminal operations through the Free Net to avoid being traced. And some places,such as the Dhamchos Thupten Khusu Monastery, are totally isolated from outsidecommunication for weeks at a time, providing perfect locations for mysteries orcovert activities.

Taking a Stand

From Preservationists to ecoproactivists, thousands of peopleare adopting causes and fighting for them. Adventurers could be members of BlueShadow, planning and executing raids on underwater settlements or corporatefacilities. This will be a life of excitement and danger perfect fodderfor gaming. Players may enjoy exploring the moral ambiguities of using violenceas a tool to fight what are seen as greater injustices. For a game of intrigue,one or more characters might become aware that they have been targeted aspotential recruits by Blue Shadow. Alternatively, law enforcement agents mightbe given the job of infiltrating such a group.

Political activity can also lead to adventures. A group ofpeople supporting nanarchy or universalism might help others to establish drifthabitats, lobby for independence or legal recognition, or help fend offunwelcome attention and hostility from governments and corporations. This canbe achieved in many ways, from negotiation and memetics to direct action,depending on the style of the campaign.

Corporate Projects

Company employees are often assigned a wide range of tasks.Simple jobs like working on cargo subs or establishing a new sea−floor outpostcould lead to unexpected difficulties or conflict. Operating in deep seafacilities, or surface habitats in extreme weather, can add environmentalchallenges to any task.

A party of troubleshooters might work for a company, from agiant like GenTech Pacifica to a small aquaculture firm, either full−time or asfreelancers. They could investigate and stamp out cases of industrial espionage,memetic propaganda against their employer, sabotage, and terrorism. Secretprojects need protection from activists and in some cases the law and someone will need to step in to save the researchers, or perform acover−up operation, if something goes disastrously wrong.

On the other side of the coin, governments or internationalbodies such as the World Trade Organisation (p. BD00) frequently want toinvestigate companies for illegal activity, and bring transgressors to justice.Agents may be sent to underwater facilities or corporate islands to determinethe truth about rumors of ecological destruction or poor working conditions.Such agents face a deceptive or hostile reception from the company.

In the Navy

Only a fool believes the role of navies is over; with 90% ofEarth's population either in the oceans or less than 40 miles from shore theyare more important now then ever before. The Pacific War proved the power oforbital superiority and also its inability to counter submersibleweapons or impact the small, tactical surface engagements that typified theconflict. Naval conflict in the Fifth Wave is fast and decisive, and in theharshest combat environment in the solar system. Under the waves stealthsubmarines still cruise so close that they occasionally ram each otheraccidentally, and incidents of piracy and ecoterrorism rise by the day.

A navy crew can be called to service to perform almost anymission, from humanitarian assistance to disaster relief, and the next day findthemselves playing cat−and−mouse with an armed pirate attack submarine. ThePLAN and U.S. Navy still conduct worldwide tours to show the flag, includingsailing to ports in unfriendly waters. In many places the major navies are theonly law, and a passing warship on international waters may be the only justicefor thousands of miles under the ancient conventions of the sea theword of a navy captain is still final.

Europa in Turmoil

"The only certainty on Europa is that nothing iscertain any more."

Dr M. Marron, CRABEpersonal log, December 2099.

A campaign focusing on the War Under the Ice provides manyopportunities for roleplaying. With spacecraft from the European Union andpossibly China on the way to Europa, tensions are reaching breaking point onthe satellite. A campaign would most likely focus on the growing turmoil withinand between the three groups on Europa.

Last Stand. Theleaders of the Europa Defense Force have a lot on their mind. How much has AmyWilson told the European Union about the organization? Is the French SDV reallybringing a negotiating team, or is it a cover for a commando unit? Is therereally a *Xingzhai* SDV on the way,after the head of Torsten Rademacher? Some recruits in the EDF are starting towonder if their cause really is worth dying for, and may attempt a coup inorder to force a surrender and avoid bloodshed. The option of underwater escapeis no longer available since Jones and Wilson made off with the EDF's onlymanned minisub, so a rebellion is looking like an increasingly attractiveoption to some of the less fanatical members. However, Rademacher and otherhardline members are not willing to sit and wait for destruction, and areprepared to take drastic measures to cause some major damage to their enemies and their increasing paranoia will make it harder for any coup attemptsto succeed. There are even rumors at ManannÆn that the EDF has a nuclearweapon in storage, ready to be used as a last–resort . . .

Lying in Wait. Avataris sensing an opportunity. With a garrison of MAD combat bioroids and two SDVsin orbit, it is willing to collaborate with the forces from Earth once theyarrive. Some personnel would be happy to see the EDF completely annihilated,while others think it is more prudent to tighten up Avatar's defenses and seewhat happens. A campaign centered on Genesis Station could include fending offincreasingly ferocious attacks on the facilities in the Kargel–Zolotov Channel.The EDF may even attempt to bring the fight directly to Genesis Station indesperation.

Mutiny at CRABE. Evenat CRABE, the situation is tense. Should a concerted attack occur atManannÆn Station, the EDF sympathizers at CRABE may be forced to decidewhere their loyalties really lie, and some may openly side with the terrorists.If they were to somehow wrest control of CRABE from the current leadership,they may offer support to EDF personnel and an escape route should they beforced from ManannÆn. Characters at CRABE could already be on eitherside of the fence, or be forced to choose sides if the situation flares up.

*The Hammer Falls.*Alternatively, characters may be outsiders: part of the negotiation team on theFrench SDV, or soldiers on the Chinese SDV. The situation on Europa will haveto be judged carefully, whether they come offering an olive branch to the EDFor bringing its destruction, and allies will need to be chosen carefully. Andthe situation may turn violent at any time . . .

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CHARACTERS

"I love you," I whispered into the ear of the ocean."Ever since I've known you, I've loved you. I must see all your marvels,know all your beauty . . ." And the ocean listened and snuggled stillcloser to me.

*Hans Hass, **Diving toAdventure**, 1951.*

"Well, it's about time you regained consciousness Ms.Desmet," clicked the Irukandji leader, "I know our method of removingyour infomorph was a bit . . . crude . . . but I expected a bit more resiliencefrom a famous human such as yourself." The terrorist's placid facebetrayed no human emotion, but his black eyes burned with malice. She was in amoon pool room, empty except for a few crates and a small tray holding thebloody dive knife that they had used to cut the implant from her jaw.

There were more clicks and the CeTalker placed in front of herspoke again with its improbable British accent. The dolphin had his mouth open,a clear sign of aggression.

"I thought you might want to see this, seeing as youhelped make it all possible." A display flickered to life above her. Itwas a TEN broadcast, live from the scene of some newsworthy atrocity. Shealready knew what it was but she couldn't turn away.

". . . least eighty fatalities have been confirmed byApplied Genentech officials, many of them young uplifted cetaceans undergoingsocialization training in the facility's crŁches. Dozens more aremissing and presumed dead in the tragedy." The dolphin made a squeak ofindignation.

*"They call it a **tragedy**!" He shook his head in outrage. "This is but thebeginning! And we owe it all to you and Applied Genentech. What a surprise itwill be when they figure out that their newest AIs have a few unintendedfeatures our agents saw fit to insert into the final code. All we needed wasfor the company to throw some chum into the water carrying an AI with ourmodifications. They showed some initiative when they decided to send thecompany's best troubleshooter to track me down. But did you expect me to be sosimple to catch as a Doolittle?" He did a roll to show his pleasure.*

Through gritted teeth she whispered, "You would kill yourown kind, Coak?" He stopped his roll and faced her, squeaking outrage.

"My kind? What do you know of it human? Engineered frombirth to be little more than an organic tool for your species, our brains"upgraded" to be more like yours. Even my name was assigned, alongwith my model number. Does it surprise you that your new toys don't showappreciation for their fate? You created us in your image, human. Despair andrevenge are emotions we now understand all too well." Coak closed hismouth and gazed at her. His all−too−human eyes locked on hers.

"But I know what I once was, I have memories from beforeI was modified into a freak. I'm one of a kind you know, state of the artexample of uplift technology." Coak clicked derisively and rolled over toshow the scars that crisscrossed his belly. "This body is just a shell,even my brain is more mechanical than organic. Others like me were beingdesigned for

the U.S. Navy, quickly produced organic weapons. Ironic that theirlittle war machine has decided to fight ***them****.*

"Even some of your fellow humans appreciate my plight.Irukandji will use the data you and your AI provide to strike a fatal blow toGenentech and their uplift projects." He gave a self−satisfied chirp andslapped his fins on the water.

She was beginning to feel light−headed from the blood loss butpride stiffened her back. "I'll never tell you anything, Coak." shegasped.

"Once my associates arrive we will make a personalityemulation of your mind. After a little tweaking, your shadows will be more thenhappy to tell us everything they know about the company's operations andplans." He turned away as the translator finished his words. "If it'sany consolation, we promise to delete them after we're through."

The bastard was ***definitely*** *smiling.*

Character Types

The oceans of Earth are home to millions of individuals, many ofwhom have adapted to their environment in strange and new ways. Many of thecharacter types found in ***Transhuman Space*** and ***Fifth Wave*** are found living in the oceans although Spacers and Mangliu are few and far between. Example charactertypes include:

Activist

"Yeah, we're protesting Metazyne's dumping of genemodfish in Lake Victoria. We're ronin with a conscience, traveling the world toprotect those less fortunate from the depredations of the transnats and theirown corrupt governments who trade short−term profit for long−term disaster.They claim this is part of an economic development assistance program and we'redepriving people of food and livelihood typical corporate doubletalk.Now please step away so people can see my sign. I have four more hours ofprotesting before I catch a suborbital to Baku to cut a ribbon at the CaspianSea Recovery Zone."

Maybe you're a bored dilettante looking for something to occupyyour time and impress your socialite friends, or maybe you're an executive at aprosperous biotech firm looking to change the world for the better. Theincredible standard of living in the hyperdeveloped nations and the ease ofworking from anywhere in the world means you can devote your free time totraveling around the world, globehopping on behalf of your chosen cause.

Advantages: Ally Group,Charisma, Contacts, Independent Income, Status, Wealth.

Disadvantages: Code ofHonor, Duty, Obsession, Overconfidence, Pacifism, Workaholic.

Skills: Diplomacy,Economics, Fast−Talk, Law, Memetics, Politics, and possibly scientific andprofessional skills related to the cause.

Coast Guard

"No sir, I can't say I've ever heard of the Free City ofNew Haven. No, I'm afraid our country doesn't recognize your territorial claimsand thus your boarding of that tanker yesterday was piracy. No, we don't carethat your Free City is recognized by the TSA. Keep your voice down sir, or Iwill have you sedated. You will be assigned a legal adviser infomorph who willexplain your rights while you are in custody. No, you will not be givenreparations for the cargo sub we sunk, and we have already arranged formilitary assets to be in the area if your "country" tests ourpatience again."

Keeping the peace in your nation's waters is your job, and oneyou know is more important every year. Thousands of people are streaming to theseas to look for a new life or escape their old one. You're there to make surethings don't turn into a lawless mess and that the corporations and settlersdon't get the idea that they can flaunt your nation's sovereignty or patience.

You've assisted local police forces at a nearby arcoblock,investigated a murder aboard an underwater mining platform, and sunk opposingcoast guard vessels from a Freedom Ship that got the impression they could setup a fish farm in your waters. You've been up and down the coast, putting outfires above and below the waves. Things can get a bit wild, but there is nevera dull moment out here on the frontier of Earth civilization.

Advantages: Alertness,Contacts, Fit, Intuition, Legal Enforcement Powers, Military Rank.

Disadvantages: Bully,Callous, Duty, Honesty, Intolerance, Overconfidence.

Skills: Criminology,Detect Lies, Electronics Operation (Sensors), Guns, Law, Powerboat,Professional Skill (Law Enforcement), Sailor, Scuba, Stealth, Streetwise.

Ecoengineer

You've gotten your hands dirty redesigning the arcology's wastetreatment system and configuring a cyberswarm network to fight that carnivorousalgae that appeared off Los Angeles; your job is one adventure in engineeringafter another. Technically you're known as an "environmental planning andoperations technician" but most people just call you an ecoengineer. Yourskills are in massive demand, a month ago you assisted architects working onthe Poseidon expansion to minimize its impact on ocean currents and fishmigration, and you were just contracted to do an inspection of a small Swedisharcoblock that has been the target of ecoterrorists. Better pack an assaultrifle this trip.

Advantages: Contacts(former employers), Reputation, Wealth (including levels of Multimillionaire).

Disadvantages: Enemy(rival corporations and ecoterrorist groups), Overconfidence, Workaholic.

Skills: Aquaculture,Ecology, Engineer (Nanotechnology, Materials Fabrication), Geology, Hydrology,Oceanography. Administration and Research may be useful.

Ecoterrorist

You're fighting mad over the development and exploitation of theworld's oceans. Maybe you've become disillusioned that you could changeanything through memetic campaigns or political action, or you've becomeinfected by a toxic meme spread by fringe Decelerationist groups (p. FW00) orradical Preservationists. Whatever the case, you're now willing to use violenceto bring about change; from a pacifist who refuses to harm anything living andwill settle for destroying aquatic cyberswarms to a hardcore radical who canjustify even the most bloodthirsty actions as being for the greater good. WhenBlue Shadow contacts you about a plan to blow an OTEC facility near FranklinCity, or your Irukandji cell members happily kill "freakish" upliftedcetaceans what will you do? There's no going back, the corporations andgovernments you've crossed in the past have your number   and even ifyou're dead they can make you talk . . .

Advantages: Ally Group,Combat Reflexes, Contacts, Independent Income, Patron, Strong Will.

Disadvantages: Enemy,Fanaticism, Paranoia, Reputation, Secret.

Skills: Guns, Scuba,Tactics, Teaching, Underwater Demolition. Memetics and Politics are importantfor those working on public relations and propaganda.

Marine Scientist

The study of Earth's oceans is more important then ever. Withmillions now living in giant arcologies or underwater habitats, knowledge ofthe sea isn't just an academic luxury. Depending on your interests you maystudy the remaining natural species before they are all displaced, try to solvethe problems of global warming and climate change, or work on a new generationof food fish. There are plenty of opportunities to be found; from miningcompanies hoping to find a new source of exploitable wealth to richPreservationist patrons privately funding genebanking   the money isthere. If you are political, the fringe Preservationists are always looking forskilled biochemists, and you hear the Green Duncanites are having someinteresting problems with their Europan parahumans. Better hurry, yourcolleagues are looking at the same jobs and you don't want to be stuck asbotboss to some analysis AIs in a stuffy lab.

Advantages: Ally Group(Programmable), Contacts, Reputation, Tenure.

Disadvantages: Loner,Odious Personal Habits, Overconfidence, Workaholic.

Skills: Aquaculture,Biochemistry, Ecology, Electronics Operation (Medical), Genetics (GeneticEngineering), Hydrology, Oceanography, Zoology. Administration, Politics, andScuba will be useful in many situations.

Meteorologist

"The media call this the age of "heavy weather"but they don't know the half of it. More people live in the littoral areas ofthe world then ever before   on the shore and in floating arcologies justoff the coast. One good hurricane and you'll have a humanitarian crisis of epicproportions. My human colleagues assist environmental management AIs such asmyself in making sure the storms stay within tolerable safety limits. But evenwith massively parallel quantum computers we still work with uncertainty andprimitive weather control technology. And there's no worldwide organization toanswer to. We try to cooperate with other nations, but no−one wants a hurricaneformed in their backyard just because it will mean less severe storms nextyear."

You work with technology that was science fiction just a decadeago, and you still have trouble preventing or predicting the next hurricane.You have tools that let you mitigate or even control the movement of weathersystems, but without international cooperation it's a chaotic game oftug−o−war. Even so, lives are on the line and your early warning or strategicuse of orbital lasers to heat just the right air mass may mean you preventhundreds of deaths and billions of dollars in property damage. When you'rewrong, people die. Now you see why most "weather masters" are AIs.

Advantages: Alertness,Intuition, Mathematical Ability, Visualization.

Disadvantages: Attentive,Obsession, Workaholic.

Skills: ComputerOperation, Ecology, Hydrology, Mathematics, Meteorology, Physics, Research.

Navy Officer

"Space may be a frontier but it's not the only one, andcertainly not the final one. The oceans of Earth are teeming with over ahundred million people and more wealth travels over the seas than throughspace. Our nation still needs to show the flag around the world and keep thepeace, not to mention making sure the arcologies and floating cities sittingoff territorial waters don't abuse our hospitality. You can't do that sittingin orbit."

You may have less freedom of action then a captain of an SDV outin the Deep Beyond, and your Admiral may be fond of micromanaging your everymove, but you'll get more real−world operational experience and the opportunityto lead, rather then simply manage, those under your command. The naval forcesof the world may be but a shadow of their former selves in terms of numbers ofships, but you know more then anyone how deceptive that is. You've devoured thetextbooks and run the Pacific War simulations from both sides and won.When the next war comes you won't be sitting in a space coffin two months awayfrom any fighting; you'll be right at ground zero making a difference.

Advantages: Fit, MilitaryRank 3+, Patron, Security Clearance.

Disadvantages: Bloodlust,Code of Honor, Duty, Fanaticism, Intolerance, Overconfidence, Secret.

Skills: Administration,Electronics Operation (Sensors), Guns, Leadership, Savoir−Faire (Military),Shiphandling, Tactics.

Salvage Operator

"I made my fortune off the bounty of the sea, son. Morespecifically the bounty of resources that man has left in the sea. Ha! I'verecovered submarines dating back to World War II for their radiologically cleansteel, and done contract work for both the TSA and PLAN after the Pacific Warin cleaning up some of their hulks. My biggest job was two years ago, when Ipirated a few artifacts from the ***Bismark*** *and* ***Titanic****for sale on the antiquities black market. Yeah, that was me. Made a tinyfortune once I eluded the assassins the trustees sent! I've seen a lot ofinteresting things, but I can't say I'm sad to retire. I won't miss beinghaunted by the bones of the dead or constantly being on alert for an ambush*

ordouble−cross by crews even greedier and rougher then me."

You're a combination grave robber and garbage man   combingthe oceans for hulks that are worth the effort of recovering for recyclablematerials or artifacts. Most specialize in a specific type of work, such asrecovering radioactive waste for sale to governments and ecologicalinstitutions that pay top dollar for removing it from the environment or"liberating" artifacts from historical sites protected by trusteesand corporations. The best salvagers get contract work for recovering sunkenships and dismantling old mining facilities. The mediocre make do withoccasional finds of archaeological significance and bulk sale of cheap metals.

Advantages: Ally Group,Strong Will.

Disadvantages: Enemy,Greed, Paranoia, Reputation (antiquities thief), Workaholic.

Skills: Exoskeleton,History, Law, Merchant, Powerboat, Research, Sailor, Scrounging, Scuba,Seamanship.

Settler

You've had enough of the landlubber life, for whatever reason.You might disagree with every government on the planet and want to get awayfrom external control, maybe you want to escape the bustle of Fifth Wave lifeand return to where it all began, or perhaps your job came with a relocationpackage to a corporate island in the North Pacific. Either way, you have sometough challenges ahead, from raising enough to eat, to dealing with those peskymilitary commanders who insist your legal settlement is anything but. You'llneed to defend yourself from the sharks, and the people who act like them,either through political action and leadership, or force of arms.

Advantages: Ally Group,Charisma, Claim to Hospitality (Atlantean Society), Strong Will.

Disadvantages: Enemy,Intolerance, Laziness, Reputation (bad PNC).

Skills: Aquaculture, Guns,Law, Leadership, Mechanic, Powerboat, Scrounging, Scuba. Drifters can useNavigation and Shiphandling.

Special Forces

Defining what constitutes an "elite" in 2100 is harderthen ever   augmented reality training, AI assistance, and smallermilitary forces have resulted in even line infantry units handling missions androles previously the exclusive domain of special operations forces. Navalspecial forces units of Fourth and Fifth Wave nations handle the niche missions(such as the U.S. Navy SEAL detachments on Mars and Titan) or in jobs thatrequire very close operational control and mission security (notably theRussian "*Delphin*" NavalSpetsnaz units and U.S. Marine Radio Recon). Most special operations units arecomposed largely of bioroids or infomorphs   even the European Union hasa significant number of citizen bioroids and AIs in their units   as theretention rate for parahuman and human personnel is astoundingly low.

Advantages: Alertness,Combat Reflexes, Military Rank, Security Clearance, Strong Will, Very Fit.

Disadvantages: Bloodlust,Extremely Hazardous Duty, Fanaticism, Sense of Duty.

Skills: Battlesuit, Guns,Gunnery, Savoir–Faire (Military), Tactics.

Volk ("Wolf")

"A lot of people have moved to the oceans to escape thestifling control of governments, corporations, their parents, the media,whatever. Many escaped the tyranny of nanny states like the United States andmost of Europe. But they still have problems they need dealt with, justicestill needs to be served at its most basic level an eye for an eye, atooth for a tooth. The sheep of the world need to hire wolves like me to keepthe other predators at a safe distance. It can get a bit messy, but that's whyI charge a premium."

Problems have solutions, and that's where you come in. You're aprofessional contract enforcer, sometimes working for criminal syndicates butusually doing your best to keep your clients safe by force of reputation. Thosewho haven't lived a day outside their carefully managed arcologies call itextortion; to the inhabitants of a floating shantytown off the New Mumbaiarcology you're the closest thing to the law they have. Communitiesoccasionally hire you to keep the peace, and those are the jobs you like thebest. At least then you can pretend you're not just a legbreaker working forthe highest bidder. You make your living based on the fact that people trustyou to complete your contract to the letter. Some people get the idea they canbribe you out of fulfilling your contract; those people usually end up dead.

Advantages: Alertness,Combat Reflexes, Danger Sense, Fit, Hard to Kill, Reputation.

Disadvantages: Bloodlust,Code of Honor (stays bought), Contacts. You may have a Higher Purpose.

Skills: Brawling, Guns,Interrogation, Intimidation, Law, Streetwise.

Parahumans and Bioroids

(((START QUOTE)))

OCEAN, n. A body of water occupying about two–thirds of aworld made for man who has no gills.

Ambrose Bierce, *TheDevil's Dictionary*.

(((END QUOTE)))

Arctic Aquamorph 71 points

Attribute Modifiers: ST +1 [10]; HT +2 [20].

Advantages: Amphibious [10]; Disease−Resistant [5]; Nictating Membrane1 [10]; Oxygen Storage [14]; Pressure Support 1 [5]; Temperature Tolerance 2(Comfort zone between 1° F and 60° F) [2].

Disadvantages: Overweight [−5].

Features: Very thick mottled or black skin; webbed feet and hands.

Date: 2078. ***Cost:*** $176,000.

This is a cold−adapted version of GenTech Pacifica's popularAquamorph line (p. TS116) that is widely used in both hemispheres thecompany is even considering a variant adapted for Mars but so far demand is toosmall to market it aggressively. Arctic aquamorphs are distinguished from theirtemperate cousins by their huskier build and relatively short limbs; their bulkout of the water is seen as a minor hindrance but not a design flaw. Theirability to maintain a high body temperature works almost too well arctic aquamorphs are very uncomfortable in any environment above 60° F andcan suffer heatstroke above 80° F.

Snow Viper: This GenTechbioroid is more animalistic in appearance, with a squat body and a feral grace.They have a more efficient method of regulating their body heat at hightemperatures and do not suffer ill effects like the arctic aquamorphs. IncreaseTemperature Tolerance to 3 (Comfort zone between 1° F and 72° F), and addBioroid Body [0], Combat Reflexes [15], Hyper−Reflexes [15], Overconfidence[−10], Short Arms [−10], and Ugly [−10]. *72 points* ($216,000; 2097).

Gillmorph 326 points

Attribute Modifiers: ST +30 (No Manipulators, −40%; ST above 20 isNatural, −40%) [84], DX +1 [10]; IQ −1 [−10]; HT +3 [30].

Advantages: 360−Degree Vision [25]; Acute Hearing +2 [4]; Alertness +2[10]; Bioroid Body [0]; DR 1 [3]; Enhanced Move (Swimming) 3 [30]; Extra Arms(6; Bad Grip, −10%) [54]; Extra Encumbrance [5]; Extra Hit Points +8 [40];Immunity to Disease [10]; Independently Focusable Eyes 5 [75]; Injury Tolerance(No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Pressure Support2 [10]; Sharp Teeth [5]; Sonar Vision (Nearsighted, −25%; Underwater only,−30%) [7]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [−40]; Horizontal [−10]; Legless [−35]; Stuttering[−10].

Features: Taboo Traits (Genetic Defects).

Date: 2098. ***Cost:*** $1,750,000.

The gillmorph is a Biotech Euphrates bioroid based on work doneby Atlantec and Duncanite contractors for a failed "paracetacean"project in the 2050s. Slightly smaller and sleeker then orcas, but with similarcoloration and outline, gillmorphs differ in a number of ways. Most noticeably,their ventral side has six flexible tentacles and two human−like arms. The armscan be stored behind muscular flaps and the tentacles contract by up to 30%when not being used. They have four pairs of eyes spaced around their anteriorend, although in practice only one pair is used at a time; heavy lids shutterunused eyes. Gillmorphs average 15 feet in length and one to two tons in mass.

Gillmorph Bioshell: Gillmorphsare also frequently used as bioshells. Add Bioshell Template [41] and removethe IQ penalty and Alertness. Note that Immunity to Disease only adds 7 pointsto the limited form present in Bioshell Template, reducing the total cost by 3points. *364 points* (2098;$1,785,000).

Nemo 84 points

Attribute Modifiers: ST +1 [10]; HT +2 [20].

Advantages: Amphibious [10]; Bioroid Body [0]; Disease−Resistant [5];Enhanced Move (Swimming) 1/2 [5]; Extra Fatigue +1 [3]; Immunity to Poison (Gasnarcosis) [4]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Pressure Support1 [5]; Resistant to Poison (Dissolved gases, −75%) [2]; Temperature Tolerance 1(Comfort zone between 33° F and 90° F) [1].

Disadvantages: Unusual Biochemistry [−5].

Features: Smooth mottled gray or black skin; webbed feet and hands;unaffected by SAD.

Date: 2082. ***Cost:*** $135,000.

The Nemo bioroid is an advanced form of Aquamorph (p. TS116).Perflubron fluid is used instead of blood and radical nerve tissuere−engineering has eliminated cerebral myelin, granting resistance to the bendsand nitrogen narcosis. Nemos can hold their breaths for periods similar to adolphin, or use nitrox breathing gear for operations as deep as 600 feet withno ill effects or need for decompression. GenTech Pacifica's Bioroid Project isinvesting heavily in turning the Nemo adaptations into a parahuman germline.

Purushagor 50 points

Advantages: Amphibious [10]; Enhanced Move (Swimming) 2 [20]; Immunityto Disease [10]; Nictating Membrane 1 [10]; Night Vision [10]; Oxygen Storage[14]; Pressure Support 2 [10]; Temperature Tolerance 1 [1].

Disadvantages: Legless [−35].

Features: Taboo Traits (Genetic Defects); unaffected by SAD.

Date: 2087. ***Cost:*** $176,000.

Bhuiyan Genetics' Purushagor is a radical parahuman design thatreplaces the legs with a fishlike lower body and tail. Purushagor are virtuallyunknown outside the TSA, but are common in Bangladeshi aquatic habitats, andsome have found their way into settlements off Burma and in the South ChinaSea. They do not require any special environmental controls on the surface, butwill be uncomfortable in cold environments and require some sort of exoskeletonto be fully mobile their tail is strong enough to stand up on, but theycan only move by hopping, or crawling like a seal.

Seawolf Series Bioroid 107 points

Attribute Modifiers: ST +1 [10]; DX +2 [20]; HT +1 [10].

Advantages: Acute Taste and Smell +2 [4]; Acute Vision +1 [2];Amphibious [10]; Bioroid Body [0]; Combat Reflexes [15]; Disease−Resistant [5];Enhanced Move (Swimming) 1/2 [5]; Fit [5]; Night Vision [10]; Oxygen Storage[14]; Pressure Support 2 [10]; Temperature Tolerance 2 (Comfort zone between1° F and 78° F) [2]; Versatile [5].

Disadvantages: Unattractive [−5]; Unnatural Feature (Few facial features);Workaholic [−5].

Features: Rubbery black skin with very light fur; webbed fingers;unaffected by SAD.

Date: 2085. ***Cost:*** $200,000.

The basic Aquamorph design (p. TS116) has its origin in GenTechPacifica military bioroids used by the U.S. and Chinese navies dating back tothe 2060s. The company has remained on the cutting edge of the field, using itsexperience to first develop the Aquamorph, and then a new generation of aquaticcombat bioroids for the U.S. Navy. The Seawolf shares many basic features withthe Aquamorph and Sea Shepherd, differing mainly in appearance; the Seawolf hasonly a vestigial nose, small pointed ears, and the body is covered in a veryfine fur.

Cybershells and Bioshells

As Jacques Cousteau used to say, the ideal means of deep−seatransport would allow us to move "like an angel." Our minds can nowgo it alone, leaving the body behind. What could be more angelic thanthat?"

Robert D. Ballard, ***TheEternal Darkness****.*

Amphibious RATS 810 points

Attribute Modifiers: ST +2 [20]; DX +1 [10]; HT +2 [20].

Advantages: Absolute Direction (Uses GPS, −20%) [4]; Acute Hearing +3[6]; Amphibious [10]; Chameleon 2 [14]; Extra Legs (4 legs) [5]; DR 60(Laminate, +33%) [240]; Enhanced Move (Swimming) 3 [30]; Extra Hit Points +5[25]; Full Coordination 1 [50]; Infravision [15]; Machine Body [37]; NictatingMembrane 1 [10]; PD 4 [100]; Polarized Eyes [5]; Pressure Support 2 [10]; RadarSense (Low−res ladar; 6 miles) [56]; Radio Speech (Laser and radio, +40%) [35];Silence 2 [10]; Sonar Vision (Enhanced, +20%; Underwater only, −30%) [23]; 3DSpatial Sense [10]; Weaponry (Recoilless rifle and assault pod, LC 0 + LC 1)[110].

Disadvantages: Dependency (Maintenance; occasional; weekly) [−20];Mistaken Identity [−5]; No Sense of Smell/Taste [−5]; Short Arms [−10]; SocialStigma (Barbarian) [−15].

Features: Complexity 6−8 compact microframe computer.

Date: 2090. ***Cost:*** $525,000 + computer.

The Darwin−Sogo Type 91 *Ookami* ("wolf") combat robot is widely used by several Fifth Wavenavies for amphibious operations. The design is a sleek shark shape in thewater, with the two rear legs locking together and extending smart fins to actas a fluke while the arms and legs retract flush with the body. They arecapable of underwater combat operations but are no match for dedicated combatplatforms; they rely on stealth to approach their target often crawlingslowly along the bottom. 8' long, 310 lbs.

Baikal Cryobot 464 points

Attribute Modifiers: ST +4 [45], HT +3 [30].

Advantages: 360−Degree Vision (Eyestalks, −20%) [20]; DR 30 [90];Enhanced Move (Swimming) 1 [10]; Extra Flexibility [10]; Extra Hit Points +5[25]; Machine Body [37]; Microscopic Vision 10 [40]; Move Through Ice (Tunnelleft behind +40%, Takes extra time, 256 times as long −80%) [6]; PD 4 [100];Radio Speech (Laser, +40%; No radio, −40%) [25]; Radiation Tolerance 1,000[41]; Sonar Vision (replaces normal vision) [0]; Vacuum Support [40].

Disadvantages: Aquatic [−40]; Mistaken Identity [−5]; Social Stigma(Valuable Property) [−10].

Features: Complexity 6−8 microframe computer.

Date: 2050. ***Cost:*** $350,000 + computer.

Vosper−Babbage's *Baikal* isa typical first−generation cryobot, designed to penetrate and study thick icesheets and autonomously explore the waters below. It resembles a larger versionof the mushroom−shaped *Vostok*cryobot (p. TS122). The hemispherical head is four feet wide, and houseshydrojet thrusters and the radiothermal unit that melts through the ice. Thecentral cylindrical post is four feet long and two feet wide, ending in ahemispherical "braincase" housing the AI and other electronics. The *Baikal*is a more rugged design than the later*Vostok*, and does not require constantmaintenance.

Like the *Vostok*, the *Baikal* has three evenly spaced arms, but only two end inmanipulators. The third is a sensory appendage capable of scanning all around thecybershell. It cannot support its full weight on these arms once in thewater, it is only capable of swimming with its hydrojets.

Early Europan explorers would set up a *Baikal* on the surface, tethered to a transmitter stationwith a sturdy commline (p. 00). The cryobot unspooled the line as it meltedthrough the ice; as the ice froze behind it, the cable was held fast. Oncebelow the ice shell (after 12 days of tunneling), the *Baikal* would detach from the commline and go exploring. Itwould return to the cable periodically, reattach itself, and send the data ithad gathered to scientists via the transmitter on the surface. Some old *Baikal* cable sites are still used by *Vostoks* and other vehicles in 2100. CRABE used several *Baikals* before the design was retired from production in2080, and still has five operational units in its inventory. 7' long, 2,500lbs.

Calamarine 246 points

Attribute Modifiers: ST +5 [60]; DX +3 [30]; HT +2 [20].

Advantages: Bioshell Body [41]; Chameleon +2 [14]; Constriction Attack[15]; DR 2 [6]; Enhanced Move (Swimming) 1/2 [5]; Extra Arms 8 [80]; ExtraFlexibility [10]; Extra Hit Points +3 [15]; Gills [0]; Pressure Support 1 [5];Sharp Teeth [5]; Smoke (Ink: Only in water, −30%) [11], Super Swimming 2(Limited endurance: 2 seconds, −20%; Takes recharge: 5 seconds, −10%) [14].

Disadvantages: Aquatic [−40], Bad Grip [−10]; Cold−Blooded [−5];Invertebrate [−20]; No Depth Perception [−10], Social Stigma (ValuableProperty) [−10].

Features: Complexity 6−8 microframe computer.

Date: 2092. ***Cost:*** $350,000 + computer.

GenTech Pacifica's *Dosidicus demelloii*, commonly known as a calamarine, is a bioshell basedon a Humboldt squid. A calamarine's computer usually runs a dedicated NAI tohandle the complex control of the squid's propulsion, chameleon, and tentaclesystems at the direction of the controlling infomorph. GenTech uses mostcalamarines in construction, mining, and aquaculture operations. The U.S. andAustralian navies each operate a small calamarine squad, using them asmaintenance and patrol shells if necessary they can hold torpedolaunchers. The RAN has begun replacing its calamarine control infomorphs withthe ghosts of Octosap IIs, which can control all of the systems instinctivelywithout requiring a NAI assistant. Irukandji has recently acquired a fewcalamarines through unknown means and used them to attack Agua Negra's oceanfloor mining operations near the Antarctic Peninsula. 12' long, 230 lbs.

Cyberdolphin 186 points

Attribute Modifiers: ST +5 [60]; HT +2 [20].

Advantages: Doesn't Breathe [20]; DR 5 [15]; Enhanced Move (Swimming;Nuisance Effect: Cannot use arms, −10%) 2 [18]; Extra Hit Points +1 [5]; FleshPockets (2 lbs.; robotic, −60%) [2]; Machine Body [37]; Modified Arm DX (botharms) +2 [20]; PD 1 [25]; Radio Speech [25]; Sonar Vision (Underwater only,−30%) [18]; 3D Spatial Sense [10]; Ultrasonic Speech [25].

Disadvantages: Aquatic [−40], Bad Sight [−10]; Dependency (Maintenance;common, monthly) [−5]; Disturbing Voice [−10]; Limited Endurance (5 hours)[−10]; Mistaken Identity [−5]; Modified Arm ST (both arms) −5 [−20]; SocialStigma (Valuable property) [−10].

Features: Complexity 5−7 small computer or Complexity 6−8 microframecomputer.

Date: 2070. ***Cost:*** $98,000 + computer.

The SagawalLlinÆs cyberdolphin is a common marinecybershell used worldwide for a variety of roles. It resembles a small dolphinfrom a distance, but is obviously artificial up close, even with its biomorphiccoating. It is natural enough that wildlife is not spooked by its presence andit is in danger of attack by some large predators. Two retractable manipulatorarms extend for detailed work and a small cargo compartment can hold tools orpersonal effects. SagawalLlinÆs markets several variants of the design,including one for use on Mars. It is not rated to dive below three atmospheresand has a crush depth (see p. 00) of 150 yards. 200 lbs.

Idmon Explorer Aquabot 169 points

Attribute Modifiers: ST −6 [−30], HT +1 [10].

Advantages: DR 10 [30]; Enhanced Move (Swimming) 2 [20]; Machine Body[37]; Microscopic Vision 10 [40]; PD 2 [50]; Radio Speech (Laser, +40%; Noradio, −40%) [25]; Radiation Tolerance 10 [14]; Sonar Vision [25]; TelescopicVision 3 [18]; Vacuum Support [40].

Disadvantages: Aquatic [−40]; Dependency (Maintenance, common, monthly) [−5];Mistaken Identity [−5]; No Manipulators [−50], Social Stigma (ValuableProperty) [−10].

Features: Complexity 5−7 small computer.

Date: 2055. ***Cost:*** $80,000 + computer.

The *Idmon* Explorer isproduced by Elwyncorp, a small company based in Southampton, England. It is asimple design essentially a camera with fins and a propulsion systemthat can be sent to observe and explore the ocean depths and report back. It iscommonly used for submarine exploration on Earth, Mars, and Europa.

An *Idmon* is teardrop−shaped,three feet long and one foot wide, with a transparent hemisphere containingforward−facing visual sensors at the wider end. Chemical sensors are on thebody behind the hemisphere. The thinner rear is truncated near the tip, endingin a hydrojet housing, surrounded by four stabilizer fins and rudders. 3' long,180 lbs.

ROV Option: Although the *Idmon* can be controlled by an infomorph as a cybershell,it is often adapted for use as a Remotely Operated Vehicle (ROV), controlledvia a tether from a manned submersible or a surface ship. Simply add a commline(p. 00).

Spionfisch −27 points

Attribute Modifiers: HT +2 [20].

Advantages: Bioshell Body [41]; DR 1 [3]; Enhanced Move (Swimming) 1[10]; Gills [0]; Pressure Support 1 [5].

Disadvantages: Aquatic [−40], Cold−Blooded [−5]; No Depth Perception[−10], No Manipulators [−50].

Features: Complexity 5−7 small compact computer.

Date: 2086. ***Cost:*** $17,000 + computer.

Fish are ubiquitous in the seas. Few people will pay attention toone extra. The Spionfisch was designed to take advantage of this as aninconspicuous surveillance bioshell. Neumann Lebentechnologie AG producesSpionfische based on several species, ranging from two−foot long bonito to10−foot tuna. Smaller fish are less conspicuous, but sometimes get eaten bypredators. Spionfische normally house NAIs or LAIs few sapients enjoythe idea of controlling a prey animal. Ordered to observe and record underwateractivities they can be extremely effective. People familiar with fish biologymay notice the atypical behavior of a Spionfisch carrying out surveillance(roll vs. Zoology). The template represents a five–foot long Spionfisch.

Bonito: For a smallSpionfisch, add: ST –6 [–50]; Reduced Hit Points –6 [–30]. *–117points* (2086; $35,000).

Tuna: For a large Spionfisch,add: ST +8 (No Manipulators, –40%) [54]; Extra Hit Points +8 [40]; and anadditional level of Enhanced Move (Swimming) [10]. *77 points* (2087; $45,000).

(((START QUOTE)))

If the songs of the humpback whale are enunciated as a tonallanguage, the total information content, the number of bits of information insuch songs, is some 10^6 bits, about the same as the informationcontent of the *Iliad* or the *Odyssey*.

Carl Sagan, *Cosmos*.

(((END QUOTE)))

Whalesinger 678 points

Attribute Modifiers: ST +990 (No Manipulators, –40%; ST above 50 isNatural, –40%) [245], HT +4 [45].

Advantages: Bioshell Body [41]; DR 10 [30]; Enhanced Move (Swimming) 11/2 [15]; Extra Hit Points +50 [250]; Independently Focusable Eyes [15]; InjuryTolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; PD 4[100]; Peripheral Vision [15]; Pressure Support 2 [10]; Sharp Teeth [5];Subsonic Speech [20]; Temperature Tolerance 1 [1].

Disadvantages: Aquatic [–40], Bad Sight [–10]; Inconvenient Size [–10];Limited Endurance (5 hours) [–10]; No Manipulators [–50]; No Sense of Smell orTaste (Can taste, –50%) [–3]; Short Lifespan 1 [–10]; Social Stigma (Valuableproperty) [–10].

Features: Poor color vision. Complexity 7–8 microframe computer.

Date: 2068. ***Cost:*** $1,350,000 + computer.

Cetanists (p. 00) who wish to commune with whales use Whalesingerbioshells. These are humpback whale clones, with their brains modified to bedecerebrate in utero (or exowomb), before they can develop awareness.Whalesingers actually predate human bioshells, since the computer to run thedigital mind does not need be as small. There are only a few dozen whalesingersin existence, almost all owned by companies who hire them out on a per–daybasis.

Taniwha: The Taniwha is acustom bioshell created from a killer whale. They are used by military forcesand some terrorist groups. Generally, Taniwha are simply converted from anadult orca, since those who use them are not particular about destroying ananimal with a prior existence. Increase HT to +5 and Short Lifespan to 2;reduce ST to +45 (No Manipulators, –40%; ST above 20 is Natural, –40%), DR to5, Extra Hit Points to +10, and PD to 1; add Sonar Vision (Nearsighted, –25%;underwater only, –30%) [12] and Ultrasonic Speech [25]; and remove Subsonic Speech.*251 points*

(2071; $500,000 +computer).

Animal Templates

Cetaceans Varies

Advantages: Acute Hearing +4 [8]; Alertness +4 [20]; Enhanced Move(Swimming) 1 [10]; Independently Focusable Eyes [15]; Injury Tolerance (NoNeck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14]; Peripheral Vision[15]; Pressure Support 2 [10]; Sonar Vision (Nearsighted, −25%; underwateronly, −30%) [12]; Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [−40]; Bestial [−10]; Distractible [−1]; Dull [−1];Horizontal [−10]; Innumerate [−5]; Mute [−25]; No Manipulators [−50]; No Senseof Smell or Taste (Can taste, −50%) [−3]; Short Lifespan 2 [−20]; Social Stigma(Wild Animal) [−10].

Features: Poor color vision.

Cetaceans are highly specialized marine mammals ranging in sizefrom three−foot long Hector's dolphins to the massive blue whales that canstretch over 100 feet. Most are gregarious creatures with well−developed socialsystems, but their intelligence is often overstated at least as measuredby humans. All have streamlined bodies, tails with horizontal fins calledflukes, flippers (actually modified forelimbs), a nostril on the top of thebody forming a blowhole, and rarely visible vestigial hind limbs. Many have adorsal fin, which aids stability. The two major suborders of cetaceans are the *Odontoceti* (toothed whales) and *Mysticeti* (baleen whales). The template above appliesprimarily to toothed whales.

Bottlenose Dolphin (Tursiops truncatus): These dolphins are found worldwide in temperate andtropical waters. They range from eight to 15 feet in length and weigh between450 and 1,000 lbs. Coastal bottlenose dolphins tend to be smaller; those nativeto offshore habitats exhibit the most pronounced size differences. Males areslightly longer and substantially heavier. Most dolphins are gray−green orgray−brown in color, darker on the back fading to a pale belly.

To the basic cetacean template add: ST +6 (No Manipulators, −40%)[42], DX +3 [30], IQ [−30], HT +1 [10], Extra Hit Points +5 [25], andChummy [−5]. *33 points*.

Augmented Dolphin: Theseare bottlenose dolphins with an implanted VI and translator NAI (see *CetaceanUplift*, p. 00). Physically they are nodifferent to unaugmented dolphins, but the opportunity to interact with humansand learn abstract concepts noticeably enhances their intelligence.

To the basic cetacean template add: ST +6 (No Manipulators, −40%)[42], DX +3 [30], IQ [−20], HT +1 [10], Extra Hit Points +5 [25], andChummy [−5], and replace Mute with Mute (Mitigated by computer interpreter,−60%) [−10]. *58 points*.

Harbor Porpoise (Phocoena phocoena): These common porpoises live in coastal habitatsthroughout the northern hemisphere and are rarely seen outside relatively coldwaters. Although often confused with dolphins they tend to be smaller the average harbor porpoise is four feet long and weighs from 90 to 150 lbs.Females are slightly larger then males. They are stouter than dolphins, lack apronounced snout, feature small, triangular dorsal fins, and have differentlyshaped teeth, but their main differences are in social behavior. They are darkblue or gray on the back with a white underbelly; albinos have become morecommon since the 20th century.

To the basic cetacean template add: ST +3 (No Manipulators, −40%)[18], DX +1 [10], IQ [−30], HT +1 [10], and Extra Hit Points +2 [10].Also add three *additional* levels ofShort Lifespan [−30]. *−42 points*.

Orca (Orcinus orca): Alsoknown as "killer whales," orcas are the largest members of thedolphin family (*Delphinidae*) andare found all over the world, although they tend to stay in colder waters suchas the Arctic. They largely range in the open ocean but have been observed infresh−water rivers at times. Orca females are smaller then males, averaging 18feet in length and weighing from one to four tons, compared to 20 feet and fourto six tons for males. Orcas are distinctively colored: black on their backsand white on their stomachs, with a white swath just behind the dorsal fin. Thefin can be up to six feet high in males and is as distinctive as a fingerprint;about one in four orcas have bent or curved fins. A white "eyespot"is located just above and behind the real eye.

To the template above add: ST +45 (No Manipulators, −40%; STabove 20 is Natural, −40%) [86], DX +2 [20], IQ [−30], HT +5 [60],Congenial [−1]; DR 1 [3]; Extra Hit Points +10 [50], Inconvenient Size [−10];and Sharp Teeth [5]. Add a half−level to Enhanced Move (Swimming) [5]. *137points*.

Humpback Whale (Megaptera novaeangliae): Humpback whales are a member of the rorqual familythat includes blue and minke whales, within the *Mysticeti*. They feed by filtering krill, small fish, and otherorganisms out of the water through hundreds of baleen plates (keratin growthsthat fray into hairlike strands near the tongue). Humpbacks average 40 feet inlength when fully grown and weigh between 25 and 40 tons. Males are slightlysmaller then females. Individuals can be identified by unique patterns on theirdorsal fins and flukes. Humpbacks are not particularly sleek creatures, with arounded body that narrows toward the tail, whose flukes can be up to 18 feetwide. The flippers are very long, averaging 25% of body length. Coloration istypically black on the dorsal side and a mottled black and white on the ventral.

Modify the cetacean template by removing Sonar Vision andUltrasonic Speech and reducing Short Lifespan to one level. Add: ST +990 (NoManipulators, −40%; ST above 50 is Natural, −40%) [245], IQ [−30], HT+4 [45], Congenial [−1]; DR 10 [30]; Extra Hit Points +50 [250]; PassiveDefense 4 [100]; and Subsonic Speech [20]. *506 points*.

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Dolphin Sapience and Psychology

Dolphins have not been domesticated. They are wildanimals, even if they are in captivity and have been trained to be aroundpeople. Dolphins are large, powerful animals that can inflict serious harm onpeople.

Wildlife can be dangerous . . . There's this misconceptionthat [dolphins are] friendly; that they're Flipper; that they want to play withpeople.

Trevor Spradlin, NationalMarine Fisheries Service, 1999.

Wild dolphins are creatures with a degree of self−awareness they have thought processes at a similar level of sophistication to afour−year−old human child or an adult chimpanzee. Even in 2100 there is a widerange of opinions about how smart dolphins actually are. The only thing anyoneknows for certain is that they are quite clever and always a source of bothsurprise and disappointment. If they possess some special insight into thenature of the universe or are in touch with nature at a mystic level theycertainly are not letting anyone know about it.

According to the Adjusted Sapience Index Test (p. TS91),dolphins qualify as "borderline−sapient." This is a simplification ofcourse, and largely measures how close a creature is to human levels ofintelligence rather then a somewhat more abstract statement about how"smart" they are.

Although as aware as a human child in general terms, dolphinshave a unique psychology that makes interacting with them difficult. They arenot humans in funny suits; they have an alien intelligence well adapted to acompletely different environment with vastly different methods of manipulatingand interacting with it. They are non−materialistic they enjoy playingwith "toys" such as bits of flotsam, but abandon them easily. Somedolphins will steal toys from others, but this is not an attribute of desiringwealth or possessions. They will usually accede to simple orders, but do notrespond to threats or violence; if threatened they simply cower. Dolphins haveno concept of freedom captives never attempt escape and freely returnif released. Strange or new things frighten them, and they are reluctant toexplore unfamiliar terrain. They are highly susceptible to claustrophobia and requireconstant social stimulation to remain healthy. They have little concept ofempathy outside of their species dolphins will torture other animals(even porpoises and seals) to death in their play but this is not doneout of bloodlust or a desire for murder. Male dolphins occasionally forceintercourse with unwilling females, but it is hard to equate this with thehuman concept of rape. Dolphins are also notoriously lecherous, but not in the ***GURPS*** sense.

Many humans tend to ignore the darker side of dolphinpsychology in their dealings possibly because these aspects areunsettlingly familiar or they have difficulty not anthropomorphizing theseactions and moralizing. Unfortunately, many find they are also not theharmless, smiling friends of humanity who simply lack the ability to tell usall of their wonderful secrets of living in harmony and peace. They are wildanimals, and when under stress can and *do*attack humans. Even trained dolphins can be unpredictable and violent, ramminghumans, raking them with their teeth, or pulling them underwater.

Cetacean Uplift

It is possible to implant a VI and"nanny/translator" NAI into an otherwise unmodified dolphin, allowingit to communicate and interact with humans. This technology is in its infancyand subject to extensive debate there is still much to know about howbaseline dolphins perceive and organize their world. It has proven to beextremely useful in training and interacting, and augmented dolphins have shownan amazing capacity for adaptation and improvization with these tools,especially those implanted when very young. This technique is not ascontroversial as uplifting dolphins to full sapience but is also not asremarkable in effectiveness.

Applied Ocean Technology was the first company to have anysuccess using gengineering techniques to produce dolphins with increasedintelligence. Throughout the 2040s and '50s several corporations were applyingtechniques similar to those used in the development of the K−10 Postcanine (p.TS118) to dolphins. (This was a sequence which led, through further refinementsof the process applied to humans, to the Metanoia−series human upgrade, p.TS116.) Nootropic treatments and surgical procedures produced dolphins withgreater cognitive capacity, but they were virtually unable to function asindependent living creatures. The breakthrough came with the Doolittle germlinein 2059 a viable species of significantly enhanced dolphins.

The research into cetaceans continued, with GenTech Pacificamaking fitful advances in recent years under the direction of Flynn Martin.Applied Ocean Technology maintains the lead in dolphin uplifts however, withrumors of a new germline to supersede the successful Delphí s.

Where GenTech has been more successful is with theenhancement of larger cetaceans. The cerebral cortex of whales can be increasedin thickness and complexity of folding, which boosts processing capabilitywithout the intricacy of neural modification needed in smaller brains. Amodified humpback whale germline with this treatment has been produced, andthose grown to adulthood display intriguing signs of modified behavior andsocialization, which some researchers claim represents enhanced abstractreasoning ability. So far, however, communication attempts with the boostedwhales have been fruitless, so if they *are*thinking advanced thoughts, they may be so alien that humans cannot yetunderstand them.

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Dolphin genitals are surprisinglydexterous and strong. The uplifts have been taught to use them for toolmanipulation: pushing buttons, manipulating joysticks, that sort of thing. Keepthat in mind the next time you reach for something your dolphin assistant ishanding you.

Dr. Martin Chambliss,Manticore Genetics.

(((END QUOTE)

Doolittle Dolphin 40 points

Attribute Modifiers: ST +8 (No Manipulators, −40%) [54], DX +3 [30], IQ−2 [−15], HT +1 [10].

Advantages: Acute Hearing +4 [8]; Alertness +2 [10]; Enhanced Move(Swimming) 1 [10]; Extra Hit Points +2 [10]; Independently Focusable Eyes [15];Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10]; Oxygen Storage [14];Peripheral Vision [15]; Pressure Support 2 [10]; Sonar Vision (Nearsighted,−25%; underwater only, −30%) [12]; Temperature Tolerance 1 [1]; UltrasonicSpeech [25].

Disadvantages: Aquatic [−40]; Distractible [−1]; Hidebound [−5];Horizontal [−10]; Innumerate [−5]; Mute (Mitigated by computer interpreter,−60%) [−10]; No Manipulators [−50]; No Sense of Smell or Taste (Can taste,−50%) [−3]; Semi−Literacy [−5]; Short Lifespan 2 [−20]; Social Stigma (ValuableProperty) [−10]; Stress Atavism (Severe, uncommon) [−10].

Date: 2059. ***Cost:*** $80,000.

The Doolittle dolphin was the first stable germline resultingfrom Applied Ocean Technology's cetacean uplift program (see *Cetacean Uplift*, p. 00). The Doolittle removed the need for bionicand chemical augmentation, at the expense of mental stability and alertness.Although considered a success by most, the uplift process proved far fromperfect the gross structural changes to the dolphin's brain resulted innear−human intelligence at the expense of instinct. Doolittles lack many basicbehaviors of baseline dolphins and require assistance to live natural lives(they are incapable of the "half−sleep" of dolphins, for example, andcannot rest underwater or they will drown in their sleep). They do notunderstand dolphin speech, but their brains are capable of processinghuman−style conceptual strings and forming meaningful sentences with them. Witha translator that can interpret the part of their speech that extends into theultrasonic range they are more then capable of being understood by humans.

Doolittles are still the most common cetacean uplift, with some15,000 around the world. Most live and work with humans but a few have tried toreturn to nature most die or return after a few months. Althoughlegally classed as uplifted animals they have extremely powerful and vocallobbies working for them; it is extremely rare for Doolittles to be mistreatedwithout consequences . . .

Although not included in the template, substantial minorities ofDoolittles experience severe personality disorders shortly after reachingmaturity. The most common symptoms are combinations of Bestial, Bully,Manic−Depressive, Low Empathy, Obdurate, Paranoia, and Slave Mentality. Theseoften manifest after an episode of stress atavism.

Delphí s: Arefinement of the Doolittle dolphin germline, the Delphí s (from Greek,plural Delphí) has further enhanced intelligence and fewer psychologicallimitations. Delphí can suffer the same personality disorders asDoolittles, but this is rare. There are 2,000 adult Delphí in existence,with a second generation still reaching maturity. To the Doolittle template:increase IQ to −1, decrease Alertness to +1, remove Hidebound, Innumerate, andSemi−Literacy, and change Stress Atavism to (Moderate, rare) [−4]. *61points* ($122,000; 2084).

Octosap 32 points

Attribute Modifiers: ST −1 [−10]; DX +4 [45]; IQ −5 [−40]; HT +2 [20].

Advantages: Alertness +7 [35]; Chameleon +2 [14]; Constriction Attack[15]; DR 1 [3]; Enhanced Move (Swimming) 1/2 [5]; Extra Arms 6 [60]; ExtraFlexibility [10]; Gills [0]; Injury Tolerance (No neck) [5]; Peripheral Vision[15]; Pressure Support 1 [5]; Sharp Teeth [5]; Smoke (Ink: Only in water, −30%)[11].

Disadvantages: Ambidexterity [10]; Aquatic [−40], Bad Grip [−10]; BadSight [−10]; Cold−Blooded [−5]; Edgy [−5]; Hidebound [−5]; Innumerate [−5];Invertebrate [−20]; Mute (Mitigated by computer interpreter, −60%) [−10],Reduced Hit Points −2 [−10]; Short Lifespan 4 [−40]; Social Stigma (Valuableproperty) [−10]; Stress Atavism (Mild, uncommon) [−6].

Date: 2072. ***Cost:*** $21,000.

GenTech Pacifica's uplift program made a significant breakthroughwith the augmentation of cephalopod intelligence, resulting in the Octosap.Based on the giant Pacific octopus, *Enteroctopus dofleini*, one could easily be mistaken for a natural animal.The changes are enhanced intelligence, the ability to operate safely at greaterdepths (up to 600 feet), a significantly longer lifespan, and unintended stressatavism. Octosaps rarely live past 20 years of age, and grow steadilythroughout their lives. A mature 10−year old weighs 160 lbs., with an armspanof 10 feet. Octosaps are seldom found in human settlements any more they have been superseded by the Octosap II and are discouraged fromreproducing. There are significant and growing populations in the wild,however, having been released by Blue Shadow actions and adapting well to awilderness lifestyle. Exogenesis' Astropus (p. TS118) is based on thisgermline, radically adapted to survive in zero−gee air and require less livingspace.

Octosap II: This is asecond generation Octosap germline produced by GenTech for applicationsrequiring greater intelligence and autonomy. The rate of growth has been sloweddown considerably. The longer education times and nootropic treatments resultin further enhanced intelligence. Octosap IIs can live 40 years or more.Increase the Octosap's IQ to −2 and DR to 2; reduce Alertness to +4 and ShortLifespan to 2. *65 points*($35,000; 2081).

(((START BOX)))

Cephalopod Psychology

Octopuses are naturally curious. Investigative behavior helpsthem learn quickly, which is useful because natural octopuses only live ahandful of years at most. They explore and like to take things apart to see howthey work and if the components can be used in other ways. Typically theyexperiment with different ways of getting a task done, using the practicalapproach rather than thinking things through to arrive at a solution first. Theyare pragmatic and will use whatever works in a given situation, whether or nota better solution might exist. For these reasons, Octosap workers make goodpractical mechanics and builders, but poor engineers and planners.

Octopuses are solitary creatures. This tendency remains inOctosaps most get along with other species but become competitive andaggressively territorial with members of their own species, while some arecomplete Loners (p. CI91). Overlying these general habits, octopuses displayindividual personalities, ranging from shy to excessively tactile todestructively curious. One common trait is unpredictability. Octosaps can bediligent workers one day, easily distracted the next, and frequently engage inbizarre activities such as disassembling and reassembling items for no reason,refusing simple requests, or breaking off social contact for a few days. Humansnever quite know where they stand with an Octosap companion.

Octopuses are not left− or right−armed they usewhatever arm is most convenient for a task with equal dexterity. They also usedirected water jets to push and manipulate loose objects, with excellentcontrol.

(((END BOX)))

War−Dop 44 points

Attribute Modifiers: ST +3 (No Manipulators, −40%) [18]; DX +3 [30]; IQ−2 [−15]; HT +1 [10].

Advantages: Acute Hearing +4 [8]; Bioelectric Shock [10]; Enhanced Move(Swimming) 2 [20]; Extra Hit Points +2 [10]; Field Sense [10]; IndependentlyFocusable Eyes [15]; Injury Tolerance (No Neck) [5]; Nictating Membrane 1 [10];Oxygen Storage [14]; Peripheral Vision [15]; Pressure Support 2 [10]; SonarVision (Superior signal discrimination, +20%) [30]; 3D Spatial Sense [10];Temperature Tolerance 1 [1]; Ultrasonic Speech [25].

Disadvantages: Aquatic [−40]; Chummy [−5]; Distractible [−1]; Dull [−1];Horizontal [−10]; Mute (Mitigated by computer interpreter, −60%) [−10]; NoManipulators [−50]; No Sense of Smell or Taste (Can taste, −50%) [−3]; ShortLifespan 5 [−50]; Social Stigma (Valuable property) [−10]; Stress Atavism(Mild, common) [−12].

Features: Complexity 4−7 tiny compact computer with puppeteerimplant. Rubbery gray skin.

Date: 2055. ***Cost:*** $170,000.

The War−Dop "D−model" was one of the first successfulanimal intelligence upgrades; the techniques pioneered in their development leddirectly to the Doolittle uplifts and the U.S. Navy's Cetacean EnhancementProgram (CEP). The original uplifts were heavily modified harbor porpoises whounderwent extensive neurological modification and cybernetic enhancement inorder to boost their natural intelligence. Their implants created an unusualsignature that could be detected by EM field scanners, betraying their location(+2 bonus to detect using Field Sense or MAD). They average five feet in lengthand weigh up to 250 lbs. They lack dorsal fins, but artificial fins aresometimes installed to contain additional equipment.

E−Model: The latestgeneration of War−Dops is based on new technology, building on theDelphí s uplift germline (p. 00). Fewer cybernetics are required to turnthe Delphí s into an even more effective combat tool than the D−model.There are only a few Es in existence, most still held by the U.S. Navy. Onenotable individual, rescued in a Blue Shadow raid, is now the major threat tothe CEP (see *Coak*, p. 00).

To the D−model template: increase ST to +8 (No Manipulators,–40%) [54], Extra Hit Points to +5 [25], reduce Short Lifespan to 2 [−20],remove the IQ penalty and Dull. *141 points*($320,000, 2085).

Advantages, Disadvantages, and Skills

The world under the waves can be as alien as any asteroid. Thefollowing outlines some differences and special cases for an aquatic campaignin ***Transhuman Space***.

Advantages

Absolute Direction seep. B19

Migrating sea creatures have an uncanny navigational sense toguide them to their destination. However, this ability is crude compared to thefull Absolute Direction advantage and is a 0−point feature.

Acute Taste and Smell see p. B19

Non−aquatic characters or Aquatic characters in their non−nativeenvironment lose all benefit from Acute Taste and Smell.

Acute Vision seep. B19

Non−aquatic characters or Aquatic characters in their non−nativeenvironment gain only half their Acute Vision bonus (round down).

Breath−Holding seep. CI21

This advantage assumes more efficient lungs and increased oxygenstorage in the blood, as well as additional lung volume. Up to two levels ofthis advantage are available; beyond that see *Oxygen Storage*.

Claim to Hospitality see p. CI21

Members of the Atlantean Society (p. 00) possess a Claim toHospitality worth 5 points.

Decreased Life Support see p. CI52

Although not widely utilized, it is possible to re−engineerhumans and cetaceans to metabolize salt water. Note that cetaceans do *not* normally have this advantage, they aredesert−adapted creatures who get their water from the fish they consume andmetabolizing fat. *5 points*.

The ability to drink contaminated water is even rarer, and issomewhat limited. You can drink most unfiltered water without worrying aboutparasites and minor amounts of pollutants; you can also drink salt water. Itdoes not allow you to drink sewage, or water with the level of pollutants foundin many ports, but you can drink brackish swamp water without difficulty. *10points*.

Gills seep. CI56

For gills to be effective, there must be significant dissolvedoxygen in the water. This is not the case for the oceans of Mars and thesatellites of the Deep Beyond, and some places on Earth (such as below 600' inthe Black Sea), where Gills are useless.

Immunity to Poison see p.CI58

The following special limitation is available: Gas Narcosis, −75%(4 points if this is the only poison immunity you have). You have no myelin inyour brain tissue. This means you are immune to the effects of narcosis causedby nitrogen and other gases at high pressures. Other poisons affect younormally. The Nerve Boosters nanosymbionts (p. TS165) replace myelin throughoutthe entire body, and grant Immunity to Poison (Gas Narcosis) [4] as well as theeffect listed on p. TS165.

Nictating Membrane see p. CI62

This advantage eliminates the Vision penalty for charactersseeing in their non−native environment without goggles (see *Senses*, p. 00).

Oxygen Storage seep. CI62

You have features in common with marine mammals like cetaceansand pinnipeds. This includes the ability to store a significant quantity ofoxygen in the hemoglobin in your blood or myoglobin in your muscles. Yourmuscles can operate anaerobically for extended periods. When diving, air is notkept in your lungs; they are evacuated and allowed to collapse under pressure(this often involves a flexible ribcage)   this reduces buoyancy andprevents problems from absorbing high pressure gases. Efficient blood routingkeeps your vital organs supplied with oxygen and helps you stay warm.

These features allow you to stay underwater for extendeddurations before surfacing to breathe. Multiply the amount of time you can holdyour breath (as determined on p. B91) by 90. You get no bonus forhyperventilation and this does not combine with Breath Holding or BreathControl. You must breathe normally for at least 10 seconds for every minute youwere under water to correct oxygen debt. Diving again more quickly than thismeans you do not get a time multiplier and must start over the next time yousurface.

This means a HT 10 character with Oxygen Storage can hold hisbreath for 60 minutes with moderate exertion. A dolphin with HT 12 can staysubmerged for 18 minutes at heavy exertion   exertion is assumed to beheavy during dives. A humpback whale (HT 14) can dive for 21 minutes.

Characters with Oxygen Storage are immune to the bends, nitrogennarcosis, oxygen toxicity (see *Breathing*,p. 00), and aseptic bone necrosis (p. 00) when diving without an externalcompressed air supply. If such characters breathe pressurized gas, they areaffected by these problems like any other air−breather.

Oxygen Storage is functionally Doesn't Breathe (p. CI53) with thelimitation Limited Duration (−30%), for a net cost of 14 points. Otherlimitations are possible: 30−minute Oxygen Storage gives a multiplier of 45 tobreath−holding time (−40%, 12 points); 2−hour Oxygen Storage gives a multiplierof 180 (−20%, 16 points).

Pressure Support   seep. CI63

This advantage keeps you from suffering harmful effects relatedto pressure levels varying from your home environment. Aquatic creatures do notnecessarily need this advantage, but they may suffer if they leave their narrow"layer" of the seas.

Characters without Pressure Support can often withstand highpressures for short periods of time, if compressed slowly and suitable precautionsagainst secondary dangers are taken (see *Breathing*, p. 00). However, living for long periods atpressure will cause them physiological problems   from stressedcardiovascular systems to muscle and bone degeneration. Pressure Support willprevent these problems and allow a full, healthy life under high pressures.

Pressure Support grants immunity to the damage caused by crushingpressure (p. 00). It also prevents oxygen toxicity and nitrogen narcosis (p.00), and maladies brought on by the stress of repeated pressure changes such asbone necrosis. It does not provide immunity to sudden or localized changes ofpressure (such as a hull breach or explosive shockwaves).

The 5−point version of Pressure Support allows safe operations inpressures up to 10 times native pressure, and the 10−point version protectscharacters at up to 100 times native pressure. The 15−point version is notavailable in ***Transhuman Space***.

Radar Sense   seep. CI63

Instead of radar, this can represent a ladar system. It istreated as a standard ladar (p. 00) with the listed range (in hexes forimaging, in miles for low−res).

Special enhancement: Ifthis sense uses actual radar it may be *low−probability intercept* for +10%. If switched to LPI mode at the beginning ofa turn the range is halved but any radar detectors can only detect it inoperation at 1.5 times the (halved) range.

Special enhancement: Ifthe low−res mode can be used for *targeting* add +25%.

Radio Speech seep. TS130

The *Laser* enhancement hasa blue−green mode for underwater communication. Treat as a normal blue−greenlaser communicator with a base range of 50 miles.

Resistant to Poison seep. CI29

The following special limitation is available: Dissolved Gases,–75% (2 points if this is the only poison resistance you have). You haveadaptations which reduce the amount of pressurized gas that dissolves in yourbody tissues. This provides resistance to the bends, nitrogen narcosis, andhigh pressure nervous syndrome. At pressures below 20 atm., you are immune tothese conditions; at pressures greater than 20 atm., you are affected as thoughthe pressure were 20 atm. lower. You have no special resistance to normalpoisons such as cyanide gas. Note that although this is presented as alimitation, the full Resistant to Poison advantage does not normally includethis form of resistance to dissolved gases.

Sonar Vision seep. CI66

You have the ability to produce sound waves that bounce offnearby objects; by analyzing the time that return echoes arrive you canconstruct an image of your environment. You have a vocal capacity to producethese sounds and the ability to receive the echoes and interpret the resultingimages. This may involve special organs such as the oil−filled melon ofdolphins or enlarged nasal cavities and ears of bats.

Sonar Vision is normally limited to a 120° arc in front ofyou; the addition of the Peripheral Vision advantage means you can scan180° to the front. Large features can be discriminated clearly to 2,400' inwater and 300' in air, with resolution increasing the closer the object is. Youhave Color Blindness (p. B28) while using Sonar Vision but do not suffer anypenalties for darkness.

Sonar Vision is not as detailed as medical ultrasound signal attenuation and processing ability make discriminating fine detail at adistance very difficult. In water, layering effects will also adversely affectresolution (see *Submarine Acoustics*, p.00). In ***Transhuman Space*** you do not receive bonuses to Diagnosis or Holdout fromusing Sonar Vision, but thin−hulled hollow objects (no more than DR 3) can bedistinguished from solid objects when within IQ yards.

Sonar Vision can be blinded by explosions and other loudmultifrequency sound sources (for 20−HT seconds after the sound ends) orinterfered with by strong sonar signals (a −1 to −5 penalty depending onintensity). Bubble walls and other techniques that disrupt sonar will appear as"blank spots" or jumbled terrain depending on the exact method used.

Special enhancement: Youhave superior signal discrimination and recover quickly from sudden noisesblinding you. The longest you remain blinded or stunned by loud noises is twoseconds. This does not help you recover from stunning caused by explosiveconcussion. cf. Polarized Eyes (p. CI63). +20%.

Special limitation: You areNearsighted (p. B27) when using your sonar and can only distinguish detailwithin 10 yards. −25%.

Disadvantages

Aquatic seep. CI101

Note that Aquatic characters suffer no penalties using skillsunderwater, but suffer a −2 penalty to DX−based skills when out of water, asper p. CI101. Additionally, for all templates in this book, Aquatic includesthe zero−point feature Amphibious (No Move on land) [0], which allows them toswim at their normal Move rate without needing Swimming skill.

Cannot Swim seep. CI101

For a species, this is a 0−point feature. For individuals ofspecies normally capable of swimming, this is a −1−point Incompetence (p.CI91).

Increased Life Support see. p. CI102

Increased Life Support levels for food requirements are one levelfor up to twice as much food as a human, two levels for three *or more* times as much. The cost of water tanks andpurification equipment for aquatic creatures in life support situations isincluded in the Aquatic disadvantage, and does not need to be bought as IncreasedLife Support.

Reputation seep. B17

A PNC (p. 00) is almost universally a negative Reputation withlaw enforcement organizations (a "large class" of people). Frequencyof Recognition is "occasionally," such as when applying for a visa orbeing processed for a crime. Nations with stringent PNC requirements will beworth Reputation −1 [0] while those known as criminal havens will be Reputation−4 [−3].

New Disadvantage

Cannot Float −5/0points

You are too dense to float on water, and sink to the bottom likea stone. If able to breathe or otherwise operate underwater, you may be able towalk along the bottom, but you cannot swim. For a species, this is a 0−pointfeature. For individuals of a species normally able to float, this is adisadvantage worth −5 points.

Enhancements and Limitations

Not Underwater −10%

This is an Accessibility limitation (p. CI110). It may only beapplied to advantages or disadvantages that normally work above and belowwater.

Only Underwater −30%

This is an Accessibility limitation (p. CI110). It may only beapplied to advantages or disadvantages that normally work above and belowwater.

Skills

Botany/TL see.p. B60

A botanist may optionally specialize in "Marine"botany. This covers nutrient distribution, phytoplankton, algae, sea grasses,etc.

Breath Control see.p. B48

This skill is Esoteric in ***Transhuman Space***. Very dedicated free divers andsome martial artists (such as Zhua, see p. ITW00) will possess and teach thisskill.

Crossbow seep. B50

The use of spear guns is a familiarity within this skill.Crossbow users will be at −4 to use a spear gun, and vice versa, untilfamiliarity is gained (see p. B43).

Ecology/TL seep. B60

An ecologist may optionally specialize in the same terrain typesas the Survival skill.

Geology/TL seep. B61

A geologist may optionally specialize in "Marine"geology. This covers submarine plate tectonics, mid−ocean rifting, hydrothermalvents, and submarine volcanoes, rocks, mineral deposits, and crustalformations.

Languages seep. B54

Baseline and augmented dolphins have a simple language which canbe used to communicate basic physical and emotional data. This is a M/Elanguage for dolphins, commonly called Dolphinspeak. The enhanced brains ofDoolittle and Delphí s uplifts enable them to learn a M/A language(called Tursin, from the Latin for "dolphin") capable of conveyingabstract information. Uplifts can learn Dolphinspeak, but it is M/H for thembecause they lack optimized interpretive neural structures, and most neverbother. Uplifts can also understand human language (treat as M/VH skills), butlack the vocal capabilities to speak them. Humans can learn a few of theobvious signals of the dolphin languages, but cannot effectively understand orspeak the full language because much of its structure is beyond human hearing.CeTalker software can translate between either dolphin language and humanlanguages.

Meteorology/TL seep. B61

Meteorology by necessity includes a good deal of oceanic science.A meteorologist will understand air−sea interactions that give rise toprevailing wind patterns, atmospheric pressure distributions, and weathereffects such as hurricanes and monsoons.

Powerboat seep. B69

This is the skill used to operate small submersibles controlledby a single person. Each type of submersible is a familiarity (see p. B43). Forlarge submersibles, use Shiphandling (Submersible).

Scuba seep. B48

This skill covers all underwater breathing apparatus systems;specifically rebreathers. Other breathing systems are treated as familiaritiesof this skill. Scuba is also used to control small powered devices used tosupply additional thrust to a diver, such as finsocks, squidpacks, anddivetorps (p. 00), with a −2 familiarity penalty. (Aquatic−adapted characters,who will not possess Scuba skill, use Endurance Swimming to control thesedevices.)

Shiphandling seep. CI161

The required specialization "Submersible" is used todirect the operation of large submersibles.

Sports seep. B49

Common water sports include water−skiing (defaults to Skiing at−4 or DX−6), surfing (defaults to DX−6), and water polo (defaults to Swimming−4 or DX−5). Many sports are familiarities of other skills, such as windsailing(Boating) and platform diving (Acrobatics).

Survival seep. B57

Aquatic survival includes a basic understanding of tides,currents, and winds, knowledge of simple water distillation methods, how tolocate or catch food in that region, and how to avoid hazards such as venomousfish, sharks, and stinging jellyfish.

In addition to the specialties listed on p. B57, the followingare applicable to the various "terrains" of the oceans and waterways:Bank, Deep Ocean Vent, Fresh−Water Lake, Open Ocean, Reef, River/Stream,Salt−Water Sea, Tropical Lagoon.

Zoology/TL see.p. B62

A zoologist may optionally specialize in "Marine"zoology. This covers zooplankton, invertebrate species, fish, marine reptiles,cetaceans, etc.

New Skills

Aquaculture (Mental/Average) Defaults to IQ−5

This is the skill of managing aquatic ecosystems and harvestingtheir output, including plankton, algae, and fisheries. It corresponds toFishing as Agronomy corresponds to Survival.

Endurance Swimming (Physical/Average) Nodefault

Available only to aquatic−adapted races, this skill is theaquatic analog of Hiking (p. CI152). It is based on HT, not DX. Roll vs.Endurance Swimming before each half−day's travel; on a successful roll,increase distance traveled by 20%. If a group is traveling together, they mustall succeed on the Endurance Swimming roll to gain this benefit. This skill canalso be used to control personal powered thrust devices such as squidpacks anddivetorps.

Oceanography/TL (Mental/Hard) Defaults to IQ−6 or Physics−6

This is the study of the fluid dynamics and thermodynamics ofoceans. It covers water properties such as density, pressure, temperature,solutes, and fluid flow (currents, tides, waves). A professional oceanographermay also have other skills such as Botany (Marine), Ecology, Geology (Marine),Hydrology, Meteorology, or Zoology (Marine).

Speed Swimming (Physical/Hard) No default

Available only to Amphibious or Aquatic races, this skill is theaquatic analog of Running (p. B48). It is based on HT, not DX. If you havestudied this skill, divide your skill level by 8 (don't round down) and add theresult to your Speed to calculate your Move in water. Dodge is unaffected.

People

Hiroko Shimada 270 points

Ghost of a human female, born 2077, uploaded 2096. Age 22. Mostcommonly encountered in a Clockwork Souls Custom Cyberdoll (p. TS122), blackAfrican female, apparent age 20; 5' 6", 138 lbs. "Dyed" blondehair, brown eyes.

ST 14 [0]; **DX** 10 [0]; **IQ** 12 [20]; **HT** 12/15 [0].

Speed 5.50; Move 5.

Dodge 5; Parry 7.

Advantages: Charisma +1 [5]; Comfortable Wealth [10]; Contacts(Cetanists, Skill 12, 9 or less, Somewhat Reliable) [1]; Cyberdoll (ClockworkSouls Custom) [182]; Ghost Mind Emulation [17]; Independent Income [5].

Disadvantages: Disowned [−5]; Impulsiveness [−10].

Quirks: Cetanist; Dislikes ghost upload cults; Eats chocolate justfor the taste; Pretends to be a natural human; Uncomfortable about transferringbodies. [−5]

Skills: Animal Handling−12 [4]; Area Knowledge (Cape Town)−12 [1];Area Knowledge (Elandra)−11 [1/2];

Axe/Mace−8 [1/2]; Botany (Marine)−9/15 [1];Brawling−11 [2]; Calligraphy−8 [1/2]; Carousing−13 [4]; Fast−Talk−12 [2]; FirstAid−12 [1]; Hydrology−12 [2]; Knife−11 [2]; Navigation−13 [1]; Savoir−Faire−11[1/2]; Scuba−13 [4]; Streetwise−14 [6]; Survival (Open Ocean)−13 [4]; Survival(Urban)−12 [2]; Swimming−13 [8]; Zoology (Marine)−10/16 [2].

Languages: English−12 [2]; Japanese (native)−12 [0].

Hiroko Shimada is the granddaughter of Tsutomu Shimada, the headof Japan's Shimada Umiya fishing company. Spoilt as a child, she grewrebellious and spent increasing amounts of time immersed in the Web andinteracting with infomorphs rather than people. She became involved withvarious Japanese cults practicing and promoting ghost uploading. A week beforeher 19th birthday, Shimada impulsively ran away from home and visited aprofessional ghost upload facility in Sapporo. With access to a largeinheritance, she bought the best care for her uploading process and was beamedto a new cyberdoll body in South Africa.

For the next two years Shimada struggled to come to terms withwhat she'd done to herself. Although she liked her new cyberdoll body, shewasn't comfortable with the idea of leaving it either for another body or toexist as a "pure" infomorph on the Web. She went through bouts ofdepression and lived day−to−day, out of touch with her family, who presumed shewas dead. Seeking some form of spiritual comfort, she was befriended by acetanist, who convinced her that she needed to get in touch with nature throughinteractions with dolphins.

Shimada travelled to Elandra in her cyberdoll body and hired adolphin shell from a cetanist bioshell rental company. She overcame her fearsabout transferring to another body and, after some training in the use of adolphin shell, spent the next few weeks interacting with wild dolphins. Theexperience was an epiphany for her, allowing her to regain a sense of purposeand confidence to face her existence as a ghost. She contacted her parents, whotook some time to be convinced that the African woman talking to them was theirdaughter.

A year later, at the beginning of 2100, it is Shimada's parentswho are having difficulties understanding and accepting what their daughter hasdone. Tsutomu Shimada has disinherited her, but her parents are moresympathetic and have helped her get casual work controlling deep−seacybershells designed for biological research near Elandra a job atwhich she has proved talented. This has boosted Shimada's self−esteem, and sheis now considerably more stable than at any time in the past few years, with awide circle of new friends. She spends most of her time in Elandra, acting likea human, with occasional forays in dolphin or whale bioshells, and occasionalassignments in a research cybershell. Although becoming used to switchingbodies, she still finds the process unnerving.

Shimada makes a useful Contact or Ally she is fairlywell−known and liked in the Elandra community, and has contacts with cetanistgroups worldwide and within the biological sciences. She resents the Japaneseghost−upload cults and may be able to give investigators leads on some of thesegroups. It's also possible that she could get into trouble in one of heraquatic shells and require rescuing. She may suffer an emotional crisis if herparents decide to visit Elandra in person, and Tsutomu Shimada might take moredrastic action against what he sees as a travesty of his grand−daughter.

Rahul Sangupta 100 points

Male Aquamorph, born 2076. Age 23; 6' 2", 184 lbs. Grayskin, no hair, gray eyes.

ST 12 [10]; **DX** 12 [10]; **IQ** 13 [30]; **HT** 11 [0].

Speed 5.75; Move 5.

Dodge 5; Parry 5.

Features: Smooth gray, mottled, or black skin [0]; Webbed fingers andtoes [0].

Advantages: Aquamorph [65]; High Pain Threshold [10].

Disadvantages: Charitable [−15]; Enemy (IndiGene; Medium Group; 6 or less)[−10]; Secret (Wants to undermine Blue Shadow) [−30]; Sterile [−3].

Quirks: Dislikes medical examinations; Enjoys feeding moray eels;Outspoken about political beliefs on the Web; Pan−sapient rights believer;Would like to have children. [−5]

Skills: Camouflage−13 [1]; Computer Hacking−13 [8]; ComputerOperation−14 [2]; Demolition−12 [1]; Escape−12 [4]; Fast−Talk−14 [2]; Knife−13[2]; Mechanic (Marine Vessel)−14 [4]; Memetics−11 [2]; Politics−12 [1/2];Research−11 [1/2]; Sailor−12 [1]; Scrounging−13 [1]; Sleight of Hand−10 [1];Survival (Bank)−13 [2]; Survival (Open Ocean)−12 [1]; Survival (Reef)−13 [2];Underwater Demolition−13 [2].

Languages: English−12 [1]; Hindi (native)−13 [0].

Rahul Sangupta is a first−generation Aquamorph, born to a humansurrogate mother in Chennai. The local company IndiGene Ltd. had licensedGenTech Pacifica's design for local production and hired cheap surrogatesrather than buy exowombs. IndiGene took the newborn Sangupta and raised himwith a group of other Aquamorphs. They were studied closely and regularlysubjected to intense medical examinations. From their early teens, they weregiven work helping to develop an underwater settlement off the coast nearChennai.

Although allowed only limited contact with the Web and theoutside world, Sangupta slowly realized his Aquamorph "family" memberswere being held as prisoners, denied the freedom to travel and seek theirfortunes in the wider world. He developed a talent for accessing Web contentwhich was supposed to be restricted and learnt that his species had beenartificially created and just how unusual his upbringing was. He tried toescape but was tracked down by an implant he didn't know about and punishedcruelly.

Searching for a way out of his situation, Sangupta postedinformation to an obscure pan−sapient rights Web site, hoping someone with thepower to help would see it, while at the same time trying to avoid theattention of IndiGene. Blue Shadow, who had already been investigatingIndiGene, used the information he provided to plan a raid on the Chennaifacility. The terrorist group struck in 2097, blowing up much of the newconstruction and freeing Sangupta and several of his friends.

Grateful and wishing to help parahumans and uplifts in a similarsituation, Sangupta joined Blue Shadow and helped them plan and carry out otherraids over the next two years. Recently, however, he has become disenchantedwith Blue Shadow's methods and increasingly resentful of the fact that he wassterilized without his knowledge when freed. He believes fervently in itscause, but is increasingly disturbed by its destructive and fearful tactics.For the moment, he continues to work with Blue Shadow, since he is not sure ifhe can stop doing so and escape retribution. If given what seems to be a wayout, where he can fight for pan−sapient rights in a more peaceful way, and evenundermine Blue Shadow without fear of retaliation, he would be likely to jumpat the opportunity.

Sangupta would make an interesting Ally for fellow parahuman oruplifted Blue Shadow members, who might also be in two minds about their"rescues". He would also be a useful Contact for investigatorsattempting to infiltrate or shut down Blue Shadow. He could be encountered on araid, where he might suddenly switch sides in the middle of a battle, or viahis increasingly political activity on the Web. He currently lives on a BlueShadow ship disguised and operated as a scientific research vessel, so could befound in any ocean.

Flynn Martin 217 points

Male human, born 2046. Age 53; 5' 10", 171 lbs. Baldingbrown hair, brown eyes.

ST 11 [10]; **DX** 10 [0]; **IQ** 15 [60]; **HT** 11 [10].

Speed 5.25; Move 5.

Dodge 5.

Advantages: Appearance (Attractive) [5]; Contacts (Biotech researchers,Skill 12, 15 or less, Usually Reliable) [6]; Genefixed Human [0]; MathematicalAbility [10]; Patron (GenTech Pacifica; 12 or less, Equipment: Expensive, +10)[70]; Security Clearance 3 (GenTech Pacifica) [15]; Status 2 [5]*; Wealthy[20].

* Includes 1 free level from Wealthy.

Disadvantages: Duty (to GenTech Pacifica, 6 or less) [ ]; Enemy(Blue Shadow, 6 or less) [5]; Greed [5]; Intolerance (Dolphins)[ ]; Reputation (Ruthless uplift researcher, recognized bysmall class, Sometimes) [ ]; Workaholic [ ].

Quirks: Can't comprehend why Blue Shadow hates him; Dressesconservatively; Enjoys photography; Prefers working on cephalopods to othercreatures; Refuses to fix hair loss. [ ]

Skills: Administration−14 [1]; Animal Handling−13 [1]; AreaKnowledge (Elandra)−14 [1/2]; Biochemistry−17 [16]; Chemistry−14 [2]; ComputerOperation−14 [1/2]; Ecology (Open Ocean)−12/18 [1]; Genetics (GeneticEngineering)−17 [16]; Leadership−14 [1]; Mathematics−15 [1/2]; Oceanography−14[2]; Photography−13 [1/2]; Physics−12 [1/2]; Physiology−13 [2]; Politics−13[1/2]; Research−16 [4]; Savoir Faire−17 [0]; Scuba−13 [1/2]; Swimming−11[2]; Veterinary−13 [1]; Writing−14 [1]; Zoology (Marine)−13/19 [2].

Languages: English (native)−15 [0]; Japanese−13 [1/2].

Dr. Flynn Martin is the Senior Research Scientist of GenTechPacifica's Uplift Project (p. 00). As such, he is one of the three people incharge of GenTech's Research and Development division, along with KayseyPatrick of the Bioroid Project and the SAI Zumfleer, who is currently directingclimate control research. The trio makes broad policy decisions on thedirection of GenTech's research, under guidance from the board of directors.Unknown to Martin and Patrick, Zumfleer is in constant contact with the boardand takes orders directly from them without question.

Martin joined GenTech Pacifica in 2073, straight out of his Ph.D.program in genetic engineering at James Cook University in Townsville,Australia, where his thesis work was developing gene sequences for hightemperature adaptation in coral species. His success in this field led to thedevelopment of several important corals over the next few years, which wereused to replenish tropical Pacific reef systems ravaged by global warming.According to his employment contract, the patents for these corals were issuedin the name of the company, and although Martin was well compensated he neverrealized how much money he'd made for GenTech.

His unquestioning loyalty and clear brilliance in gengineeringled Martin through a rapid rise and assignment to the Uplift Project, where heproduced significant enhancements for the Octosap II. He went on to work ondolphin uplift, but did not find it as interesting as invertebrate work. Martincut corners on the research and came up with genemods that enhanced dolphinintelligence but at the cost of undesirable secondary traits. His indifferenceand cruelty to the dolphin specimens became legendary within GenTech, and by2093 Martin had become Blue Shadow's "most wanted" biotechnologist.

Today, Martin is administrative head of the dolphin upliftprogram, but has returned to cephalopods for his own work attempting touplift squid species. He encourages free experimentation and less−than−ethicalpractices on dolphin research subjects which suits the GenTech boardbecause it produces results. He is aware that his life is in danger from militantPreservationists, but can't understand why they object to his work. He lives inElandra and commutes to Australia a few times a year under heavy guard. BlueShadow tries to track his movements, but is frequently taken unaware by them.

Martin is just the sort of person the GenTech board wants as asenior administrator: loyal, hard working, ruthless. He has no loved ones whocould be used as leverage against him, but interacts with many researchcolleagues and rivals on the Web. He could be a useful Contact for charactersdealing with the biotech industry, probably via the Web rather than in person.Personal interaction with Martin is more likely to come in the form ofattempting to assassinate him, or protect him from such attempts. He would alsobe a valuable prize for Blue Shadow if captured alive.

Coak 260points

Male dolphin, born 2085. Age 14; 10' 5" long, 612 lbs.Smooth, dark gray−green skin, shading to white on belly, which is covered infaint surgery scars.

ST 18 [0]; **DX** 13 [0]; **IQ** 12 [20]; **HT** 11/16 [0].

Speed 6.00; Move 13 (swimming).

Dodge 7.

Advantages: Ally Group (Irukandji, Large group, 12 or less, 100 points)[80]; Combat Reflexes [15]; Strong Will +2 [8]; War−Dop (E−model) [141].

Disadvantages: Bad Temper [−10]; Enemy (Major law enforcement agencies, Formidablegroup, 6 or less) [−20]; Fanaticism (Gengineering and uplift of animals must bestopped) [−15], Odious Personal Habit (Gloating) [−5]; Sadism [−15];Stubbornness [−5].

Quirks: Amused by irony; Enjoys showing off surgery scars; Likeschocolate; Proud; Swims rather than taking vehicles when practical. [ ]

Skills: Acting−13 [4]; Administration−11 [1]; History−10 [1];Interrogation−14 [4]; Intimidation−15 [8]; Leadership−18 [12]; Memetics−14[16]; Strategy−17 [14]; Survival (Open Ocean)−13 [4]; Survival (Reef)−12 [2];Tactics−12 [4]; Zoology−10 [1].

Languages: Tursin (native)−12 [0].

The U.S. Navy's Cetacean Enhancement Program suffered a majorsetback in 2092 when Blue Shadow raided their Pearl Harbor research facility,rescuing two E−model War−Dops before their final conditioning. Blue Shadowdeactivated their puppeteer implants, sterilized them, and tried to deprogramthem to live a reasonably normal life. One of the Es suffered from chronicstress atavism and developed bestial tendencies, becoming uncontrollablyviolent until finally released to the wild. The other turned out to be evenmore intelligent than GenTech or the CEP could possibly have hoped . . .

Coak, as he was named by the CEP, took to the Preservationistphilosophy and eagerly agreed to join Blue Shadow. Following a couple oflow−key assignments in which he was observed discreetly for loyalty andeffectiveness, Coak was welcomed as a full and trustworthy member of theterrorist group. He immediately began cultivating contacts reaching far beyondthe small cell of fellow members to which he was supposed to have access. Hefound several people who were increasingly frustrated with Blue Shadow's policyof minimizing loss of sapient life, seeing it as restricting the effectivenessof their operations.

Early in 2096, Coak activated his plans and left Blue Shadow,along with several of his contacts. Four months later, a spectacular explosiondestroyed a Biotech Euphrates gengineering laboratory ship in theMediterranean. A document claiming responsibility was circulated on the Web,signed with the name of a new terrorist group: Irukandji.

Coak is probably the most intelligent dolphin in the solarsystem, and also the most bitter and vindictive. He resents the treatments andsurgery used to turn him into a machine of war, he despises the research andthe ideas which produced his very body, he is pained by the sheer indignity ofthe way in which animals have been used as tools by humans. He has researchedwidely and been disgusted to find that humans have *always* treated animals as lesser beings.

The tremendous fury in Coak's soul is tempered by the knowledgethat he alone among the animal world is uniquely placed to exact revenge.Although only moderately bright by human standards, he retains an animalcunning and is a strategist *par excellence*.Irukandji boasts excellent scientists, technicians, memetic engineers, andfield operatives amongst its scant hundred members. They are all fanaticallyloyal to Coak and do their best to further his goals and plans. This networkhas access to stolen equipment and funds from Blue Shadow indeed manyof Coak's followers still pose as Blue Shadow members so they aresurprisingly well−equipped.

Irukandji is run from a prefabricated underwater habitat that canbe carried and placed anywhere in the world's oceans by a carrier ship. It hasbeen moved several times by infiltrated Blue Shadow cells who remain none thewiser. Coak prefers to swim under his own power, because this gives him time topretend that he is a wild baseline dolphin, and to think up his dementedschemes. Since he resembles a baseline to all but close inspection, he can passunnoticed in many places where humans would be suspicious.

Coak is an obvious Enemy for many types of characters, includingbiotech researchers, corporate troubleshooters, law enforcement agents, andnaval personnel. It would be difficult to use him as a Patron or Contact exceptin a game where the PCs are themselves militant terrorists. Other characterscould meet Coak briefly, perhaps even without being aware of it, in the fieldwhen he is taking one of his intelligence–gathering jaunts. Anyone who runsinto him and becomes aware of his identity would be in line for a huge rewardif he could be captured.

Aquatic Technology

The oceans have long been an unregulated highway for thosewith the technological prowess to travel it.

Harlan Cleveland, U.S.Ambassador to NATO 1965−1969.

Ridley glided along a wall that appeared to have escaped theIrukandji attack unscathed. Some of the buildings had been completely destroyed   ruptured hulls allowing the sea to spill in, killing those inside.Others were critically damaged and had been tended to swiftly. The living wallsof the habitats were marked with the telltale sonar beacons from the emergencyresponse crews and fluorescent dyes released by the maintstars that crawledover every surface. Divers, cybershells, and Octosaps swarmed around thelargest buildings and the water was thick with sonar transmissions. Almosteveryone was armed; Irukandji was infamous for booby traps and surprise attacksafter they lured out maintenance crews.

He spotted a dye marker and turned to investigate, controllinghis squidpack with practiced ease. A crack the width of his finger gaped in thestructure. The flexible metal jacket within was intact, but the limestonecovering had taken a scab and needed repair if maximum strength was to bemaintained. He transmitted a sonarcoder burst with the damage assessment to thecontrol center and went to work.

Ridley pulled a roll of fine copper mesh from a pouch and bentit into shape. He pushed it into the crack, attached an energy cell, and letchemistry get to work. Chemistry could only go so far, however, so he took aspray canister and released small clouds of velox growth hormone onto the coralon either side of the gap. Within a few days the coral would grow over thewound, sealing it as though it had never existed.

Habitats

(((START BOX)))

Seacrete and Aquacrete

Seacrete is anunderwater construction material produced by a technique invented by WolfHilbertz in 1976. A frame of wire is placed in sea water and an electriccurrent passed through it. This causes chemical reactions in the water,resulting in the deposition of calcium carbonate   limestone   onthe framework. It accretes at a rate of 0.02 inches of thickness per day. Underideal conditions, 2 lbs. of seacrete are produced per kWh of energy used, buteach kW of power requires 500 sf of mesh on which to grow the limestone. (This impliesan even accumulation of 0.01 inches per day, but seacrete is lumpy andsemi−porous.)

In practice, seacrete is useful only for laying down afoundation structure, since the rate of accretion drops as the mesh electrodesare covered. Its main advantage over conventional construction is that the meshcan be produced in any shape before accretion is begun, creating structuresimpossible to cast in concrete.

Aquacrete is thepopular name for the limestone deposits left by a rapidly growing gengineeredcoral known as *Acropora* *velox*.Based on one of the fastest−growing natural coral species, a colony of *A.velox* can deposit a layer of structurallysound limestone 0.2 inches thick per day. This rate of accretion requires waterrich in dissolved calcium and carbon dioxide as well as organic nutrients, sogrowing *A. velox* colonies areirrigated with fresh sea water by impeller pumps. Aquacrete is commonly grownon a foundation shape of seacrete.

Several varieties of *A. velox* have been developed and are used for applications requiring differentgrowth patterns. Although the limestone is strong, it is not solid, andcontains small chambers and channels which can be colonized by other creaturesto form a living structure. Once a structure has reached the requisite strength,a synthetic hormone released into the water switches the coral into aslow−growth mode, in which it adds less than an inch of material per year.Maintenance on aquacrete structures can be carried out either conventionally orwith a supply of various hormones to influence growth rate.

Structures made of aquacrete have DR 4 and require 60 pointsof damage per inch of thickness to be breached. A wall of aquacrete used ascover provides DR 40 per inch of thickness to whatever it is protecting. A yardof aquacrete has a radiation PF of 64 (see p. TS60).

(((END BOX)))

Construction Material

Seacrete Mesh: A precisionmetal mesh used for shaping structures to be constructed from seacrete (seebox). Comes in two grades: *fine*for small areas and repair jobs, and *course* for new walls and buildings. Coarse mesh is only sostrong though, and requires a stiff framework to tether the edges if coveringan area greater than 10 square feet. Fine mesh is $1 and 0.1 lb. per sf; coursemesh is $3 and 0.4 lb. per sf.

Acropora Velox: Thegengineered coral polyps that produce aquacrete (see box) include a"terminator" gene sequence that renders them unable to reproducesexually and kills them if they do not receive regular doses of a particularhormone. They can reproduce by budding, and do so rapidly when in rapid growthmode. Polyps are available for a nominal fee, but the control hormones must bepurchased from GenTech Pacifica. Life−sustaining hormone is $50 per dose; adose keeps 10 sf of coral alive for a week in fast growth mode or a year inslow growth mode. Hormones to switch growth modes are $20 per dose each,affecting the same area of coral. Each dose is 0.01 gal. and 0.1 lb.

Prefabricated Habitats

Although technology like aquacrete has made it easier toconstruct buildings underwater, most are still prefabricated on land in modulesthat can be hauled out to sea and assembled on site. To design a habitat,select components from the list below and add up the volumes, costs, and powerrequirements, then add enough power generation to cover the requirement.Multiple modules of the same type can be combined to form larger examples ofthe same structure: e.g. 10 Basic Quarters combined makes a communal bunkroomfor 10 people. Note that if food and water production facilities areinadequate, supplies will need to be imported.

General maintenance on habitats costs $0.10 per cf per year.

Living Space

Basic Quarters: Crampedcabin–style accommodation for a single person. Usually combined in pairs ormultiples to house two or more people. $1,500, 250 cf.

Roomy Quarters: Morespacious accommodation for one person. $5,000, 500 cf.

Studio: Living space aboutthe size of a hotel room. $12,000 ,1,200 cf.

Apartment: Enough spacefor a person to live comfortably with personal possessions and extra space forentertaining guests, etc. Families apartments use multiple modules. $30,000,3,200 cf.

Communal Space: Corridorsand common assembly spaces that connect personal quarters. For a fully enclosedhabitat, assign enough for the entire population. If the habitat is fragmentedinto parts separated by water, less space might be required. Per person: $500,100 cf.

Environmental Control: Airconditioning, heating, and lighting system to keep inhabitants comfortableindefinitely. If the system is overloaded, carbon dioxide will build up todangerous levels. $5,000 plus $500 per person, 10 cf plus 10 cf per person, 10kW per person.

Industrial Space

Laboratory: Anequipment–filled laboratory designed for one person using a specific Scientificskill (pp. B59–62 and pp. CI155–159). For tasks where a lab is a prerequisite,it provides no bonus to skill. For procedures where a lab is a luxury, it givesa +2 bonus. A lab can only be used for one task at a time. $1,000,000, 1,000cf, 3 kW.

Factory: Usually aminifacturing plant, although large versions can be dedicated factories forproducing specific equipment. Use statistics for *Large Printer*, *Optimized Printer*, *Modular Robofac*, or *Biofac* on p. TS153.

Food Production: Fauxfleshvats, hydroponic gardens, or aquaculture facilities. Each module can supportone person indefinitely (i.e. produces one man–day of food per day), butfauxflesh vats and hydroponic gardens require 1 kW and $2 of raw materials perday. Aquaculture costs money to set up, but its volume can be outside thehabitat, and it has no ongoing costs. $2,000, 1,000 cf.

*Water Desalinization Plant:*Produces fresh, clean water from sea water. Each module produces five gallonsper day enough for one person to drink, cook, and wash without requiringstrict conservation measures, or enough for 10 people to drink in survivalconditions. $500, 25 cf, 1 kW.

Amenities

Moon Pool: A hole in thefloor to be used as a moon pool can be added to any module at no extra cost.Note that the interior must be pressurized to match the external waterpressure, or the module will flood.

Airlock: Airlocks arechambers that can be pressurized, flooded, or filled with air to matchconditions on either side of two hatches, which open into differentenvironments. They can serve as uncomfortable decompression chambers ifnecessary. An airlock takes 10 seconds, plus 10 seconds ¥ any pressuredifference (in atmospheres), to cycle. Each module can accommodate one personor 10 cf of equipment. $1,000, 50 cf.

Decompression Chamber: Achamber used to decompress divers to avoid the bends. It usually has two exits,to environments at different pressures. Since people often spend long times inthem, decompression chambers are roomier and more comfortable than airlocks,and may include smaller secondary locks for the passage of food and otheritems. Per person capacity: $2,200, 200 cf.

Vehicle Dock: The externalhatch of an airlock can be designed to mate with the hatch on a vehicle, for noextra cost.

Power Generation

Nuclear Reactors

Both fission and fusion reactors are used in underwater andfloating environments. Newer reactors are more efficient, but more expensivethan older reactors. Use the rules on p. TS185 or p. 00 to determine size,mass, cost, and power output of nuclear reactors.

Oceanic Energy

Ocean Thermal Energy Conversion: OTEC generators (see p. 00) require long vertical pipes to access seawater at different temperature layers. A surface habitat needs a tube extendinginto the depths, while a sea−floor habitat requires a tube reaching up towithin a few hundred feet of the surface. Per MW of power produced, an OTECgenerator costs $2,625,000, occupies 35,000 cubic feet, and weighs 1,050 tons.This includes pumps, heat exchangers, working fluid (usually ammonia), and turbines.Much of the volume is spread out along the length of the piping.

Tidal Power: A tidal powerstation must be anchored to land or the sea bed, to take advantage of the riseand fall of the sea level. The greatest tides are in narrow coastal inlets, sotidal power is mostly used on land. A tidal power station costs $6,800,000 persquare mile of water which it entraps. It generates an average of 35 kW persquare mile ¥ the square of the mean tidal rise in feet. Power output maybe tailored to demand throughout the day by careful management of entrappedwater levels.

Wave Tube: Wave energy canbe harnessed with an anchored tube using wave motion to drive a two−wayturbine. A tube turbine costs $15,000 per foot of diameter, and generates 0.03kW ¥ the square of the diameter ¥ the mean wave height in feet. Thelargest practical diameter is 20 feet, but several tubes can be built along astretch of coastline. Typical wave heights in a location can be gauged from theBeaufort wind scale (p. 00).

Wave Duck: Another way toextract wave energy is with floating "ducks" that use wave motion todrive a gyroscopically stabilized turbine. A typical wave duck is 100 feet longand 20 feet wide. It costs $2,200,000, weighs 600 tons, and generates 60 kW¥ the height of the waves. Ducks are not as efficient as wave tubes, buthave the advantage of being deployable in the open ocean.

Microgenerators

These are small, portable generators widely used on boardfloating habitats for recharging energy banks or powering small devices. Eachmicrogenerator includes an integral self−sealing fuel tank and convenientcarrying handles. They are sealed and ruggedized in a DR 5 carbon compositeshell. Gasoline engines can run on alcohol, but multiply fuel consumption by1.2. See p. 00 for fuel weight and cost.

Small Gasoline: Generates2 kW and uses 0.08 gph of gasoline from a 3−gallon tank. $420, 0.55 cf, 8.3lbs.

Large Gasoline: Generates5 kW and uses 0.2 gph of gasoline from a 5−gallon tank. $855, 1 cf, 17.5 lbs.

Small MHD: Generates 1 kWand uses 0.18 gph of hydrogen from a 1.8−gallon tank. $320, 0.43 cf, 11.18 lbs.

Large MHD: Generates 5 kWand uses 0.9 gph of hydrogen from a 5−gallon tank. $1,210, 1.55 cf, 47.25 lbs.

Muscle Generators

These consist of one or more seats and either pedals or oarhandles. They are widely used by Isolates as a combination exercise machine andbattery recharger. Most are designed for long−term comfort. Versions designedfor cetaceans are available from specialty resellers. Muscle generators produce0.02 kW ¥ combined ST of operators, up to the maximum rated output.

Cycle: Consists of anextra−light steel frame with a cycle seat. Commonly mounted on a stabilizedplatform and tied to a HUD interface for virtual bike tours. The 0.4 kW ratedmuscle engine can charge an integral 0.4 kWh battery. $110, 5 cf, 20 lbs.

Scull: A sliding seat withfoot restraints and oar handles. Statistics as per Cycle generator.

Cetacean Static Exercise Unit ("Fish Trap"): A rigid frame with padded straps and restraints forsecuring a dolphin. Flexible active feedback devices provide a naturalresistance to swimming motion and transfer power to the generator. Often usedfor exercise by dolphins in space, but on Earth most cetaceans would bereluctant to get into one. The generator produces up to 0.6 kW and comes with a2 kWh battery. $360, 35 cf, 95 lbs.

Solar Panels

Solar cell power output depends on the brightness of the sun, andthus varies by weather conditions and from planet to planet. In any environmentdark enough to cause a −1 or worse Vision penalty, cells provide negligiblepower. Under sunny skies (or in vacuum), the formula for power in kW is solarcell area ¥ P, where P is 0.5 for Mercury, 0.2 for Venus, 0.08 for Earthand Luna, 0.04 for Mars, 0.01 for most major asteroids, 0.003 for the moons ofJupiter, and 0.001 for the moons of Saturn. Further out, solar cells producenegligible power. (The formula for P is 0.08 / (square of the distance from sunin AU).)

All panels are retractable and built on super−light carboncomposite frames. Power output is for Earth conditions.

25 sf Panel: 5'¥5'.Generates 2 kW. $3,250, 0.2 cf when retracted, 10 lbs.

75 sf Panel: 10'¥7.5'.Generates 6 kW. $9,750, 0.6 cf when retracted, 30 lbs.

Personal and Expedition Gear

(((START BOX)))

Consumer Items

Deep Soda: Carbonateddrinks don't fizz well at greater than atmospheric pressure, or at all if thepressure is high enough. Deep soda is the same as regular soft drink, but itcomes in cans with an integral piezoelectric pressure sensor and pressurizedcarbon dioxide canister. When opened, a precise amount of CO_2dependent on ambient pressure is released into the drink, creating enoughsupersaturation to force bubbles to appear. Even when flat the soda stillcontains dissolved gas, and should not be drunk for 12 hours prior todecompressing, to avoid embarrassing releases of gas. $1.50 a can. Champagneversions are also available, from $25 to $300 or more a bottle.

DjinnPipe: An inhalerthat generates an artificial flame−free smoke from aerosolized chemicals.Commonly used in places where flame is either dangerous or unsustainable (e.g.,low−oxygen pressurized habitats like Elandra), or underwater, for recreationaldrugs that are smoked under normal conditions. $3.

Jellyfood: A foodproduct related to pharm jellies. Simply scoop some up and chew. Available in avariety of flavors from malt to cinnamon. $0.50 each.

*Macropearls:*Gengineered oysters make it easy to grow cultured pearls as large as tennisballs. Quality is not as high as natural pearls, but they can't be beaten forgaudiness. $40−$100 for tennis ball size.

NewtGlu: Sticky padsusing gecko setae (feet hair). After removing the protective covering they canbe attached to almost any surface, and they have hairs on both sides. A tinyelectrical pulse (from an included wand) causes the hairs to extend or release.A one square inch patch can hold 800 lbs. indefinitely. $0.10 per square inch.

*S.P.I.D.E.R. Crab:*Robotic companion and toy based on a popular children's InVid series. TheS.P.I.D.E.R. is a stylish cybershell containing a custom NAI−4; the sealedtranslucent shell (PD 1, DR 3) resembles a large crab with four tentacles (ST3), two pincers (ST 5), and a single glowing sensor eye (normal human−levelvision). The AI is programmed to act like a member of S.P.I.D.E.R Squadincluding mock−fighting toys from the K.H.A.O.S. ecoterrorist faction (usinglow−powered blue−green lasers and compressed air "torpedoes"). Crabshave Move 5 and a Tactics skill of 8. Several Blue Shadow cells have a perverseattachment to these toys (as K.H.A.O.S. is a thinly veiled allusion to theirorganization) and many use reprogrammed models for errands or for bombjacking.2C (1 week). $500.

Starfish Construction Kit: For the budding young genestheticist in your family! Contains a dozenassorted starfish, starfish food, a scalpel, tubes of rejection inhibitor andgrowth hormones, and full instructions. Graft together pieces of starfish toform living creatures in shapes and color combinations limited only by yourimagination! $80, fish tank not included.

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Basic Gear

Survival Watch: Smallwristwatch with a tiny Complexity 2 computer, which is operated by voice andruns a Survival−11 skill set. It monitors the wearer's pulse, skin temperature,local pressure, location (through GPS), as well as telling time. Its smallflywheel battery can be recharged by vigorous shaking. It is waterproof to1,500 feet. $100, negligible weight.

Diving Goggles: A basicset of goggles incorporates a text−only heads−up display and a biomimetic sealbased on squid suckers; a tiny electric charge relaxes the mask for removal.The mask will tear off skin if forcibly removed without relaxing the suckers(requires a ST−5 roll, success deals 1 point of damage to the wearer). $5, 0.1lb.

Frame Goggles: Divinggoggles with attachments for most VIGs (p. TS142). $10, 0.1 lb.

Diving Mask: This headgearis standard for most recreational divers. It is a one−piece faceplate dividedinto a wraparound visor with mounting points for a VIG display, and a nosepiece.It has no straps; it is placed on the face, adjusted, then squeezed to sealusing the same biomimetic suckers as diving goggles. Takes 2 seconds to don orremove. $50, 0.5 lbs.

Dive Computer: Anextremely tiny dedicated computer running a diving expert system. It has aneffective Scuba skill of 12 in the areas of safety, emergency protocols, anddiving physics. Often included as an integral part of diving goggles or masks,interfaced to the HUD. $10, negligible weight.

Heater: A small electricalheater that is placed over the user's back to warm the blood, which distributesheat throughout the body. Extends the user's temperature comfort zone downwardby 15° F for both wetsuits and drysuits (see *Cold and Heat*, p. 00). $10, 0.1 lbs., 1B (4 hours).

Stab Jacket: A stabilizerjacket is a combination buoyancy system and load−bearing vest. It can hold arebreather system in a large back pocket and has a number of pouches andattachment points for gear and weights. In the water it has neutral buoyancy,but can be inflated using an integrated gas canister to provide 50 lbs. ofbuoyancy. $50, 5 lbs.

Life Jacket: A thin jacketthat will automatically inflate if the wearer is completely submerged (not justdrenched). The jacket orients the wearer head−up and leaned back at a slightangle. Provides 25 lbs. of flotation but reduces Swimming skill by −1 whenuninflated. $10, 1 lb.

Magnesium Flare: A flarethat burns underwater, providing bright white light (no Vision penalty) thatfalls off with a −1 darkness penalty per 20' of range. It self−ignites andlasts 3 minutes. $2, 1 lb.

Rescue Marker: A buoyantstick that, when broken, releases a high−visibility dye into the water andactivates a small emergency beacon. The dye creates a glowing green30'−diameter circle in the water within 3d seconds. The beacon incorporates aGPS receiver and will broadcast SOS and location signals on emergency channelsto a range of 10 miles. The beacon broadcasts for 5 hours and the dye lasts 2hours in relatively calm waters. $10, 1 lb.

Swim Fins: Smart−plasticswim fins with adjustable shape. Provides +1 to swimming Move. $10, 1.5 lbs.

Smartfins: Memswearswimming fins that can be programmed to vary their shape and rigidity. Thedefault settings significantly increase swimming efficiency and add +2 toswimming Move. Most users set unique thrust profiles either for a minor gain ineffectiveness or to make swimming harder in exercise programs. $100, 1.5 lbs.

Powerfins: Power−assistedswim fins, using responsive materials powered by an energy bank. Allowsnon−aquatic individuals to use their full Move underwater; they also swim longdistances as if aquatic−adapted as long as the power holds out. Aquatic−adaptedcharacters wearing these fins add +1 to underwater Move. $800, 2 lbs., 2C (4 hours).

Breathing Equipment

Snorkel: A simple set ofno−fog goggles with an attached breathing tube (1' long). In rough seasperiodic Swimming rolls may be required to keep the snorkel from being swamped,but valves prevent water from being inhaled. $1, 0.1 lb.

*Rebreathers:*Closed−circuit rebreathing systems are the dominant technology used byrecreational and professional divers; older technology is regarded as quaint ordangerous. The basic rebreather setup is a diving mask plus air tanks asdescribed on p. TS152. Rebreather tanks include a primary pure oxygen reservoirand additional tanks of mixed gas (which can be customized for various divingapplications). A dive computer is required to control the oxygen partialpressure for various depths. A rebreather system is neutrally buoyant. Charginga used gas tank costs $10/hour of capacity. Older rebreathers have only 80% ofthe endurance due to lower efficiency and weigh twice as much but theyare only half the cost.

Artificial Gill: Thesesystems, described on p. TS152, extract pure oxygen directly from water andsupply it as a breathing gas. Despite several years of work they are bulky,have limited endurance, and have yet to overtake even archaic open−circuitdiving systems in efficiency. They are not mass−produced and are only availablethrough specialty manufacturing outlets. They have neutral buoyancy. Artificialgill use is limited to a depth of 30' to avoid oxygen toxicity. A separaterebreather system is usually carried as a safety bailout in case of electronicsfailure. Older systems weigh twice as much and halve battery endurance; theyare available at a 20% discount.

*Fluorohalide Respiration:*This is a tank of oxygenated fluorohalide liquid (such as"perflubron" perfluorooctylbromide) mated to an assistedbreathing system. The user slowly lets the breathing liquid fill his lungs andthen activates the respirator, which assists in moving the liquid into and outof the lungs. An ultrasonic transducer creates convection currents to aid in CO_2diffusion and removal. Use requires the Scuba skill; an unfamiliar user mustmake a Fright Check at −3 when first filling the lungs (to suppress thedrowning reflex) and another at no penalty when he begins any serious exertion.A gallon of oxygenation fluid lasts up to five minutes current portablesystems cannot usually reoxygenate the fluid themselves but cetaceans are largeenough to carry reoxygenator units (see below). Using a fluorohaliderespiration apparatus allows the diver to ignore all of the usual problemsassociated with breathing high pressure gases, including making arbitrarilyfast descents and ascents without decompression. It is significantly harder tobreathe a liquid even resting is treated as mild exertion. Speaking,even subvocalization, is impossible. The basic system includes a 10−gal.ultralight tank. The system is dead weight unless the tanks are purged, inwhich case it generates 70 lbs. of buoyancy. Each gallon of breathing liquidcosts $50 and weighs 17 lbs. $20,000, 20 lbs., 1C (24 hours).

*Fluorohalide Oxygenator:*This device recycles and reoxygenates expended fluorohalide breathing liquid.It sterilizes the fluid, adds surfactants, and recharges it with oxygen. Itrequires access to pressurized oxygen to function at full efficiency,recharging 10 gal. per minute. If necessary it can use an integral aircompressor to oxygenate the fluid, at 2 gal. per minute. Requires 1 gal. ofadditional chemicals ($250) for every 100 gal. of recharged fluid. $25,000, 0.5cf, 30 lbs., 1D (2 hours if running compressor, otherwise 1 day).

Environmental Wear

Drysuit: A waterproof suitwith sealed cuffs for the face, hands, and feet, which keeps the wearer drywhile diving. A hood, boots, and gloves complete the suit. It provides someinsulation from the trapped air for extremely cold water additionalinsulating clothing can be worn. Drysuits give the wearer his full temperaturetolerance range when underwater; assuming proper undergarments are worn.Drysuits can be inflated to provide neutral buoyancy. DR 2. $250, 5 lbs.

Combat Drysuit: Drysuitssuitable for use in combat have the statistics of nanoweave vacc suits (p.TS159) but half the weight and cost. They are less buoyant then a conventionaldrysuit and should be counted as dead weight. Smartsuit and memswear versionsare also available.

Wetsuit: A flexibleone–piece synthetic or biofactured suit used in diving. Most cover the chestand upper and lower arms. Full–length suits that leave only the hands, feet andhead exposed are readily available, but slightly less flexible. Wetsuitsinsulate by trapping water next to the body, which is warmed by body heat. Theyare slightly buoyant. The most popular wetsuits are self–adjusting (see *Memswear*, p. TS146). A half–body suit extends the wearer'stemperature comfort zone in water (see *Cold and Heat*, p. 00) downward by 10° F. DR 1. $50, 2 lbs.Full–body suits worn with the included gloves, boots, and hood extend thecomfort zone 20° F for double weight and cost.

Spray–on: A tripleapplication of suitspray (p. TS146) provides the same benefits as a normalwetsuit. It breaks down after 1d hours in the water.

Lift Bags

These are inflatable gas bags that are attached to objectsunderwater, then inflated with gas. As the bag rises the gas expands and isusually vented out of the bag's open bottom or valves. Lift bags are rugged andrip resistant, often reinforced with arachnoweave; they are assumed to have DR1 nonrigid armor. The bottom of the bag has a number of attachment points forcables and chains.

Individual bags take a number of forms when inflated, fromteardrops to giant pillow shapes, depending on the mission. Many have attachedsonar or radio tags for easy location. All have an integral CO_2canister good for one inflation and a pocket for at least one more smaller bags can also be inflated by releasing air from a diver's tanks.Replacement cartridges weigh 5% of the bags rated lift (in lbs.) and cost $0.01per lb. Bags take 1 second to inflate for every 10 lbs. of flotation.

5–lb. Fishing Buoy: Usedby spear fishers to float small catches to the surface. 0.08 cf inflated. HP 1.$25, 0.45 lb.

25–lb. Personal Float: Alarger bag that can carry small items or large fish.0.4 cf inflated. $40, 1.2lbs.

50–lb. Diving Bag: Themost popular bag used by recreational divers. 0.8 cf inflated. $60, 1.8 lbs.

*500–lb. Recovery Float:*Used to float small salvage items and, in emergencies, function as a rapidascent system. Popular with cetacean and Aquamorph divers. They are oftenmounted on hardsuits. 8 cf when inflated. $240, 7.2 lbs.

*3,000–lb. Salvage Tube:*These bags are used to bring up boats and other large items. Several areattached vertically along a wreck; when it reaches the surface the tubes areslung horizontally under the keel so it floats high enough that it can bepumped out. They can also function as makeshift pontoons for crippled vessels.48 cf when inflated. $1,000, 30 lbs.

Personal Transport

The following items are all commonly found in coastal, surface,and underwater habitats on Earth. Modified versions to deal with local waterconditions are in use on Mars, costing 1.5 times as much. Move for all theseitems except the sled is reduced by 1 for every 10 lbs. over 200 lbs. that theuser weighs or carries. Except where noted, all devices are operated with Scubaskill (or Endurance Swimming for aquatic−adapted characters).

Finsocks: High−poweredpowerfins (p. 00) with an integral fin−drive that can propel the wearer at Move6. They are steered by ankle alignment, which takes practice, and switched onand off by clicking heels. Characters with a swimming Move of 6 or more gain nobenefit from wearing finsocks. $790, 6 lbs., 1C (5 hours).

Finpants: This is awearable fin−drive that covers the entire lower body, often styled to resemblethat of a mermaid. It has a tiny cheap Complexity 4 computer, 0.4 cf (8 lbs.)cargo space, and DR 1 carbon composite armor. It takes (30−Exoskeleton skill)seconds to don, half that to remove. It is operated with the Exoskeleton skill.Maximum speed is Move 7. $16,375, 96 lbs., 1E (10 hours).

Squidpack: This is abiomechanical device produced by Manticore Genetics that resembles a squatsquid with four arms (hence the name). It latches around the wearer's bodyusing the tentacles and forces water out of its natural hydrojet for propulsion.The wearer's body tension and head orientation guide the squid, but it takespractice to perform more then straight−line jaunts. It provides a Move of 5while underwater. It needs to be fed daily, but is perfectly happy with tablescraps and vitamin supplements. Malnourished squidpacks have substantiallyreduced capability. Manticore sells the creatures at a loss to promote itsbiomechanical consumer product initiative, promoting them heavily along withthe *Nadezdha* bioship (p. SSS21).Young genestheticists often tinker with squidpacks to produce custom shapes andcolors, as the modifications are simple and Manticore licenses access to thegenetic template for only a few dollars. $300, 10 lbs., 1C (1 week).

Divetorp: Resembling afour−foot−long torpedo with handlebars, this is simply a ducted hydrojet thatcan pull a diver along behind it. It provides Move 4 underwater, but users take1 point of fatigue every half hour. Divetorps can also be rigged to haul cargoin straight lines. $1,250, 45 lbs., 1E (1 week).

Sea Sled: This is a smallautonomous underwater vehicle (AUV) used for hauling cargo loads. It is a LargeWaterbike (Size +1) with two 0.1 VSP wings (Size −2) for lift. It is propelledby a 10−kW hydrojet and can haul 450 lbs. (22.5 cf) of cargo at Move 6 on thesurface, or Move 7 underwater. Fully loaded, it has a hydrodynamic stall speedof Move 6 before it begins to float to the surface. It has DR 5 aluminum armor,computerized controls, and both a short range sonarcomm and simple sonar array(see Appendix for additional information). It has basic sound baffling and issealed. A slot for a tiny or small computer is standard. It is controlled withthe Powerboat skill. 43 hit points and HT 8 for the body, crush depth of 23yards. $8,445, 405 lbs., 2E (4 hours).

Cetacean Equipment

Moistsuit: This iseffectively a drysuit that traps water inside. It is used to keep the skin ofcetaceans moist and clean for extended periods. Suits are custom tailored forthe species and individual. Moistsuits are most useful for cetaceans inmicrogravity space habitats. Use the statistics for drysuits but if thecreature is significantly larger or smaller than humans multiply by(weight/200).

Nanny: This is thestandard VI interface and NAI implant that can be used to allow dolphins tointeract with humans (see *Dolphin Sapience and Psychology*, p. 00). It converts dolphin vocalizations intohuman language and broadcasts the results to nearby VIs. Translation in theother direction (either from voice or radio) is fed to the dolphin's auralsenses by bone induction. A Nanny is basically a Tiny dedicated computerrunning a NAI–4 and a CeTalker program (p. 00). The NAI advises the dolphin onissues of human social interaction, and is capable of communicatingindependently if it feels the dolphin's best interests are at stake. Powered bythe dolphin's bodily myeloelectricity. $650, 0.1 lbs.

Brachiobot: A small AUVwith arm–like manipulators that can be controlled by a Nanny–equipped dolphin.Brachiobots come in several different types and have vectored hydrojets forthrust. A general purpose model typically has two ST 10 arms and can be usedfor carrying objects up to 100 lbs. at Move 5. In a pinch, one arm can beattached to an immobile object to gain some leverage with the other. Aheavy–duty model has four ST 20 arms and an integral NAI for assessing the bestways to manipulate heavy or stubborn objects; it can lift 250 lbs. (more withtwo arms anchored) and swim at Move 8. *General purpose:* $27,500, 45 lbs., 1D (2 weeks). *Heavy–duty:* $86,000, 130 lbs., 1E (1 week).

(((START BOX)))

Whale Computers

Not computers for whales   computers *made from* whales. Whales have the largest mass of brain tissueof any animal, and gengineering techniques can be used to enhance the thicknessand complexity of the folds in the cerebral cortex, increasing surface areadramatically and producing unparalleled raw processing power. This is oneavenue pursued for uplifting cetaceans, although simply making these changes tobrain morphology usually results in serious mental instabilities.

Another option is to modify the neural pathways to interfacewith computer implants and program a NAI to use the cortex as a massivelyparallel processor. Researchers have had some success with this, producingwhale brains equivalent to a Complexity 6 computer, although roughly 1,000times slower. Although a research curiosity at the moment, computing expertshave high hopes for the technology   much to the disgust of cetanists andPreservationists who see it as a final slap in the face of marine mammalrights.

(((END BOX)))

Drugs, Biomods, and Medical Gear

"Pathetic."

Coak turned away from the tank that held what had once been asapient creature, able to converse and reason. A product of the same genes thathad led to himself, twisted, tortured, and now finally broken into the pitifulspecimen swimming fitfully in circles behind him.

"Humans made you, and humans gave you the seeds of yourown destruction. Now there's an irony. To escape from the shackles ofDoolittlehood, you lobotomize yourself so all you're good for is doingbackflips in a zoo. This isn't a natural existence. Your suffering ends here .. ."

Myelin Replacement: Asimple biomod can produce bioroids whose brain tissue contains a variant formof myelin, the fatty tissue surrounding nerve cores. This has no effect oncognition, but grants Immunity to Poison (Gas Narcosis) [4] (p. 00). Adds$1,000 to bioroid model cost.

*Myelin Replacement Nanovirus:*Cerebral myelin can also be replaced in a living being by a proteus nanovirus(p. TS165). Gives Immunity to Poison (Gas Narcosis) [4]. $5,000, 2 days.

Perflubron Blood: Bioroidscan be created with radically modified circulatory and support systems, using a"blood" composed of polymer particles coated with perflubron,suspended in plasma. Compared to normal blood, this provides greater oxygenutilization capabilities and faster elimination of undesirable gases. The bloodis a milky white fluid and is sticky when exposed to air (because of a clottingagent). Perflubron blood gives Extra Fatigue +1 [3], Resistant to Poison(Dissolved Gases) [2] (p. 00), and Unusual Biochemistry [−5]. Adds $5,000 tobioroid model cost.

*Perflubron Transfusion:*Perflubron blood can be transfused directly into the bloodstream of creatures withnormal blood. This is harmless, and the perflubron is broken down by the bodywithin 48 hours. For the first 12 hours following transfusion it providesResistant to Poison (Dissolved Gases) [2]. If given to a person suffering thebends, it allows a roll vs. HT+4 every 5 minutes to recover completely.$50/gal. (4 doses).

Wetskyn: An advancedversion of plastiskin, this is a 6"¥6" biomimetic patch forunderwater use on wounds. It has active directional ion channels that allow thewound to "breathe" while preventing dehydration due to osmosis in seawater. A different version is used for fresh water   both must be appliedwith the correct side against the wound. $20, negligible weight.

Nanodrugs

Atman: Commonly used bycetanists, this drug brings a feeling of peace and harmony with the naturalworld, effectively granting Animal Empathy [5]. It also produces the Delusionthat the user can communicate with animals [−5], usually projected on todolphins. Long term (1 day), pill (HT−6 to resist), $500/dose, LC 5.

Blue Light: Thisadjusts the user's optical sensitivity to parts of the spectrum, de−emphasizingred and green and using their parts of the visual cortex to enhance blue. Thisproduces Color Blindness [−10], but reduces Vision penalties in dim blue light(such as underwater) by up to 3 points. In full sunlight, the spectralimbalance gives a −2 Vision penalty. Long term (1 day), injection (HT−6 toresist), $800/dose, LC 5.

Focus: Focus is acommon drug used to make diving safer by increasing the user's awareness andreducing any panic reactions. It can however make users *too* cautious to perform many jobs underwater. GrantsAlertness +2 [10], Composed [5], and Careful [−1]. Medium term ([25−HT]/4hours), pill (HT−6 to resist), $160/dose, LC 5.

Morlock: This is a"regression" drug tailored for Doolittle dolphins, which makes thembehave like a wild animal. It was developed by Preservationists as a humane wayto reverse the uplift process, and promoted to Doolittles as a method ofexperiencing a more "natural" existence. Unfortunately the drugdidn't work exactly as hoped, and is psychologically addictive. It adds Bestial[−10] while in effect, but also has a permanent damaging effect on brainchemistry. After each use the user must roll vs. HT+4. On a failure either addStress Atavism (Mild, Rare), increase the frequency of existing Stress Atavismby one step, or (if attacks are already common) increase the severity one step.Once Stress Atavism is severe and common, the next failure makes Bestialpermanent. Morlock also works on baseline cetaceans if the user isalready Bestial, it adds Berserk [−15] and triggers an immediate berserkepisode. It has been used this way by some naval forces. Medium term ([25−HT]/4hours), pill (HT−6 to resist), $450/dose (dolphin sized), LC 4.

Nanosymbionts

*"AquaDude":*A common nanomod for water enthusiasts. It is a cheaper alternative toRespirocytes (p. TS165). Provides Extra Fatigue +1 [3] and Breath Holding 2[4]. $350/$17,500.

*Electroreceptors:*These nanosymbionts reside in nerve tissue just beneath the user's skin. Theyare sensitive to electrical fields and initiate artificial nerve pulses undercertain conditions, granting the user Field Sense (No Absolute Direction, −50%)[5]. This allows the user to detect electrical emanations, such as fromelectric fish or equipment, and determine the direction and approximate powerlevel. $600/$30,000.

Lateral Line: Similarto Electroreceptors, but these nanosymbionts detect pressure variations,sending nerve signals that simulate the lateral line sense of fishes. Thisgives the user Faz Sense (In water, not air, +0%) [10], which allows him todetect erratically moving fish or other creatures in the water, as well asgiving a general sense of the surroundings see p. CI55. $500/$25,000.

Communications, Sensors, and Surveillance

Sonarcoder: A smallultrasonic transducer that converts audible language and data into a compresseddigital sonar emission. It uses the same technology (albeit lower−power) asvehicle−mounted sonarcomms (p. 00). The emitter is usually mounted on a divemask, with a set of small hydrophones worn over the diving suit to pick upbroadcast signals from every direction (the body also serves to transmit thesignals to the hydrophones). The system has a broadcast mode that will reacheveryone within 540' of water, or a tight−beam mode with a range of 1 mile.This allows limited data transmission (50 MB/hour); triple ranges if set tovoice−only mode. The user effectively gains Ultrasonic Speech and SubsonicSpeech. $500, 3 lbs., 1C (500 hours).

Sonar Datacoder: This is asonarcoder for high−speed data transmission. It uses high frequency ultrasonicsignals that can damage cetacean hearing any character withUltrahearing or Ultrasonic Speech within range must roll vs. HT to avoid Hardof Hearing for 1 day; critical failure indicates this damage is permanent.Datacoders are legally restricted in many jurisdictions (LC 3). It has a rangeof 2 miles, and a data broadcast rate of 500 MB/hour. 1C (5 hours). $4,000, 100lbs.

Portable Sonar Unit: Ahand−held or suit−mounted active sonar transceiver with a range of 2,500'. Theresulting images can be displayed on any VI or HUD. This grants the user theequivalent of Sonar Vision (Superior Signal Discrimination, +20%) [30]. $860, 1lb., 1B (3 days).

CeTalker: This is adedicated NAI system that translates human language (or at least the parts ofit that can be translated) into a form understandable by dolphins, and viceversa. It can distinguish various regional and species "dialects" ofnatural dolphins, as well as the Tursin language used by Doolittles.Communication with baselines is restricted to simple concepts such as food,danger, "go that direction," and so on. A CeTalker transmits audibleand ultrasonic sounds into water and receives them with its hydrophone. Itinterfaces with a VI for human language. A program−only version is alsoavailable for use with sonarcoders and other hardware. *Stand−alone:* $350, 0.2 lbs., 2A (1 month). *Program−only:* Complexity 5, $300.

Commline: Rugged opticalfiber reinforced with carbon nanofiber. Some newer production is sheathed withfibrokelp (p. 00). Commline is 0.01 lb. and $0.1 per yard. Multiply weight andcost by ¥1.2 if the line can reel itself in (at 30 feet per second). Storedcommline occupies (weight/50) cf.

Combuoy: Combuoys aredeployed by divers who wish to remain in radio contact with the surface. Thebuoy is a 0.25 cf submersible body with DR 10 carbon composite armor, a radiowith a range of 200 miles which can relay via satellite if necessary and a 1,000−foot retractable spool of commline. The line is tethered tothe diver and unspools with virtually no resistance. If the diver swims nearobstacles or engages in combat, a DX+2 roll is needed to avoid becoming snaggedor entangled. The free end can also be tethered to an AUV drone (Move 3) thatautomatically stays 10' above the diver, using sonar to bridge the gap.Combuoy: $1,870, 14 lbs., 1C (3 weeks). Drone: $3,625, 45 lbs., 1E (1 week).

Pinger: Used as a noisesource for navigation and for locating targets with separate hydrophones. It isan active sonar with 250' range and no targeting. $80, 2 lbs., 2C (20 hours).

*Sonar Navigation System Buoy:*SNS Buoys are most commonly used on Europa, but are also used on Mars and thesea floor on Earth. They are spherical buoys 10' in diameter attached to thesea floor by long cables. Negatively buoyant versions also exist that aredesigned to hang from a fixed ice cap (usually used on Europa, but also on Marsand in the Arctic). They emit sonar pings at one minute intervals, each buoyhaving a unique low frequency and ping structure so that they are individuallyidentifiable. The pings can be detected at a range of 10 miles on Earth, 12miles in the denser seas of Mars and Europa. A more portable emergency versionexists as a one−foot diameter sphere, capable of broadcasting sonar pings to0.5 miles on Earth, 0.6 miles on Mars and Europa. *Tethered SNS Buoy:* $300,000, 525 cf, 7,000 lbs., 2 Heavy Cells (6months). *Portable SNS Buoy:*$3,000, 1 cf, 45 lbs, 5D (10 days).

(((START BOX)))

Sonar and Aquatic Life

Sound intensity is measured in decibels (dB). A sound withthe same "loudness" is 62 dB higher underwater than in air, becauseof the difference in sound transmission characteristics subtract 62 dBfrom an underwater intensity to determine its equivalent intensity in air.Underwater sound levels above 180 dB can cause tissue damage in marinecreatures, rupturing membranes surrounding lungs or swim bladders. Lowfrequency sound of this intensity can also trigger the formation of gas bubblesin the bloodstream of deep−diving animals such as whales and tuna (or deepscuba divers), producing the effects of severe bends, including strokes anddeath.

In the late 20th century, NATO powers tested low frequencyactive sonar with an intensity of 230 dB. Because water carries sound betterthan air, lethal intensities covered a vast area of sea, killing whales over 60miles away from the test zone. Several other whale beachings were tied tonearby military sonar activity. After a period of research and public outcry,NATO abandoned plans to deploy these systems throughout the world's oceans.

Less intense sonar systems are now standard in ***TranshumanSpace***. At 175 dB, anactive sonar signal must however compete with other man−made sounds and thevocalizations of whales. The cargo ships of 2100 are quieter than theirpredecessors, but still generate 170 dB as they ply the oceans. Whales producesounds up to 175 dB.

All this artificial noise has an adverse effect on whalesocialization. Prior to the industrial revolution, subsonic whale vocalizationscarried thousands of miles around the globe, creating a dense pattern ofoverlapping sound, similar to being in a crowded room. With other noises nowdrowning out whales within a few miles, the world feels a lonelier place forthem. Cetacean psychologists continue studying the effects of this on whalebehavior, but findings are still controversial and laced with bias on bothsides.

((END BOX)))

Sonobuoy: A buoy thatcan be deployed from aircraft to scan the water below with sonar and relay databack to the aircraft or a base. Sonobuoys have a small parachute fordeployment, GPS for navigation and location, and a radio with 100−mile range.They have a 1−mile sonar range (Scan 11). *Passive sonar only:* 1C (24 hours). $1500, 1 cf, 50 lbs. *Active/passivesonar:* 1D (24 hours). $5000, 3 cf, 160 lbs.

Weaponry

(((START QUOTE)))

The two killer whales were a little under thirty feet long .. . Franklin reminded himself that he was looking at the most ruthless killerin the sea.

No, that was not quite correct. The *second* most ruthless killer in the sea . . .

Arthur C. Clarke, *TheDeep Range*.

(((END QUOTE)))

Most of the weapons on pp. TS155−159 are usable underwater, butrefer to p. 00 for exceptions and details such as range reductions. Thefollowing weapon types are also available.

*Supercavitating Bullets:*Nicknamed "scabs," these are a type of smart ammo (p. TS157) designedspecifically for underwater use. These bullets are dynamically shaped bypiezoelectric actuators to form a supercavity (see *Supercavitation*, p. 00) and thus travel faster and farther thanother bullets. They have half the gun's Maximum and 1/2 Damage rangesunderwater (10 times that of non−supercavitating bullets), and the same rangesin air since they are optimized for water. ¥2 cost.

Minitorps

15mm and 30mm mini−torpedoes are available for underwater use.Most are fitted with HEMP warheads, but SEFOP and MBC are also available (pp.TS158−159). They have a fixed range, independent of the weapon from which theyare fired. All minitorps are *stabilized*(p. TS157). Homing varieties are available but of limited use because of poorlight penetration in water. They are fired from standard launchers.

15mm: Travels at Move 22on the second it is fired, then supercavitates at Move 38 for the next threeseconds. It does 1d−3 crushing damage if it uses a solid warhead. 0.1 lb., $180each. Cost does not vary with warhead.

30mm: Travels at Move 22on the second it is fired, then supercavitates at Move 71 for the next threeseconds. It does 1d+1 crushing damage if it uses a solid warhead. 0.8 lb.,$1,440 each. Cost does not vary with warhead.

(((START BOX)))

Large Warheads

These warheads can be used on torpedoes, or used to build airor space AKVs.

HEMP

100mm: 6d¥30concussion and 10d cutting fragmentation; 5d¥20 (10) shaped charge.

250mm: 6d¥500concussion and 12d cutting fragmentation; 6d¥40 (10) shaped charge.

300mm: 5d¥1,000concussion and 12d cutting fragmentation; 3d¥100 (10) shaped charge.

400mm: 6d¥2,000concussion and 12d cutting fragmentation; 4d¥100 (10) shaped charge.

600mm: 6d¥6,750concussion and 12d cutting fragmentation; 6d¥100 (10) shaped charge.

SEFOP

100mm: 7d¥40concussion, and either 2d¥100 (5) crushing or 10d cutting fragmentation.

250mm: 6d¥732concussion, and either 5d¥100 (5) crushing or 12d cutting fragmentation.

300mm: 6d¥1,265concussion, and either 6d¥100 (5) crushing or 12d cutting fragmentation.

400mm: 6d¥3,000concussion, and either 4d¥200 (5) crushing or 12d cutting fragmentation.

600mm: 6d¥10,125concussion, and either 2d¥600 (5) crushing or 12d cutting fragmentation.

MBC

100mm: Covers 37−hexradius (444 doses) or carries a 4−hex cyberswarm.

250mm: Covers 234−hexradius (18,174 doses) or carries a 72−hex cyberswarm.

300mm: Covers 337−hexradius (37,744 doses) or carries a 125−hex cyberswarm.

400mm: Covers 600–hexradius (119,800 doses) or carries a 296–hex cyberswarm.

600mm: Covers1,350–hex radius (607,050 doses) or carries a 1,000–hex cyberswarm.

Bus Warheads

These warheads carry multiple 30mm minitorps or projectilesthat can deploy at any time after firing. Each missile travels at Move 650 atrelease, or decelerates to that speed after a few seconds.

100mm: No missiles.

250mm: 26 missiles.

300mm: 45 missiles.

400mm: 106 missiles.

600mm: 360 missiles.

(((END BOX)))

Torpedoes

Torpedoes are self–propelled submarine or surface missiles.Although guided by NAIs, they have not had to reach the same level ofsophistication as AKVs since naval countermeasures are not nearly assuccessful as space point defense lasers and are still generally called"torpedoes."

Smart reactive surfaces and rocket propulsion systems allowtorpedoes to supercavitate (see p. 00) and travel around 300 mph whilesubmerged. Supercav torpedoes use vortex combustor ramjets (VCR) or solidrockets (see p. 00) for propulsion. They navigate by dead reckoning after beinggiven the range, direction, and velocity vector of a target. If a VCR torpedomisses, it can drop out of supercavitation and use sonar or visual sensors toreacquire its target. Solid rocket types simply continue at top speed untilexhausted, at which point they can turn into proximity mines if so desired.Cheaper torpedoes use hydrojets and do not supercavitate.

Although usually launched from marine vehicles, torpedoes canalso be fired from stationary bases, dropped into the sea by aircraft, or evenfired from space. A dropped torpedo deploys parachutes to slow impact with thewater, acquires its target through relayed telemetry or its own sensors, thenactivates propulsion.

Torpedoes should be built as vehicles with large warheads (seebox), using the Appendix. Two example torpedoes are given in the *Vehicles* section of this chapter.

Cyberswarms

Lamprey Cyberswarm: Abasic aquatic devourer swarm. The swimming microbots are powered by RTGs. Thesehave been deployed on Europa in the War Under the Ice. $10,500 per hex, Move 4,1 year endurance, 12 hit points per hex, LC 1.

Pearlweb: A pearlweb is acyberswarm consisting of hundreds of spherical aquatic microbots connected bymachine−phase struts that can become flexible or stiff. Each "pearl"has a small hydrophone and the entire array can move and rearrange itself formaximum efficiency forming a 3D array, line, net, or any combinationthereof. In an optimal configuration a pearlweb can swim at Move 8, which isenough to catch most fish not actively trying to flee. Once it has caught afish, the pearlweb engulfs it, restricting water flow to the gills andimmobilizing the body, then homes in on a sonar beacon with its prize.Pearlwebs are useful for selective fishing of species with no wasted bycatchand for biological research sampling. They can also be programmed foranti−personnel tasks. Larger pearlwebs are needed for heavy targets onecapable of catching a human requires six hexes. $6,500 per hex, Move 8, 3 hoursendurance, 12 hit points per hex. Available with RTG power supplies, giving 1year endurance, for $3,500 extra per hex.

Piranha Cyberswarm: Theseswimming devourers are built to look like small toothed fish. The individualmicrobots are larger than most other cyberswarms, so that potential victimsseeing the swarm can recognize it and react with fear (GMs may require a FrightCheck). Piranha swarms are generally used as guards for sensitive facilities.Statistics are as per Lamprey Cyberswarm.

ReefClean: MbungweEngineering's ReefClean cyberswarm is designed to look after coral reefecosystems. The swimming, crawling, and burrowing microbots can detect and neutralizemany potential threats to reefs, including chemical contamination, foreignorganisms, and minor physical damage to corals caused by impacts or heavyweather. A hex of swarm can patrol an area of 100 square yards. They run on agastrobot power system and must surface a few times a day for air. $8,000 perhex, Move 4, unlimited endurance, 12 hit points per hex.

Living Creatures

Rose Fox looked around her. The world was shimmering blue. Shefelt the cool currents on her skin. She turned with a kick of her tail, glancedto her left, and saw the hulk of the gillmorph gliding through the water besideher. It was a Frankenstein's monster of tentacles with two human arms, thehottest new design from Biotech Euphrates. Sensing her stares, one of his eyes turnedto focus on her. She quickly looked away and suppressed a shudder. She couldnever understand why Atlantec decided to use such horrid looking bioshells.

There was a buzz in her skull and her AI began translating theultrasonic speech of her guide. "This way." Apparently to emphasizethe point the gillmorph also signed using his arms and tentacles for her tofollow him away from the ship. It was oddly hypnotic.

She swam easily with the fluid grace of her dolphin bioshell.Her echolocation indicated a large object floating in the water just ahead.Before she could tell what it was, the sun was blacked out as a vast shadowloomed overhead. She looked up and was staggered by the size of the thing."A whale?" she thought, slipping into her old marine biology career."No . . . whales aren't that broad . . ."

The gillmorph was waving a sonar transponder at the creature.It slowed and came to a stop in the water, drifting slowly to the surface."Okay, topside," he buzzed to her.

Rose surfaced and saw the animal was a whale shark, but threetimes as long as any she'd heard of, and a mottled green color. The Atlantecship had drawn alongside, and crew were climbing on to the shark's back withhoses and buckets. A man attached a hose to a port near the dorsal fin.

"Emptying the storage bladders," explained thegillmorph in croaky English, "And the engineers are replacing damagedmicrobots.

"There's enormous amounts of junk floating in the oceans.Plastic, non−biodegradable chemicals, microscopic droplets of oil theflotsam of two hundred years of abuse and neglect. This leviathan takes all ofit out. In the three months between maintenance calls it filters seventymillion tons of sea water and collects up to three thousand gallons of stuff itcan't process safely. With a hundred or so of these in each ocean we'll be ableto remove over twenty thousand tons of pollution a year. Before long the oceanswill be cleaner than they've been since the age of sail . . ."

Rose chittered at the gillmorph in Dolphinspeak. "You'veconvinced me. I'll have my AI authorize the donation immediately."

Diving Squid

ST: 15 **Move/Dodge:** 12/10 **Size:** 4

DX: 14 **PD/DR:** 1/2 **Weight:** 240 lbs.

IQ: 4 **Damage:** 1d−3 cut **Habitat:** SW

HT: 14 **Reach:** C, 1−2

This is a gengineered Humboldt squid about 12 feet long, which ismostly transparent. A diving squid contains a body cavity large enough for oneperson to fit inside, or two if they are very friendly. A control organ can beused to command and steer the squid, which swims long distances by beating itsfins. It can also make short bursts at speeds up to Move 25 by squirting jetsof water. Water flows through the cavity, supplying oxygen to water breathingpassengers, but air−breathers need their own air supply. Diving squid can diveto about 1,000 feet, but offer no pressure support to their passengers. Theyare mostly used as short−range transport by underwater dwellers.

Grappler

ST: 16 **Move/Dodge:** 7/7 **Size:** 1

DX: 14 **PD/DR:** 1/1# **Weight:** 140 lbs.

IQ: 3 **Damage:** 1d−4 **Habitat:** SW

HT: 12/15 **Reach:** C,1,2,3

Grapplers are bioroid designs using octopus and bivalve features.They live in a shell three feet across and passively filter feed most of thetime. Neural implants allow them to recognize friends by receiving a VI code;if anyone without the pass−code approaches the grappler will reach up to 3yards from its shell and grab the trespasser. It hits on a successful DX roll,with Dodge the only possible defense. A grabbed victim must win a Contest of STto break free; if he fails he takes constriction damage. The grappler will holdone person for 48 hours, or until given a release signal. Listed PD and DR arefor the body; the shell has PD4, DR 6.

Leviathan Filterer

ST: 1200 **Move/Dodge:** 5/− **Size:** 4

DX: 10 **PD/DR:** 1/4 **Weight:** 150 tons.

IQ: 3 **Damage:** − **Habitat:** SW

HT: 12/800 **Reach:** −

This is an enormous genemod fish, designed by Atlantec to swimslowly through the oceans filtering the water of any pollutants. Leviathans arebased on whale sharks and resemble them, but grow up to 100 feet long. They arepassive filter feeders, and also extract solid and liquid contaminants from thewater, including many types of waterborne microbots and nanobots they mayencounter. Leviathans generally swim near the surface, where photosyntheticcells in their skin allow them to absorb carbon dioxide and produce oxygen.Each leviathan carries a specialized microbot swarm that keeps the creaturegroomed and free of parasites. The microbots recharge by attaching to solarpowered recharge stations implanted in the leviathan's back. Other microbots inthe gut assist in breaking down foreign matter. Each leviathan is tracked bysatellite and Atlantec ships occasionally rendezvous with them to empty storagebladders, replenish microbots, and perform other maintenance.

Smartshark

ST: 25−40 **Move/Dodge:** 9/6 **Size:** 4−6

DX: 13 **PD/DR:** 1/1 **Weight:** 1,000−2,000 lbs.

IQ: 4 **Damage:** 2d−1 cut **Habitat:** SW

HT: 12/20−35 **Reach:** C

Once people began experimenting with gengineering marinecreatures, it was inevitable that someone would try to make a smarter shark.These sharks *are* somewhat moreintelligent than the unmodified mako sharks on which they are based (which haveIQ 3), but their simple neural structures could only take so much improvement.The most notable difference is in behavior. Normal makos are solitary creatures,but smartsharks patrol in packs and use cooperative attack patterns to killcreatures larger than the species would normally tackle, including cetaceansand humans. Several have been released into the wild around the HawaiianIslands, and have established themselves by outcompeting the baseline sharkpopulations. Specimens have turned up all around the Pacific Rim andPreservationist groups fear further losses in several baseline shark species.(Smartshark statistics can also be used for normal sharks.)

(((START BOX)))

Starfish Technology

*Nobody wishes on a star**fish** . . .*

Clare Booth Luce, toSylvia Earle, 1979.

Well, let's hope not.

Isaac Zakob, LeadGengineer, Mbungwe Engineering Minestar Project, 2096.

Starfish are incredibly malleable creatures, genetically, andhave been adapted for many uses. They have multiple sensitive and dexterouslimbs, a natural regenerative ability, and come in sizes from under an inch upto eight feet across. Starfish move slowly, have no effective Dodge, and canonly be killed by 1 point of crushing damage per inch of diameter. A point ofcutting damage per inch of arm diameter will sever an arm, but both pieces willeventually regenerate into full starfish. Although more practical technologyexists for most purposes, genemod starfish are popular among "wet"technologists.

Foodstars live amongsthuman colonies, eating a nutrient mix oozed from pipes for them. Differentvarieties are color−coded and produce flesh with different designer flavors.Arms can be cut or bitten off and eaten directly the remaining bodiesregenerate rapidly.

Lockstars have asensitive pad on their top sides. When stroked there, their arms fold toenclose whatever they have been placed on. Another stroke will release thegrip. A single lockstar has enough strength to hold 10 lbs. of force per inchof diameter, and will do so for a day before relaxing and seeking food.

Maintstars aredesigned to live on the surface of underwater structures or vehicles. They feedon algae, barnacles, and other encrusting life−forms, keeping the structuresclean and free of fouling. The latest versions can detect stressed metal with asimple magnetic sense and feel eroding aquacrete or other constructionmaterial. When they encounter such a spot, they eject an organic dye on to thearea, marking it for attention by maintenance workers.

Minestars are sterilebioroids designed by Mbungwe Engineering to be scattered from ships overabyssal plains rich in manganese nodules. The foot−wide starfish sink to theseabed and seek out the nodules. When one finds a loose nodule, it wraps itsarms around it and begins inflating an internal bladder with carbon dioxideproduced by metabolism. Within a few days, the starfish begins floating to thesurface, carrying its cargo. Gas vents from the bladder as it expands underlower pressures, and the starfish eventually reaches the surface where it canbe collected by skimming ships. The collected minestars are fed and recycledwhile the ore is processed. Releasing similar creatures capable of reproductioncould have disastrous consequences, and Mbungwe has been exceedingly careful toavoid this.

(((END BOX)))

Plants and Small Animals

Fibrokelp

Gengineered giant sea kelp produces useful commercial fibers.Fibrokelp grows at fantastic rates, each strand producing a yard of material afoot wide per day. After harvesting and processing, fibrokelp is used forclothing, flexible armor, sails, and building material. A layer of fibrokelpprovides PD 1, DR 4 (PD 1, DR 2 vs. impaling), but items made of it cost halfthe price of arachnoweave (p. TS159).

Gorgonfish

These vile creatures are modified hagfish, the size of pencils.The hooks in their jawless mouths latch on to victims and a rasping tongue digsinto the flesh, causing 1 point of cutting damage. If not removed within 10seconds, the gorgonfish will have burrowed into the victim, where it feeds onthe flesh from the inside, causing another point of damage each minute untilremoved. They penetrate flexible armor at a rate of 30 seconds per point of DR rigid armor will stop them completely. Removing an attached fish isdifficult because of their slimy skins and wriggling, requiring a successful DXroll with one attempt allowed each five seconds. A single point of damage, orsimply crushing in a hand, will kill a gorgonfish. An embedded fish may beremoved with a successful First Aid−4 or Surgery roll; the attempt causes 1d−4points of cutting damage, or none on a critical success.

Guardian Urchins

These are spiny sea urchins that produce a deadly neurotoxin.Anyone brushing against the spines must roll vs. HT−6. Failure indicates 3ddamage from the venom and nausea and dizziness for 1d hours, causing a −3penalty to all attribute checks and skill rolls. Critical failure means deathwithin one minute. A successful roll indicates nausea and dizziness for 3dminutes, with −3 to rolls as above. Only a critical success or Immunity toPoison will negate the effects. Guardian urchins are engineered to stay withinthe range of a weak sonar beacon. Shallow−water shipwrecks and archaeologicalsites are often protected by urchins, which swarm on every available surface,making it difficult to touch anything without being scratched by one. Thisprotects sites from casual treasure hunters, but does not deter professionals.

Pharm Jellies

Biotech companies have turned several jellyfish species intobiological drug factories. The grow quickly, turning food particles into cellsladen with desired pharmaceuticals. Processing is easy entire jellyfishare simply fed into a pulper and the drug is distilled out of the slurry.

Vehicles

This section presents nine vehicle designs in the standard formatused to describe vehicles in other ***GURPS*** books. Use these as a guide when creating your ownvehicle designs.

(((START BOX)))

Vehicle Key

The vehicle descriptions list components in the formatdescribed here.

Subassemblies: Themajor parts of the vehicle. The number following each subassembly is thetargeting bonus to hit. Abbreviations include *Tur* for turrets, *Hyd* for hydrofoils, *OM* for open mount, and *Wng* for wings.

Power and Propulsion (P&P): Describes the size and type of all propulsion andlift systems, power plants, and energy banks.

Fuel: For fuel, givesthe amount, type (with Fire number in parentheses), type of fuel tank, androutine or cruising endurance. For energy banks, provides endurance data undervarious conditions. Fire is the chance, on 3d, of a fire breaking out in thefuel tank if the vehicle is disabled (drops to zero or less hit points) ordestroyed.

Occupancy: Each numberis followed by an abbreviation. CCS is a cramped crew station, NCS a normalcrew station, and RCS a roomy crew station. Passenger seats use CS, NS, and RSfor cramped, normal, and roomy positions, respectively. An exposed position isnoted with an X (e.g., XNCS for an exterior normal crew station). Cycle crewstations are listed as "cycle."

Cargo: Gives capacityin cubic feet. Each cubic foot generally holds 20 lbs.; exceptions are noted.

Armor: Vehicleswithout this notation have no armor. F indicates frontal armor, RL right andleft, B back, T top, and U underbody. If the entire subassembly has the samearmor, only one value is listed. Special circumstances are detailed below thetabular columns of armor values.

Weaponry: Vehicles withoutthis notation have no integral weapons. Location notation gives the facing ofeach weapon, as per *Armor*. Allweapons are assumed to have full stabilization (cancels up to −3 in movementpenalties). Weapons in turrets have universal mounts (they can elevate up to90°). Ammunition includes all shots stored on the vehicle, not just roundsin a magazine. Following each weapon is the targeting modifier provided by allthe vehicle's supporting systems.

Equipment: Grouped bylocation, these are the gameplay−essential accessories of the vehicle; otherswill be described in *Design Notes*,below.

Statistics: *Size* is a *rough* indication of dimensions, usually length¥width¥height.*Payload* is the sum of the usual payload(occupants and cargo), fuel, and ammunition weights. *Price* is the full price excluding fuel and ammunition. *Lwt.* is loaded weight. The lowercase letter before aperformance rating indicates a mode of travel; *a* is air, *w*is water, *u* is underwater, *c* is supercavitating. e.g., *wSpeed* is top water speed, and *uMR* is underwater maneuver rating. *Speed* is in mph (halve to get Move in yards per second). *Accel* is acceleration in mph per second. *MR* is the maximum safe Gs that a vehicle can pull in amaneuver; to determine turning radius per p. B139, square the vehicle's currentspeed then divide by (40 ¥MR). *SR* is the stability rating; if the GM rules that a vehicle operator has tomake a skill roll to perform a potentially hazardous maneuver, failure by morethan SR should result in not only failing the maneuver, but also potentialdisaster (e.g., crashing into something, spinning out of control, etc.) at GM'soption. Hydrofoils have separate wSR and wMR when they rise on their foils. Forair vehicles, stall speed is the lowest air speed the vehicle can have and stillfly. For submarines, *crush depth*is listed; see *Crush Depth*, p.00.

Design Notes: Acompilation of everything else, the vehicle accessories and data that rarelycome up in play, but are useful for reverse–engineering or modifying thedesign.

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Verodyne Sea skimmer Luxury Hydrofoil

Verodyne's *Sea Skimmer* isa popular luxury vehicle for wealthy patrons who wish to travel the world. Itis expensive to operate but performance is excellent for such a large craft.

The *Sea Skimmer* requiresthe Shiphandling (Steamer) skill. It has computerized controls. Visibility isgood. It uses 288 gallons of alcohol per hour. A full load of fuel costs$6,500.

Subassemblies: Large Cutter Body +7, Large Cutter Hydrofoil +5.

P&P: Two 4,000–kW hydrojets [Hydrofoil], 8,000 kW gas turbine,two 100 kWh batteries.

Fuel: Four 3,250 gallon self–sealing alcohol fuel tanks (Fire 9);45 hours endurance from gas turbine.

Occupancy: 4 RCS ***Cargo:*** 225 cf.

Armor	**F**	**RL**	**B**	**T**	**U**
All:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: Duplicate maneuvercontrol; 10 cabins; 10–man environmental controls; Complexity 6 small computerwith backup; long–range radio; small radar (no targeting, surface search); oldsmall sonar (no targeting); precision navigation instruments; IFF transponder;compact safety system; two halls.

Statistics

Size: 80'¥12'¥12.5' *Payload:* 40.35 tons. *Lwt.:* 84.1 tons

Volume: 13,800 cf *Maint.:* 18.94 hours. *Price:* $1,115,400.

HT: 8. *HP:* 3,000 [Body] 750 [Hydrofoils]

wSpeed: 150 w*Accel:* 20 *wDecel*: 5 (15) *wMR:* 0.25/0.25 *wSR:* 6/6

Draft: 4.4' Flotation: 375 tons

Design Notes

Structure is light with waterproofing. Armor is aluminum.Short–term access space. Crew stations have bridge access. Base wSpeed is 50mph before planing; it can begin hydrofoiling at 60 mph. This is the same craftas presented on p. FW133, as built with the design system in the Appendix.

(((START BOX)))

Aquatic Vehicle Operations

Sensors

Sensor rolls take "no time" but the intervalbetween detection attempts is set by the GM. The rolls should be made by the GMsecretly. Add together the sensor's Scan number and the vehicle's Size,Speed/Range, Penalties, and special adjustments to get the adjusted skillmodifier to Electronics Operation (Sensors).

Speed/Range Modifier: Speedis *subtracted* from range ratherthen adding to it! A moving target is far more likely to be noticed.

Penalties: Sensorshave the following penalties when used in clear water. Double or triplepenalties for poor water conditions (suspended sediment, abundant plankton,etc).

Sensor type	**Scan penalty**
Ladar	–1 per yard
Radar	–3 per yard
Low–Light	–1 per 3yards
Infrared and Thermograph	–1 per yard
Normal Vision	–1 per 5 yards

Sonar Range: Multiplythe range of active and passive sonar by 1.2 on Mars and Europa.

Passive Sonar: Passivesonar is indirect and does not require a line of sight to detect a target.

*Maintaining Contact:*Once achieved, detection is maintained without need for any die rolls unlessthe target moves out of line of sight, travels beyond the sensor's maximumrange, or launches a decoy and the sensor operator fails a skill–4 roll.

Prior Contact: Othervehicles sharing sensor information over datalinks have a +4 bonus to detect atargeted object.

Communications

Radio: Treat everyyard of water as 100 miles of range. If the radio is ELF then treat each yardof water as 3.5 miles of range.

Laser: Treat each yardof water as 100 miles of range. Multiply by the absolute value of anyadditional Vision penalties for turbid water.

Collisions

A vessel colliding with another vessel inflicts a number ofdice of damage equal to its original body hit points ¥ speed in mph / 200.A collision with a solid object (rocks or a large iceberg) causes the vessel totake this much damage itself. Intentionally attempting to collide with a movingtarget requires a Quick contest of vehicle operation skills; the winner choosesif the collision attempt was successful.

Crushing

A pressurized submersible operating below its test depth (p.00) must make a roll vs. HT+2 every hour to avoid flooding, or whenever placedunder stress such as combat maneuvering or depth charge attack. Each minute offlooding causes hull damage equal to 1d ¥ (Pressure – 1). If a submersibleexceeds its crush depth, it must roll vs. HT to avoid destruction.

Maneuvering

A deliberate change in direction is called a *maneuver*. Maneuvers are rated for the Gs (gravities) theyrequire.

Bend: A basic turn.Bends have a direction (right, left, up, or down) and an angle (up to90”), e.g., "bend right 60” ."

Drift: In a drift thevehicle edges to one side or, if submersible, moves up or down 5 yards withoutchanging facing.

To determine the G–force for a drift, multiply mph by0.00625. For a bend, multiply mph by 0.0125 for 15” , 0.025 for 30” ,0.0375 for 45” , 0.05 for 60” , and 0.075 for 90” . Round to the nearesttenth of a G.

Control Rolls

A control roll is rolled against the vehicle operator'sskill, in the following circumstances: if the G–force of a maneuver exceeds thevehicle's MR; once per *Control* intervalfor surface vessels (from the Beaufort wind table, p. 00); and each time acraft takes more than 5 points of crushing or explosive damage per ton from asingle damage roll.

If a control roll fails, the operator has temporarily lostcontrol and no maneuvers can be attempted until the next second. Subtract thevehicle's SR from the number of points by which the roll failed, to a minimumof zero. All weapons have a penalty to hit of –1 per point of the result andlose any aiming bonus. Standing characters must make a DX roll at the samepenalty or fall down, or possibly off the vehicle. If the result is 5 orgreater, the vehicle capsizes or springs a leak. If the vehicle issupercavitating, a result of 2 or greater means the supercavitation bubblecollapses.

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Asagai Ikan Mas Waterski

The *Ikan Mas* (Malay for"goldfish") is one of the most popular personal watercraft on theworld market, and has enjoyed consistently high sales in Australia, the UnitedStates, and China.

The *Ikan Mas* requires thePowerboat skill. It has computerized controls. Visibility is good.

Subassemblies: Medium Waterbike Body +1.

P&P: 80−kW hydrojet, four 40 kWh batteries (160 kWh total).

Fuel: 2 hours endurance from batteries.

Occupancy: 1 XCS (cycle) ***Cargo:*** 0.5 cf.

Armor	**F**	**RL**	**B**	**T**	**U**
All:	2/2	2/2	2/2	2/2	2/2

Equipment

Body: Complexity 4 tinycomputer (cheap).

Statistics

Size: 4'¥2'¥1.5' *Payload:* 250 lbs. *Lwt.:* 580 lbs.

Volume: 40 cf *Maint.:* 195.27 hours. *Price:* $10,490.

HT: 12. *HP:* 15

wSpeed: 70 w*Accel:* 55 *wDecel*: 10 (35) *wMR:* 1 *wSR:* 4

Draft: 0.7' Flotation: 0.93 tons

Design Notes

Structure is extra−light with waterproofing. Armor is foamedalloy. Short−term access space.

Variants: The PiroshkiWaterworks *Daemon* is similar, butuses an 80 kW new gas racing engine instead of batteries. It has a 12–gallonlight tank that gives 1.5 hours of endurance with alcohol (Fire 9) for $6.Payload: 319.6 lbs.; Lwt: 557.7 lbs.; Price: $15,560; HT 11. Double enduranceif using synthetic gas, but a full load of fuel costs $60.

Verodyne <u>Sunrunner</u> Sport Biphib

The *Sunrunner* is a smallpersonal watercraft that can function both above and under the waves. In manyrespects it is the marine version of a car, capable of operating almosteverywhere that people live in the sea. The vessel uses hydrodynamic lift inorder to sink as it does not use a ballast system.

The *Sunrunner* requires thePowerboat skill. It has computerized controls. Visibility is good.

Subassemblies: Medium Boat Body +3, Medium Boat Retractable Hydrofoils +1.

P&P: 100–kW hydrojet, two 100 kWh batteries (200 kWh total).

Fuel: 2 hours endurance from batteries.

Occupancy: RCS, CPS ***Cargo:*** 1 cf.

Armor	**F**	**RL**	**B**	**T**	**U**
Body:	4/20	4/20	4/20	4/20	4/20
Hyd:	3/5	3/5	3/5	3/5	3/5

Equipment

Body: 1 man–day limitedlife system; Complexity 6 small computer; short–range radio; short–rangesonarcom; simple sonar array.

Statistics

Size: 10'¥4'¥3' *Payload:* 500 lbs. *Lwt.:* 1.62 tons.

Volume: 140 cf *Maint.:* 102.83 hours. *Price:* $37,825.

HT: 12. *HP:* 450 [Body] 38 [Hydrofoils]

wSpeed: 75 w*Accel:* 12 *wDecel*: 10 (16) *wMR:* 0.75/1 *wSR:* 5/5

Draft: 1.1' Flotation: 3.75 tons

uSpeed: 18 w*Accel:* 12 *uDecel*: 10 (16) *uMR:* 0.75 *uSR:* 5

Draft: 6.5' Crush Depth: 60 yards StallSpeed: 9

Design Notes

Body structure is heavy with lifting body. Hydrofoil structure islight. Vehicle is sealed. Armor is aluminum. Flotation assumes retractedhydrofoils. Short–term access space. Base wSpeed is 25 mph before planing; itcan begin hydrofoiling at 20 mph.

(((START BOX)))

Supercavitation

Cavitation is the formation of vapor–filled bubbles in aliquid caused by changes in the speed of objects moving rapidly through it.Originally a nuisance for aquatic craft when produced inadvertently by screwpropellers, cavitation can also be used advantageously.

Supercavitating hullsuse careful design to promote the formation of a single vapor–filled cavity a giant bubble surrounding most of the vehicle. Creating asupercavity requires moving at high speed, but once the bubble forms most ofthe hull is no longer in contact with water. Drag is significantly reduced,allowing the vessel to accelerate to even higher speeds, or to sustain itsspeed with less power.

Torpedoes and bullets can also be made supercavitating,increasing their speed, range, and (for bullets) damage.

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Hicks Naval Architecture Mk 90 Torpedo

The *Mk 90* torpedo is thestandard heavy torpedo in use by the U.S. and Japanese navies. It is reasonablycompact and has both a long–range "cruise" capability and asupercavitation sprint option. A recent product improvement program hasupgraded the sonar and doubled the bubble generator's capability.

The *Mk 90* requires thePowerboat skill. It has computerized controls. Visibility is not applicable. Ituses 3,200 gallons of metallic dust per hour. A full load of fuel costs $40.

Subassemblies: Large Waterbike Body +1.

P&P: 95–kW hydrojet, 20,000–lb. VCR, 100 kWh battery, 15 kWhpower pack.

Fuel: 20 gallon ultra–light metallic dust tank (No Fire); 22second VCR endurance. Battery powers hydrojet and sonar for 1 hour. Power packdrives bubble generator for 23 seconds.

Occupancy: None ***Cargo:*** None.

Armor F RL B T U

Body: 4/17 4/17 4/17 4/17 4/17

Weaponry

250mm Warhead (HEMP)

Equipment

Body: Small Complexity 6computer; short–range sonarcomm; new small sonar (active/passive); electricbubble generator 6.

Statistics

Size: 10'¥0.98'¥0.98' *Payload:* 368 lbs. *Lwt.:* 0.93 tons.

Volume: 30 cf *Maint.:* 54.61 hours. *Price:* $134,120.

HT: 12. *HP:* 180 [Body]

uSpeed: 37 u*Accel:* 20 *uDecel*: 5 (15) *uMR:* 1 *uSR:* 3

cSpeed: 300 *cAccel:* 213 *cDecel:* 2 *cMR:* 0.5 *cSR:* 1

sDraft: 4.1' Flotation: 0.94 tons Crush Depth:162 yards.

cThresh: 36 cDepth: 9 cFloor:509

Design Notes

Body structure is heavy foamed alloy with advanced submarinelines. The frame has the supercavitating design option. Armor is titanium andvehicle is sealed. No access space.

<u>Rubikon</u> Land–Attack Missile

The *Rubikon* isrepresentative of most modern long–range hypersonic anti–ship missiles. Themissile can be launched from surface platforms or dropped from aircrafthardpoints. In a typical flight the missile exits the launcher and engages itssolid rocket booster. After five seconds the ramjets activate and the missileaccelerates to cruising speed (20% to 30% of top speed) just a few yards abovethe water. As it approaches the target it activates its AESA in LPI mode toacquire a lock–on, then goes passive again. It can maintain low speed forstealth, or accelerate to maximum speed for a closing sprint. Depending on thelaunch profile, the retractable wings will remain folded for maximum speed orextend for maneuverability.

The *Rubikon* requires thePiloting (High–Performance Aircraft) skill. It has computerized controls.Visibility is not applicable. The ramjets use 400 gallons of jet fuel eachhour. A full load of fuel costs $639. The basic solid warhead costs anadditional $1,280. Rocket acceleration is 69 mph/s. Performance in parenthesisis with wings retracted. A weapons bay for the missile is 650 lbs., 63 cf.,(12.6 VSP) and $945.

Subassemblies: Body +2, two Standard Wings +1.

P&P: Four 800–lb. ramjets, 12,000–lb. solid rocket (5 secondendurance), 40 kWh battery.

Fuel: 213–gallon light self–sealing jet fuel tank. Tank providesenough fuel for 32 minutes at full power. Battery powers all systems for 3.5hours.

Occupancy: None ***Cargo:*** None.

Armor	**F**	**RL**	**B**	**T**	**U**
All:	4/20	4/20	4/20	4/20	4/20

Weaponry

400mm Warhead

Equipment

Body: Medium–range radio;medium sensor suite [F]; IFF; inertial navigation system; laser spot tracker[F]; advanced radar/laser detector; Complexity 7 microframe computer.

Statistics

Size: 10'¥4'¥1' *Payload:*1,385 lbs. *Lwt.:* 1.73 tons.

Volume: 70 cf *Maint.:* 7.8 hours. *Price:* $6.5 million.

HT: 12. *HP:* 75 [Body] 50 [eachWing]

aSpeed: 2,685 (3,100)a*Accel:* 22 *aDecel*: 35 (1) *aMR:* 8.65 (0.25) *aSR:* 3

Stall Speed: 210 Glide Ratio: 28:1 GlideSpeed: 1,118

Design Notes

Body structure is light carbon composite with radicalstreamlining, wings are heavy carbon composite. Armor is carbon composite andstructure is sealed. Structure has basic emission cloaking and radical stealth.Wings are retractable. No access space.

H.T.D. Palani Hardsuit

Hawai'i Technical Designs produces cutting–edge hardsuits for thecommercial and military markets. The *Palani*is one of their most popular designs, and is a common sight at underwatermining facilities. It has proven to be a rugged and dependable vehicle. It isone–person mini–submarine, shaped like a torpedo, with a transparent bubbledome at one end and two cybernetic manipulator arms. The operator lies proneinside the tube, looking out of the dome, and operating the propulsion systemand arms.

The *Palani* is technicallynot an exoskeleton, but it is controlled very similarly operators canuse the Exoskeleton skill at no penalty or Powerboat. It has computerizedcontrols. Visibility is poor.

Subassemblies: Large Waterbike Body +1, 0.1 VSP full–rotation turret –2,two ST10 arms –4.

P&P: 20–kW vectored hydrojet and 100 kWh battery.

Fuel: Battery powers all systems for 3.7 hours.

Occupancy: 1 CCS ***Cargo:*** None.

Armor	**F**	**RL**	**B**	**T**	**U**
Body:	4/20	4/20	4/20	4/20	4/20
Turret:	4/20	4/20	4/20	4/20	4/20

Equipment

Body: 1–man environmentalcontrol; 1–man gill filter; Complexity 5 tiny computer; short–range radio;sonar IFF transponder; 1.27 ballast tanks. *Turret:* Tiny sonar (flat: facing forward); light sensorsuite [F].

Statistics

Size: 9'¥4'¥2.5' *Payload:* 0.1 tons. *Lwt.:* 0.9 tons

Volume: 31 cf *Maint.:* 68.65 hours. *Price:* $84,935.

HT: 12. *HP:* 360 [Body] 6 [Turret] 12[each Arm] *uSpeed:* 8 w*Accel:* 4 *wDecel*: 5 (7) *wMR:* 1 *wSR:* 5

Draft: 4.1' Flotation: 0.94 tons CrushDepth: 720 yards

Design Notes

Body structure is extra−heavy, turret is medium. Armor istitanium. Entire structure is sealed. No access space.

Verodyne <u>Kasatka</u> SSK

The Verodyne *Kasatka*(Russian for "killer whale") is a modern combat submersible used byIran, India, and several microstates (such as Elandra) for low−endurance patroland surveillance. It is not a popular design for crews, with grossly inadequateaccommodations compared to competing vessels, but it is small and extremelystealthy, even on the surface. The design lacks an air−independent propulsioncapability, a crucial concession made to space that has proven to be its onlydrawback.

The submersible has an outer form hull with a reinforced 500 VSPpressure hull inside. It is considered very survivable for such a small vessel,but combat experience has shown that any major hit will flood the ballast tankscompletely and often rupture the fuel tanks, both of which are conformalsystems that wrap around the length of the hull.

The *Kasatka* requires theShiphandling (Submersible) skill when underwater, or the Powerboat skill whenon the surface. It rarely operates on the surface as it is easily swamped andhas a tendency to roll to the sides. It has computerized controls. Visibilityis poor. It uses 336.6 gallons of alcohol per hour. A full load of fuel costs $42,108.Payload weight includes basic armament of six Mk 90 torpedoes whicheffectively fills the cargo space and 4,000 lb. of carried equipment inthe dock.

Subassemblies: Medium Cutter Body (Form Hull) +6, 0.05 VSP pop−upfull−rotation turret (periscope), snorkel +0.

P&P: 5,000−kW hydrojet [Pressure Hull], 5,100−kW gas turbinew/snorkel [Pressure Hull], 8,000 kWh batteries.

Fuel: Two 3,630−gallon self−sealing alcohol tanks (Fire 7); 2.56hours endurance at full power. Batteries can power all electronics andpropulsion systems for 1.57 hours.

Occupancy: 4 RCS ***Cargo:*** 250 cf.

Armor	**F**	**RL**	**B**	**T**	**U**
Form Hull:	4/300	4/300	4/300	4/300	4/300
Pressure Hull:	4/900	4/900	4/900	4/900	4/900

Weaponry

Two reloadable torpedo bays (30 cf each) [PH: F]

Equipment

Form Hull: Smallactive/passive sonar; long–range sonarcomm; 125 ballast. *PressureHull:* Duplicate maneuver controls; 2 bunks;6–man full life support; Complexity 6 small, high–capacity computer; twelveComplexity 5 tiny computers; inertial navigation system; 200 cf dry dock;compact safety system; 79.5 bilge space. Turret: Medium–range radio; lightsensor suite [F]; 20–foot periscope system.

Statistics

Size: 55'¥7'¥8' *Payload:* 29.03 tons. *Lwt.:* 167.44 tons

Volume: 6,000 cf *Maint.:* 10.59 hours. *Price:* $3.56 million.

*HT:*7 (Pressure Hull9). *HP:* 3,000[Form Hull] 7,200 [Pressure Hull] 4[Turret]

wSpeed: 28 w*Accel:* 6 *wDecel*: 5 (8) *wMR:* 0.25 *wSR:* 5

uSpeed: 44 u*Accel:* 6 *uDecel*:5 (8) *uMR:* 0.25 *uSR:* 5

sDraft: 24' Flotation: 187.5 tons (164tons minimum) Crush Depth: 1,464 yards (Pressure Hull).

Design Notes

Form hull structure is medium aluminum with advanced submarinelines. Pressure hull is extra–heavy with a metal–matrix composite structure andtotal compartmentalization. All subassemblies are sealed. Armor is carboncomposite. Long–term access space. Crew stations have bridge access. Body haschameleon surface and radical sound baffling.

(((START BOX)))

Escape Capsule

This is an emergency survival vehicle deployed on some largecombat submersibles. They became popular after a string of gruesome accidentswith civilian and military submarines in the 2020s. This version is a MediumBoat hull with no hydrodynamic lines. It has a heavy foamed–alloy structure andis sealed. There are five cramped seats and 3.5 VSP of cargo space foremergency supplies. When full loaded the air supply will last 288 minutes,plenty to reach the surface. It has a DR200 titanium hull with a crush depth of420 yards on Earth. An IFF transponder will signal on emergency channels whenit reaches the surface. All systems are powered by a D–cell. 3,770 lbs., 120cf., $36,650.

(((END BOX)))

Short Vehicle Descriptions

Tabarka MotorTech Bizerte Motorboat

The *Bizerte* is a typicalof the majority of small boats. It is powered by cheap ducted screw propellersand the controls are limited to throttle and steering. The vehicle hasmechanical controls. Visibility is good. It uses 2.16 gallons of alcohol perhour. A full load of fuel costs $5. Requires Powerboat skill. 15' long, 2,120lbs loaded. Has PD 3, DR 5, and 113 HP. Water Speed is 25 mph for 4.6 hours.$7,290.

Hicks Naval Architecture Mk 95 Lightweight Torpedo

The *Mk 95* is typical of alarge number of conventional high−speed torpedoes that do not supercavitate.The *Mk 95* is available with anumber of specialized 250mm warheads, electronics, and even propulsion systems.Cheap versions without a warhead or computer are used as target drones. It hasan integral commline and can be passively directed to a location before cuttingthe line and activating its sonar. It has computerized controls. Visibility isnot applicable. It has a positive buoyancy and will bob to the surface if it isnot moving. Requires Powerboat skill. 5' long, 320 lbs loaded. PD 4, DR 10, and30 HP. Underwater Speed is 52 mph for 30 minutes. $13,345.

Glossary

amniotism: "NewAge" philosophy encouraging living in the ocean, as the spiritual home oflife.

aquaculture: Deliberatehusbandry of aquatic life forms for the harvesting of food and other resources.

aquatic−adapted: Refersto ***GURPS***characters with either the Amphibious advantage or the Aquatic disadvantage.

archaeobiology: Theresurrection of extinct species by cloning preserved tissue.

aseptic bone necrosis: Degenerationof bone mass caused by repeated compression and decompression of the body. See *Pressure*,p. 00.

Atlantean: A member ofthe Atlantean Society, a social group encouraging brotherhood and communitysupport amongst underwater dwellers.

atoll tower: A towerconstructed on the seabed and reaching up to or beyond the surface.

AUV: AutonomousUnderwater Vehicle.

bends, the: Pain causedby dissolved gas bubbling out of body tissues during decompression. See *Breathing*,p. 00.

benthos: Organismsinhabiting the floor of the seas or lakes.

bombjacking: Takingcontrol of a cybershell or bioshell, fitting it with explosives, and sending itto explode in a secure area to which it has access.

CEP: Cetacean EnhancementProgram. A U.S. Navy program to develop combat−capable cetacean cyborgs. See *War−Dop*,p. 00.

cetanist: A personespousing the belief that cetaceans are spiritually uplifting beings, andwishing to live as a dolphin or whale by uploading into a cetacean bioshell.

citizenship haven: Anation offering Permanent Non−Resident Citizenships (PNCs) to people as a cheapway of raising revenues.

Coriolis effect: Thedeflection of objects moving along the surface of a rotating sphere, such as aplanet. Objects in the northern hemisphere are deflected to the right, those inthe southern hemisphere deflect to the left. This produces characteristic patternsof winds and ocean currents.

deek: Slang term coinedby uplifted dolphins for humans and infomorphs who have a fetish for pursuingsexual relations with cetaceans.

deep sound layer: A layerin the oceans at the base of the thermocline, where sound is trapped in achannel and propagate vast distances.

drifter: An inhabitant ofa floating community which sails on the open seas. See *Drifting*,p. 00.

dry technology: Technology based on mechanical engineering principles. cf. *wet technology*.

DSL: Deep ScatteringLayer. A layer of marine life which migrates from the depths to the surface atnight, and reflects sonar. See p. 00.

E: An E−model War−Dopcybernetic combat dolphin. See p. 00.

ecohostile: Disruptive toan ecosystem.

EDF: Europa DefenseForce. Preservationist radicals who initiated the War Under the Ice to protectEuropa's ecosystem from Avatar Klusterkorp's pantropic life forms.

EEZ: Exclusive EconomicZone. As defined by the Law of the Sea, a region extending 200 nautical milesfrom a nation's shore, up to 350 nautical miles if the continental shelfextends that far.

euphotic: Describing theregion of the sea where enough sunlight penetrates to allow photosynthesis from the surface to about 350 feet deep.

fauxfish: Artificial,vat−grown seafood meat. Usually fish, but can include shellfish.

genesthetics: Usingliving beings as artistic raw material, shaped by genetic engineeringtechniques. Also known as *gene sculpture*.

halocline: The boundarybetween layers of water of different salinities.

heliox: A breathing gasmixture of helium and oxygen, used for pressures up to 11 atmospheres.

high pressure nervous syndrome: Muscle tremors and other effects caused by high partial pressures ofhelium. See *Breathing*, p. 00.

high seas: The regions ofthe ocean outside the limits of any nation's EEZ.

hydrox: A breathing gasmixture of hydrogen and oxygen, used for pressures up to 18 atmospheres.

JMSDF: Japanese MaritimeSelf−Defense Force.

krakenism: Fringe beliefthat the seas should not be explored or colonized because unknown evil lurksbeneath the waves.

Law of the Sea: A U.N.treaty which came into effect in 1994, establishing international laws for theuse of the oceans, the sea bed, and the resources within.

methanogen: Life formwhich metabolizes carbon dioxide and hydrogen, producing methane as abyproduct.

methanotroph: Life formwhich metabolizes methane for energy.

moon pool: An opening inthe floor of a pressurized, air−filled room which leads directly to water.

nanogaian: An advocate ofthe philosophy that Earth should be populated with self−replicating nanobots,to produce a single planet−sized living "being."

nekton: Organisms capableof swimming in the seas under their own propulsion.

neomalthusianism: Thebelief that low technology societies have demonstrated a lack of survivalability and should be exterminated.

nitrogen narcosis: Inhibition of mental processes caused by nitrogen binding to brain tissue athigh pressures. See *Breathing*, p. 00.

non−aquatic: Refers to ***GURPS*** characters without either theAmphibious advantage or the Aquatic disadvantage.

Oceanus Noctis: The Oceanof Night; the name of Europa's globe−wide, sub−ice ocean.

oxygen toxicity: Toxiceffects caused by the absorption of oxygen at high partial pressures. See *Breathing*,p. 00.

partial pressure: Thecomponent of pressure exerted by a particular gas in a gas mixture. See *CalculatingPressures*, p. 00.

pelagic: In the openocean, above the sea floor.

perflubron: Common namefor perfluorooctylbromide, a chemical with a high binding affinity for oxygen.It can be used as a substitute for blood, or as a breathable oxygenated liquid.

PLAN: People's LiberationArmy Navy, China's navy.

plankton: Organisms whichfloat freely in ocean currents, unable to propel themselves.

PNC: Permanent Non−ResidentCitizenship. A type of citizenship offered by some nations, establishingnothing more than nationality and specifically not conferring a right to residein the issuing state, in exchange for a fee. See *Citizenship Havens*,p. 00.

Promethean: One whoencourages exploration and colonization of remote locations simply because itleads to more knowledge and human mastery over the cosmos.

pycnocline: The boundarybetween layers of water of different densities.

RAN: Royal AustralianNavy.

SAD: Seasonal AffectiveDisorder. Clinical depression caused by lack of exposure to sunlight. See p.00.

scab: Slang contractionfor "supercavitating bullet."

supercavitation: Theformation of a bubble of gas around a submarine craft moving at high speed,reducing drag. See *Supercavitation*, p. 00.

surfi: A person whoembodies the lifestyle of a late 20th century surfer, as part of a culturalrevival movement.

technodarwinism: Thebelief that societies with high technology have demonstrated their inherentsuperiority to lower technology societies, and that the principles of evolutionjustify their dominance.

thermocline: A narrowlayer of sea water where the water temperature changes rapidly with depth.Water below the thermocline is at 29° F to 37° F.

thiotroph: Life form whichmetabolizes sulfide compounds for energy.

TNI–AL: Tentara NasionalIndonesia–Angkatan Laut, the Indonesian navy.

trimix: A breathing gasmixture of helium, nitrogen, and oxygen, used for pressures up to 18atmospheres.

tsunami: A huge wavecaused by an undersea earthquake or volcanic eruption.

turbidity current: Adense current of sediment–rich water which flows along the sea floor, down theslope of the continental shelf or slope.

Universalism: A politicalbelief that parts of Earth and space should be left unclaimed and unowned byanyone.

uplift: The process ofgranting sapience to animal species.

VCR: Vortex CombustorRamjet. A form of underwater rocket propulsion. See p. 00.

wet technology: Technology based on biological and genetic engineering principles, as opposedto mechanical. cf. *dry technology*.

whalesinging: Thepractice of an infomorph uploading into a whale bioshell and participating inwhale songs with natural whales.

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Appendix: Aquatic Vehicle Design System

Battleships are the ships of yesterday, aircraft carriers arethe ships of today, but submarines are going to be the ships of tomorrow.

Fleet Admiral Chester W.Nimitz, U.S. Navy, 1945.

The system presented here is a tailored version of the ***GURPSVehicles,*** *Second Edition*system specifically for designing watercraft in the ***TranshumanSpace*** universe. Thesystem is compatible with the Wheeled Vehicle Modular Design System from ***TranshumanSpace: In The Well***.

Starting Out

This system measures volume in VSPs (vehicles spaces) of 5 cubicfeet each; exactly 1% of a spacecraft 500−cubic−foot Space. Weight is measuredin pounds. Cost is in dollars. Surface area (SA) is given in square feet. Powerrequirements are given in kilowatts (kW) and most fuel requirements are ingallons per hour (gph). A capital M next to a number means millions and acapital K means thousands; i.e. M$2.5 means $2,500,000.

Step 1: Concept

The most important part of this system is deciding on what youwant the vehicle to be. The following concepts should give a rough guide tohelp determine where the ship fits in to the world of ***Transhuman Space***.

Surface Craft

Waterbike: Small one− ortwo−man high−performance personal watercraft. Often designed with advancedmaterials and oversized propulsion systems. A few "hydroskis" alsouse a hydrofoil system for maximum speed and maneuverability in calm seas.

Speedboat: Highperformance watercraft. Usually built to hold no more then six people, usinglarge hydrojets. A few luxury models use gas racing engines.

Trawler: A civilian boatis built with cheap components and plenty of cargo space for equipment. A fewhave sparse accommodations for trips lasting a few weeks.

Patrol Boat: Lightly−armedboat with some type of sensor package. Common armament is a mix of small emagsand pintle−mounted infantry heavy weapons. Fourth Wave models will have droneracks for two or more small recon UAVs and multirole missile racks.

Cruise Ship: Luxurytransports are still a common sight on the worlds oceans, but they are muchsmaller then the massive proto−freedom ships that plied the seas in the mid21st century. Most are now smaller (200 to 1,000 passenger) craft with far morespecialization and a "theme."

Freedom Ship: More a floatingcity then a ship, with its own banks, entertainment facilities, smallfactories, and docks. A few even have landing strips for aircraft. Most freedomships are beyond the scope of these rules, but smaller versions carrying"only" a few thousand people are constructible.

Submersibles

Diver Propulsion Vehicle (DPV): This is a small submersible that a diver can grab on to and be pulledby. They typically have no real hydrodynamic streamlining, simply being arugged shell containing a small aquajet and battery.

Biphib: A small vehiclethat is a combination of waterbike and submersible. They range in size fromsmall one−man craft that the operator straddles like a motorcycle to two−manmodels that are completely enclosed. All have powerful aquajets for their size.

Recreational Sub: A small(2−6 person) submersible designed for quiet operations in shallow waters (feware designed to exceed 100 yards in depth). Most use small alcohol−burningturbines that recharge batteries for use underwater.

Research Sub: Small,usually unmanned, submersible vehicles used for long−term underwater studies. Afew are licensed to use RTGs or even small nuclear power plants and can stayunderwater for months or years if they receive appropriate maintenance.

Subfighter: Usually unmanned,these are combat submarines armed with supercavitating torpedoes and machineguns, blue−green lasers and mines. Most are capable of supercavitating forseveral minutes but prefer to remain stealthy for as long as possible whileclosing with a target. Most of conventional design, but advanced models uselifting body hulls and active flotation to maximize usable volume.

Cargo Sub: Although therehas been little economic incentive to replace surface cargo vessels withsubmersibles, there are a large number of such vehicles used to shuttle goodsand people between underwater facilities and the surface.

Strike Submarine: Anunderwater weapons platform that can serve a variety of functions. Most arerelatively small and stealthy, armed with long−range missiles, torpedoes,UCAVs, and even laser arrays. Most are fusion powered with a minimal crew.

Carrier Submarine: Largesubmersibles that can carry dozens of UCAVs, such as the Strix (pp. TS124−125)and a handful of larger manned aircraft.

Step 2: Hull Design

This table offers a number of common hull sizes from which aship can be built. Each chassis includes the basic framework for the vehiclebody but no armor. To the right of the hull data is an *optional* hydrofoil subassembly. A vessel may pick a hydrofoilassembly matched to a larger hull if desired (but it may not exceed the mainhull's VSP).

Hull	**Hydrofoil**

Type	VSP	Wt.	Cost	HP	Area	Top	Size	VSP	Wt.	Cost	HP	Area	Size
Small Waterbike	1	80	$1,000	30	20	5	+0	0.2	24	$300	9	6	−2
Medium Waterbike	2	160	$2,000	60	40	10	+1	0.4	40	$500	15	10	−1
Large Waterbike	5	240	$3,000	90	60	20	+1	1	72	$900	27	18	+0
Small Boat	10	400	$5,000	150	100	30	+2	2	120	$1,500	45	30	+0
Medium Boat	20	600	$7,500	225	150	50	+3	4	200	$2,500	75	50	+1
Large Boat	30	800	K$10	300	200	60	+3	6	240	$3,000	90	60	+1
Small Runabout	50	1,200	K$15	450	300	100	+3	9	400	$5,000	150	100	+2
Medium Runabout	100	2,400	K$30	750	500	160	+4	18	500	$6,250	188	125	+2
Large Runabout	200	3,600	K$60	1,200	800	260	+5	36	800	$10,000	300	200	+3
Small Cutter	500	12,000	K$150	2,250	1,500	500	+5	90	1,800	$22,500	600	400	+4
Medium Cutter	1,000	24,000	K$300	3,000	2,000	660	+6	180	3,600	$40,000	900	600	+4
Large Cutter	2,000	48,000	K$600	6,000	4,000	1,330	+7	360	7,200	$90,000	1,500	1,000	+5
Small Corvette	2,500	60,000	K$750	6,000	4,000	1,330	+7	450	4,800	$60,000	1,800	1,200	+5
Medium Corvette	4,000	96,000	K$1,200	7,500	5,000	1,660	+7	720	8,000	$100,000	3,000	2,000	+6
Large Corvette	5,000	120,000	K$1,500	9,750	6,500	2,160	+8	900	8,000	$100,000	3,000	2,000	+6
Small Ship	10,000	240,000	M$3	22,500	15,000	5,000	+8						
Medium Ship	20,000	480,000	M$6	45,000	30,000	10,000	+9						
Large Ship	50,000	1,200,000	M$15	127,500	85,000	28,300	+9						
Small Arcoblock	100,000	2,400,000	M$30	202,500	135,000	45,000	+10						
Medium Arcoblock	200,000	4,800,000	M$60	405,000	270,000	90,000	+10						

Large Arcoblock	500,000	12,000,000	M$150	1,050,000	700,000	235,000	+11

Type is descriptive termused for each size of body.

VSP is the number of"vehicle spaces" of components that can be installed.

Wt. is the weight of thestructural frame in pounds.

Cost is the cost of thebody in dollars.

HP is the structure's hitpoints, assuming a frame of medium strength.

Area is the surface areain square feet.

Top is the area of the topdeck, if any, in square feet. People can walk on the deck and cargo can bestacked there. Each person on the deck needs at least 9 square feet.

Size is the Size Modifier(p. B116) to target the hull or subassembly.

Hull Options

Hydrodynamic Lines

A craft moving through water is faced with resistance in the formof *hydrodynamic drag*. Hydrodynamic linesattempt to reduce water resistance by minimizing the wetted area (surface areaactually in the water) or shaping the hull to minimize the drag induced frombow waves and other sources. Hulls from the chart above have *average* or *submarine* lines by default (for flotation hulls and submersibles respectively);for different lines multiply the number of VSPs by the number from the table.

None: Like a barge orplatform, the vessel is basically a floating box.

Mediocre: Large sailingships and bulk cargo ships have this level of hydrodynamic streamlining. Thesevessels have a length−to−width radio of 3 to 5:1.

Average: Typical ofpowerboats, ocean liners and personal watercraft. Typical length−to−widthratios are 5 to 7:1.

Fine: Often found withsleek warships and racing boats. Length−to−width ratio is 8:1 or more.

Submarine: This is thetypical level of drag reduction for submersibles. Length−to−width ratio isusually at least 5:1.

Advanced Submarine: Usually seen on high–performance submersibles. The hull is a sleek cylinderwith minimal protruding subassemblies. Length–to–width can be as high as 10:1.

Hydrodynamic Lines

Lines	VSP
None	¥1.2
Mediocre	¥1.1
Average	¥1
Submarine	¥1
Fine	¥0.9
Advanced	¥0.9

Frame Strength

This represents the overall structural integrity of the hull andincorporates many factors cross–bracing, load balancing, stress seams,etc. that affect hull weight and crush depth. The table assumes a hullof *medium* strength, but other optionsare available. A high–performance speedboat will have an *extra–light* or *light*frame. Most submersibles will have *heavy* frames. Military vessels are usually *extra–heavy*. Multiply hull weight, cost and HPs by the numberson the Frame Strength table.

Frame Strength

Strength	Weight	Cost	HPs
Extra–Light	¥0.25	¥0.25	¥0.25
Light	¥0.5	¥0.5	¥0.5
Medium	¥1	¥1	¥1
Heavy	¥1.5	¥2	¥2
Extra–Heavy	¥2	¥5	¥4

Materials

These materials are described on p. TS174. The table assumes theframe is made of aluminum. For a given material, multiply hull weight and costby the numbers from the Materials table.

Materials

Material	Weight	Cost
Cheap Steel	¥1.5	¥0.25
Steel	¥1.25	¥0.5
Aluminum	¥1	¥1
Titanium	¥0.75	¥1.5
Foamed Alloy	¥0.625	¥2
Carbon Composite	¥0.375	¥10
Metal Matrix Composite	¥0.25	¥30
Nanocomposite	¥0.15	¥100
Diamondoid	¥0.1	¥500

Structural Options

For a given option, multiply hull weight and cost by the numbersfrom the Structural Options table.

Flexibody: This optionallows the ship's hull to undulate like a fish. It is required in order to usea fin drive (p. 00). This is only available for ships that also have the *responsive* option.

Responsive: A responsivehull incorporates micro–mechanisms that alter hull shape in response to varyinghydrodynamic environments and speeds. Only available for ships whose structure *and* armor are diamondoid, nanocomposite, metal–matrixcomposite, or carbon–composite.

Lifting Body: The hull isdesigned to produce maximum hydrodynamic lift.

Smart: The hullincorporates micro–robotic sensors and processors, allowing self–diagnosis ofstructural damage and stress. Only available for vessels whose entire structure*and* armor are diamondoid,nanocomposite, metal–matrix composite, or carbon–composite.

Submersible: The ship hasadditional structural reinforcement to withstand the stresses of diving andsurfacing.

Supercavitating: Thisallows the ship to supercavitate (see p. 00). Supercavitating ships tend to belong and skinny, with wedge, conic, or paraboloid noses. Bow– or strut–mountedcontrol surfaces stabilize the craft inside the bubble and create drag to allowmaneuvering. The ship should not have any subassemblies unless they areretractable and it must have some level of hydrodynamic lines.

Wings: If the craft haswings (see *Subassemblies*, p. 00)then it requires expensive hull design modifications.

Structural Options

Option	**Weight**	**Cost**
Flexibody	¥1	¥1.5
Responsive	¥1	¥1.5
Lifting Body	¥1	¥1.2
Smart	¥1	¥2
Submersible	¥2	¥2
Supercavitating	¥1.05	¥5
Wings	¥1	¥10

Compartmentalization

All large vessels are split into a number of compartments thatcan be sealed off in the case of flooding. Well–protected civilian and militaryships (and all submarines) have additional watertight interior walls,extra–strong pressure doors, and carefully spaced fuel and power systems toreduce damage in the case of flooding.

"Heavy" compartmentalization weighs 10% of the hull orsubassembly's structural weight, figured after any adjustment for strength ormaterials. "Total" compartmentalization is 20% of structural weight.Either costs $5 per pound of weight added.

(((START BOX)))

Concrete Hulls

Most vessels that use rock or concrete hulls do not have adiscernible "hull" and are essentially built by pouring concretearound the components in molded forms. Do not use the listed hull weights,costs, or HP. Instead, determine how much of the vessel will be usable volume(that is, how much is hollowed out of a chunk of concrete in the size and shapeof that hull) after applying any modifications for hydrodynamic lines. Theremaining volume that is not used for components is solid concrete. The type ofconcrete and reinforcing mixture determines hull weight; do not use the framestrength modifiers. Concrete–hulled vessels generally will not have hydrofoils!

Hull Weight: Aconcrete–frame vessel weighs (in pounds) M ¥ Hyd ¥ (1 + unused volume).Where M is 900 is a heavy concrete frame or 300 if low–density concrete and Hydis the hydrodynamic lines volume modifier.

Hull Cost: Multiplyhull weight by $0.1.

Hull HP: Multiply thelisted HP by 0.5 for heavy concrete and 0.25 for low density.

Hull DR: The hullconstruction itself provides starting DR. Divide hull weight by 150. This DR isconsidered ablative, for every 10 points of damage it sustains (regardless ofwhether it protects or not) one point of DR is destroyed afterward. Additionalarmor may be layered over the concrete.

For example, a Small Boat hull with all 10 VSP used bycomponents will have a hull weight of (900 ¥ 1 ¥ 1) = 900 lbs. if usinga heavy concrete hull. It costs $90, has 75 HP and DR 6.

(((END BOX)))

Step 3: Subassemblies

Many vessels have one or more subassemblies attached to the hull(or a larger subassembly). For example, a surface ship may have a box hull anda smaller box hull connected on top to serve as a command center, livingquarters, or simply a place to stand higher over the water.

Arms are described on p.00.

Hydrofoils typicallytake the form of vertically mounted "wings" with an underwaterairfoil that generates lift, bringing the main body of the ship out of thewater   significantly reducing drag. They are listed with the hulls on p.00.

Superstructures includeconning towers on submarines or control centers.

Pods are separate housingsconnected to the main hull, such as outriggers or missile tubes.

Turrets are rotatingsuperstructures that require volume in the hull or subassembly on which theyare mounted. For each turret decide if it has limited (180°) or full(360°) rotation and determine where it is placed. Other turrets orsuperstructures will likely restrict the actual arc of fire. *Popturrets* can retract into the hull when notin use, but require additional storage space and may not be feasible in everycase. A small turret may be placed on top of a larger one, in which case it isknown as a cupola.

Open Mounts are brackets,pedestals, or masts used to mount equipment   usually sensors or weapons   *outside* the ship'sstructure. Instead of subtracting rotation space from the supporting structurethey subtract it from their own volume. They do not use the listed weight andcost from the chart (see below).

Internal Compartments arecontained entirely inside the main hull, representing special compartments. Inthis case subtract the superstructure's volume from the main hull. Thedimensions of the compartment cannot exceed that of the main hull. The mostcommon examples are the pressure hulls of submarines, reinforced compartmentsthat hold the crew quarters, engines, and vulnerable systems. Sphericalinternal compartments have only 10% of the usable volume but are far moreresistant to crushing pressures. They may occupy no more then 10% the volume ofthe outer "form" hull. Internal compartments do not add to the ship'stotal area (p. 00).

Wings: A subassembly up to50 VSP in size may be designated as a wing. Wings are almost always installedin matching pairs. Multiply weight, cost, HP and area by ¥1.5. Volume isunaffected.

Subassemblies

VSP	**Weight**	**Cost**	**HP**	**Area**	**Size**
0.05	10	$125	4	2.5	−3
0.1	16	$200	6	4	−2
0.2	24	$300	9	6	−2
0.5	44	$550	17	11	−1
1	72	$900	27	18	+0
2	120	$1,500	45	30	+0
5	240	$3,000	90	60	+1
10	400	$5,000	150	100	+2
20	600	$7,500	225	150	+2
50	1,000	$12,500	375	250	+3
100	2,000	$25,000	600	400	+4
200	4,000	$50,000	900	600	+4
500	10,000	$125,000	1,800	1,200	+5

Open Mounts: Rather thanthe listed cost, weight, and HP, select an appropriate size and note thesurface area. Multiply surface area by 3 to get weight in pounds, by $10 to getcost, and by 2 to get HP. For example, a 5−VSP open mount is

180 lbs., $600,120 HP.

Rotation Space: Therotation space (in VSP) required is determined by multiplying the turret oropen mounts VSP by: ¥0.1 if limited rotation, ¥1.1 if limited–rotationpop turret, ¥0.2 if full rotation, ¥1.2 if full–rotation pop turret.

Retractable: Asubassembly (usually a hydrofoil or arm) can be designed to retract fully intothe hull. It requires its volume ¥1.2 in the hull when retracted. They take10 seconds to extend or retract; propulsion systems and many other componentsinstalled in the retracted subassembly will no longer function (GM discretion).The vehicle may not be moving at greater then its non–hydrofoiling or planingwSpeed when extending hydrofoils or wings.

Subassembly Options

Subassemblies may be given different structural strengths,materials, and structural options than the hull. Use the hull frame strength,materials, and structural options tables. If the *responsive*, *submersible*, or *smart* options areapplied to any subassemblies, they must be applied to *all* subassemblies   except internal compartmentsneed not be *responsive* or *submersible*.

None of this applies to open mounts.

(((START BOX)))

Periscopes

A periscope is an extendible sensor stalk that can be usedunderwater. Various sensors, and even weapons, can be placed in the periscopeto be used on the surface while most of the vessel remains underwater.Periscopes rarely exceed 60 feet in length; beyond that point it is moreeconomical to use AUVs and tethered buoys.

Treat a periscope as a turret or open mount, but increaserotation space by 10% for every foot of length it can extend. A periscopeextends or retracts at 10' per second.

(((END BOX)))

Step 4: Armor and Sealing

All ships must have some degree of armor just to stay afloat;minimum DR is 1. DR is also used when determining crush depth (p. 00).

The composite types, and diamondoid, are considered to belaminate armor, with DR doubled against shaped–charge warheads like HEDP andHEAT.

(((START BOX)))

Structural and Total Area

Once the surface area of the body and all subassemblies areknown, find the *Total Area* by addingtogether all their surface areas. For example, a small boat hull with ahydrofoil and 2 VSP turret has a total area of (100 + 30 + 30) = 160 sf. Thenrecord the *Structural Area,* whichis the total area *excluding* openmounts.

(((END BOX)))

Armor

Type	**M**	**C**
Cheap Steel	0.6	0.25
Steel	0.5	0.5
Aluminum	0.4	1
Titanium	0.3	1.5
Foamed Alloy	0.25	2
Carbon Composite	0.15	10
Metal–Matrix Composite	0.1	30
Nanocomposite	0.06	100
Diamondoid	0.04	500

M is the weight of onesquare foot of DR 1 armor.

C is the cost per pound ofthe armor.

Figure armor weight (in pounds) as:

armor weight = area ¥ DR ¥ M

Calculate the armor cost (in dollars) using this formula:

cost = armor weight ¥ C

Subassembly Armor

If the vehicle has one or more subassemblies (such as turrets orarms), use the same procedure, with the exception that the subassembly's areais used rather than the hull area. DR may be the same, more, or less than thehull.

Armor Options

Location Armor: Asubassembly or hull can optionally be given armor whose DR varies by facing.Hulls have six faces: front (F), back (B), right (R), left (L), underside (U)and top (T). Subassemblies have five sides; exclude the side attached to thebody, e.g., underside. If this is desired, multiply DR by 6, and redistribute"DR points" among each of the six sides. For a subassembly, do thesame, but multiply by 5, since the connecting side is already covered. Openmounts may only be armored on one face. Arm armor may not vary by face.

Waterproofing and Sealing

*Waterproofing:*Waterproofing a vehicle ensures that it will not leak if floating or suffercorrosion from salt water, but does not protect from the effects of corrosiveatmospheres or extreme pressures. This is required for the vehicle to float.The vehicle will flood if fully submerged.

Sealing: Protects againstcorrosion and the effects of pressure changes. Vehicles with submersible hullsare already sealed for no extra cost. Sealed vehicles are automaticallywaterproofed. A sealed vehicle must have DR 1 or more over its entire body(excluding open mounts).

Module Type	**VSP**	**Wt.**	**Cost**	**Power**
Waterproofing	0	0	$2	
Sealing	0	0	$10	

Multiply cost by the vehicle's total surface area. (While onlythe body of a watercraft is directly in the water, the rest of it iswaterproofed to prevent corrosion from spray.)

Step 5: Powertrain

Even ships that simply sink and surface will have one or morepowerplants that drive a propulsion system.

Aquatic Propulsion

Most vessels rely on proven propulsion technology ductedpropellers, fin drives, and hydrojets. Electromagnetic ducted waterjets, andvarious other technologies are less common. None of these drives functionswhile supercavitating.

Ducted Screw Propeller

The ducted propeller is the most common propulsion system forcivilian and military surface craft where cost is more important thenefficiency or speed.

Fin Drive

The ship can bend and ripple sections of its hull like a fish togenerate thrust. Only ships with a flexibody hull can use fin drives.

Hydrojets

Also know as "aquajets," hydrojets suck in water andexpel it, squid–fashion, at high speed to create thrust. Their biggestadvantage over screw propellers is that they are quiet and lightweight.

Propulsion Type	Weight per kW	Base	Cost	Thrust
Ducted Screw	4	80	$5	20
Fin Drive	3	135	$200	35
Hydrojet	1	20	$40	20

Location: Ducted screwsmay be installed in the hull or a pod. Fin drives may only go in the hull.Hydrojets can go in the body, pods, or hydrofoil.

Per kW and *BaseWeight* are used to figure the overallweight: Multiply the engine's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight.

Cost is multiplied byoverall weight.

Thrust is multiplied bythe output in kW to get total aquatic thrust.

Volume: Most vehiclesrequire access space for the powertrain, to allow maintenance to be performed.For standard access space, divide weight by 125 to find the system's totalvolume in VSPs. For systems mounted in pods, or in automated ships that do notrequire access space (and thus often require partial disassembly to repair),divide the weight by 250. For most ships that can maintain their systems frominside the hull divide weight by 80. In all cases, round *up* to the nearest tenth of a VSP.

(((START BOX)))

Active Flotation

Any aquatic propulsion system except a flexibody can beinstalled to point down, so its thrust offsets part of the vehicle's weight.

Subtract the active flotation thrust from the vehicle'sloaded weight to determine if the vehicle can float, or when computing itshydrodynamic drag. Alternately, it can be designed to add to loaded weight, toenable a light vessel to submerge.

Vectored Thrust: Anactive flotation system may be built with vectored thrust (1.5 ¥ weight, volume,and cost). This enables it to increase or decrease loaded weight for flotationpurposes and to propel the vehicle. Actual thrust will vary on what percentageof the total thrust is devoted to propulsion.

(((END BOX)))

Rockets

Rockets are use by submersibles to attain the speeds required tosupercavitate, and to propel them once they have formed the vapor bubble.

Liquid–Fuel Rockets

These use a mixture of fuel and oxidizer, expelling the resultinghot exhaust to create thrust. For underwater use the most common type ishydrogen–oxygen as the fuel is cheap. Each HO rocket module generates 10,000lbs. of thrust and consumes 66,000 gallons (1,980 VSP) of rocket fuel per hour.

Vortex Combustor Ramjet (VCR)

Also known as a hydro–reactive engine, these rockets use a metaldust, usually aluminum or magnesium, and the surrounding water to generatethrust. They can be used while supercavitating as the intakes are designed toextend beyond the air bubble. Each VCR module generates 10,000 lbs. of thrustand consumes 1,600 gallons (48 VSP) of metallic dust per hour.

Solid Rocket

These include their own fuel, but once activated they cannot beturned off! They burn 85% of their weight as fuel; refuelling takes severalhours and costs 20% of the original cost. Each solid rocket module provides1,400–lb. minutes of thrust, i.e. 1,400 lbs. for one minute, 2,800 lbs. for 30seconds, 700 lbs. for two minutes, etc. The burn time *must* be set when the rocket is designed.

Rocket Type	VSP	Weight	Cost
HO Rocket	1	240	$6,000
VCR	1	250	$25,000

Solid Rocket	1	500	$2,500

Adaptive Nozzles: Theserockets are optimized for use underwater; if used in air the nozzle area ratiois too small for optimal expansion of the exhaust. With adaptive nozzles thiscan be corrected, doubling thrust in air or space. Multiply final rocket priceby ¥1.2.

Power

The ship's propulsion system and components require power. Thiscan be provided by any combination of the following systems.

Air−Breathing Engines

Internal combustion engines require oxygen at about Earth−normalpressure to work; they do not function underwater, in vacuum, or inextraterrestrial atmospheres significantly lacking in oxygen. All can bemodified to accept a snorkel for operations underwater and all except thestandard and racing gasoline engine can be modified to run closed−cycle in theabsence of air.

*Standard Gasoline Engine:*A traditional gas−burning engine, essentially unchanged since the 20th century.They have become rare with the scarcity of real gasoline and the high cost ofsynthetic substitutes.

Racing Gasoline Engine: Ahigh−performance, but extremely expensive and maintenance−intensive, engineoften used by racing boats and some high−performance personal watercraft.

Ceramic Engine: Anadvanced rotary engine made of lightweight materials, and capable of running onmost fuels. Most burn cheap alcohol blends.

Gas Turbine: Derived fromjet engine technology, with spinning turbine blades rather than pistons. Theyare popular for high−performance watercraft. Optimized turbines are designedfor fuel−efficiency.

*MHD Turbine:*Magneto−hydrodynamic turbines use magnetic fields and ionized plasma as theirworking medium. They are coupled to a hydrogen−burning turbine.

Hydrogen Fuel Cell: Theseelectric power plants produce power chemically, by combining hydrogen andoxygen. As a by−product, fuel cells produce water, which may be stored forconsumption, or turned back into fuel. Every gallon of hydrogen used produces0.63 gallons of water.

*Hydrocarbon Fuel Cell:*These consume hydrocarbon fuels and atmospheric oxygen, producing water andcarbon dioxide, though there is usually some intermediate chemistry involvingcatalytic water to convert the hydrocarbon to hydrogen, methane, and carbonmonoxide. Hydrocarbon fuel cells will run on high−grade multi−fuel, but notcheap ones like diesel, or even most standard gasoline or alcohol mixtures.

Engine Type	Weight per kW	Base	Cost	Fuel
Old standard gasoline	5	25	$5	0.04G
if turbo or supercharged	4	20	$10	0.04G
New standard gasoline	4	20	$8	0.035G
if turbo or supercharged	3	15	$15	0.035G
Old racing gasoline	1	5	$100	0.055G
New racing gasoline	0.75	5	$150	0.05G
Ceramic	3	15	$6	0.03M
if turbo or supercharged	2	10	$12	0.03M
Gas turbine	1	15	$30	0.055M
if optimized	2	25	$12	0.045M
if high−performance	0.5	10	$80	0.06J
MHD turbine	1	35	$20*	0.18H
if high−performance	0.4	28	$80*	0.2H
Hydrogen fuel cell	5	25	$5	0.115H
Hydrocarbon fuel cell	5	50	$5	0.04M

Location: These powerplants can go in the hull or pods.

Per kW and *BaseWeight* are used to figure the overallweight: Multiply the engine's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight.

Cost is multiplied byoverall weight. An asterisk indicates the engine has a minimum cost of $500,regardless of weight.

Fuel is consumption ingallons per hour (gph) for each kW of output. The fuel used is gas (G),multi−fuel (M), hydrogen

(H), or jet fuel (J). Gasolineengines running on alcohol multiply the gph by 2.

Volume: The rulesregarding access space for propulsion systems (p. 00) also apply to powerplants.

(((START BOX)))

Air−Breathing Engine Options

Multi−fuel

Multi−fuel assumes the use of gasoline, diesel, aviation gas,or jet fuel. Multiply fuel consumption by 0.8 if using aviation gas, 1.2 ifalcohol, or 2.0 if methane. Hydrocarbon fuel cells can also run on hydrogen,multiply fuel consumption by 3.45.

Closed Cycle Operation

Some engines can be designed to operate closed−cycle in theabsence of oxygen.

Gas turbine, ceramic, and MHD turbine: Multiply weight, volume and cost of the engine by¥1.5. Add an additional fuel consumption of 2.35 gph of liquid oxygen (LOX)per gph of other fuel consumed.

Fuel cells: Add a LOXrequirement equal to half the fuel consumption.

Snorkels

A snorkel is a long ventilation tube that allowsair−breathing engines to work in up to 30' of water. A snorkel has a +0 SizeModifier to detect or hit. A snorkel multiplies engine VSPs, weight, and costby ¥1.01 for each engine which uses it; round up to the nearest 0.1 VSP.

(((END BOX)))

Nuclear Power

*Radiothermal Generator (RTG):*These use a thermoelectric system to convert the heat from a decayingradioisotope to energy. They have no moving parts and the radioisotope lastsseveral years.

Fission Reactor: Anatom−splitter. Power is produced directly using thermoelectric materials ratherthen by driving a steam turbine.

Fusion Reactor: This plantgenerates energy through the D−He−3 reaction (p. TS66).

	Weight			
Reactor Type	**per kW**	**Base Cost**	**Core**	**Endurance**

Radiothermal Generator	5	75	$50*		14years
Fission Reactor	2	2000	$100	K$400	2years
Fusion Reactor	1	20,000	$200	M$5	200years

Location: These powerplants can go in the hull or pods.

Per kW and *BaseWeight* are used to figure the overallweight: Multiply the engine's output in kW by the *per kW* figure then add the *Base Weight* to get overall weight.

Cost is multiplied byoverall weight and added to the *Core*cost. An asterisk indicates that RTGs have a minimum cost of $2,000, regardlessof weight.

Volume: The rulesregarding access space for propulsion systems (p. 00) also apply to nuclearpower plants.

Batteries

Batteries have largely replaced internal combustion engines asthe primary source of power in small– to mid–sized marine vessels. Even olderships are being converted to electrical power to take advantage of the lowcost, negligible environmental impact, and mechanical simplicity. Batterytechnology is discussed on pp. TS140–141. All batteries can report theirremaining charge through a data connection (built into the installation slots)or via v–tags.

Note that the maximum power drain a battery can sustain persecond is kWh ¥ 4. A 1,000–kW hydrojet would require at least a 250 kWhbattery to run at full output, and the battery would be drained in 15 minutes.

Pentapack: Rather thenrelying on custom batteries, many small craft have convenient slots forstandard batteries. For small craft this is often a pack of five D–cells in asingle container. A pentapack stores 25 kWh of energy.

Twin–Cells: Two E–cellbatteries. One or two of these packs is enough for most small boats andpleasure craft. A twin–cell holds 40 kWh of energy.

Industrial Cell: Sometimescalled an "I cell," these batteries store 100 kWh in a compactcontainer.

Heavy Cell: This is alarge battery intended for mounting in banks aboard large ships. It stores1,000 kWh of energy.

Custom Battery: Largerbatteries can be extrapolated from those listed below, or determine theirweight and cost as per p. TS141, dividing weight by 250 to get VSP.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**
Pentapack	0.1	25	$750	*

Twin−Cell	0.16	40	$1,200	*
Industrial	0.4	100	$3,000	*
Heavy Cell	4	1,000	$30,000	*

* Uses no power; see description.

Power Packs: These carbonnanotube flywheels can release energy instantly, and are used to power beamweapons and emags. Multiply energy storage capacity by ¥0.1. For example, aheavy cell power pack holds only 100 kWh (360,000 kWs).

Storage Tanks

Storage tanks can hold fuel, water, or other liquids. Tanks arerated in increments of 3 VSP, each holding 100 gallons. Fuel tank modules maybe combined to produce a big tank, or divided for a smaller tank.

These modules list the weight of the tank itself; see p. 00 forliquids that can be stored in a tank. A tank can normally only carry one typeof liquid; it is *not* recommended that afuel tank later be used to store drinking water or argon.

Storage tanks can have various options that affect their weightand cost.

Light: Built oflightweight polymers and composites. Often seen on small watercraft.

Ultralight: Rarely seen onmarine vessels, as weight is not a crucial element. A tank cannot be both lightand ultralight.

Self−Sealing: Common onmodern vessels, if just to help prevent environmental damage if a fuel tank isdamaged. It can be combined with light and ultralight tanks.

Module Type	**VSP**	**Wt.**	**Cost**	**Fire**
Standard Tank	3	50	$500	−2
Options				
Light	¥1	¥0.5	¥2	+1
Ultralight	¥1	¥0.1	¥5	+2
Self−Sealing	¥1	¥2	¥2	−1

Fire Number: Some fuelshave a "Fire" number (p. 00). The fuel tank and options adjust thisnumber. For example, a light tank has a Fire number modifier of (−2 +1) = −1.

Step 6: Components

Crew and Passengers

Controls

These are used to maneuver, accelerate, and decelerate thevehicle. A vehicle must have controls unless it is unmanned.

*Computerized Controls:*Standard controls display information on multifunction digital displays.Digital links connect every system on the ship to report any mechanicalproblems, status, and damage.

Mechanical Controls: Oldmechanical controls are found on some manned vehicles; they cannot be remote controlledor operated by infomorphs.

Duplicate Controls: Large ships and submarines may have a multiple sets of controls.

Module Type	VSP	Weight	Cost	Power
Computerized Controls	0	0	$1,000	
Mechanical Controls	0	0	0	
Duplicate Controls	0.1	25	$500	

Crew Stations and Seats

A crew station is a position manned by a singlecrew member. It controls one or more vehicle systems, and includes a seat andconsole. Seats are just that a seat inside the vehicle that isn'tassigned to control anything.

Cramped: A seator workspace with little room.

Normal: This hassomewhat more elbow room and is more comfortable to work at.

Roomy: Roomyseats are typical of vehicles built for comfort, like civilian automobiles.

Cycle: A compactcontrol panel and seat outside the vehicle. It is used on small vehicles likewaterbikes. It can only be used on vehicles that require only one crew stationand are 10 VSPs or less. The occupant is unprotected by vehicle armor.

Module Type	VSP	Wt.	Cost	Power
Cramped	4	20	$100	
Normal	6	30	$100	

Roomy 8 40 $100

Cycle 0 10 $50

Crashweb: Seats can beequipped with a crashweb (an advanced type of seatbelt). This adds 0.1 VSP, 5lbs., and $100 per seat.

Exposed Seats: Thesefigures assume seats are inside the vehicle. If a seat is exposed to theelements, halve the VSP requirement. The occupant has no armor protection fromthe top and sides. Cycle seats are already exposed.

Improved Access: Extraspace can be added to vehicles with crew stations or seats, to allow occupantsto move without displacing anyone else, and to recline the seats comfortably.Multiply seat volume by ¥1.5.

Bridge Access: Largevessels often group several important crew stations together as a"bridge." Multiply the volume of all bridge stations by ¥3.

Quarters

These are bunks and cabins for vessels that will be occupied forlong periods. Any ship with one or more quarters is assumed to have commonfacilities like bathrooms, passageways, etc., commensurate with the number andquality of the accommodations, at no extra cost.

Hammock: A hanging bedconstituting minimal sleeping accommodations for one person.

Bunk: A fixed bed, usuallyin a cramped alcove or room with other bunks. The hammock and bunk both includea small (1 to 5 cubic feet) locker for personal possessions.

Cabin: A furnished roomfor one or two people. A luxury variant with more opulent fittings is alsoavailable.

Module Type VSP Wt. Cost Power

Hammock 20 100 $20

Bunk 20 200 $100

Cabin 100 2,000 $3,000

Luxury Cabin 200 4,000 $10,000

Improved Access: ExtraVSPs can be added to any quarters to provide increased spaciousness. Weight andcost are unaffected.

Environmental Systems

*Environmental Control:*This provides standard heating, air conditioning, etc. It cannot deal withextreme conditions, but adjusts temperatures by up to 40° F toward theoccupants' comfort zone.

Fluorohalide Breathing System: Some deep–diving manned vessels have experimented with FBS systems forthe crew so they do not have to pressurize the interior, with each memberwearing a breathing apparatus (p. 00) connected to a large reservoir tank andscrubber (in one case combined with a gill filter). No vessel simply floods theinterior with breathing liquid for sanitary reasons among others. Usethe gear on p. 00, with larger reservoir tanks for the breathing liquid.

Gill Filter: An artificialgill and regulator system that draws oxygen from the surrounding water andadjusts oxygen partial pressure to match the internal environment (up to 100atm.).

Limited Life System: Asfor environmental controls, but also provides bottled oxygen and water for alimited time. Limited life systems are rated in *man–days*; 100 man–days will keep one person alive for 100days, or two people alive for 50 days, or four for 25 days, etc. The vehiclerequires the *sealed* surfaceoption.

Full Life System: Like alimited life system, but self–regenerating and capable of working indefinitely.A full life system has a basic volume, weight, and cost, plus an additionalrequirement for each person it supports. The vehicle must be *sealed*.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**
Environmental Control	0.02	5	$50	0.25
Gill Filter	0.04	10	400	5
Limited Life System	0.4	100	$500	*
Full Life System Core	2	800	$5,000	
plus, per person	2	200	$500	10

* The power requirement of a limited life system is 0.5 kW ¥the number of occupants (*not* the numberof man–days).

Support: Eachenvironmental control module or full life system component will support *one* occupant. Buy one for each person the vehicle isexpected to hold. Each limited life system module provides one man–day of lifesupport; multiply the weight, VSP, and cost by the number of occupants anddesired duration.

Electronics

Computers

All the computers listed on p. TS141 are available for ships.Volume in VSP is equal to weight divided by 250; power consumption isnegligible. Large ships will often have several computers networked togetherfor redundancy.

(((START BOX)))

Embedded Processors

Even inflatable rafts and canoes will have at least one ofthese computers, which are extremely tiny, cheap computers with Complexity 2.Large vessels may have thousands of these systems running variousadministrative and analysis software. As a general rule assume one freeembedded processor per VSP of volume and one per module. These systems will berunning what ***GURPS Vehicles*** calls the *Damage Control* and *Datalink* programs, providing a +2 bonus to all damage control rolls.

(((END BOX)))

Communication Systems

Radio: A standard radio.On Earth, parts of Mars, and other areas with a local cellular network, radioscan be used to connect to the phone system, so their range becomes moot.Available in short–, medium–, and long–range. Radios are not useful to anysignificant range underwater.

Sonarcomm: These systemsuse pulse–coded sonar to transmit information. Text–only messages can be sentmuch farther (10¥ the listed range).

Laser Comm: A tight–beamcommunication system. The recipient must be visible and have a laser comm ofhis own. It is impossible to eavesdrop on a laser communication withoutblocking the beam.

Trailing Antenna: This isa 900–foot long cable that can be extended by a submerged vehicle to float tothe surface and act as a standard radio antenna.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**	**Range**
Short–Range Radio	neg.	0.12	$25	neg.	100
Medium–Range Radio	neg.	0.5	$100	neg.	1,000
Long–Range Radio	0.02	5	$300	neg.	10,000
Short–Range Sonarcomm	neg.	1.25	$250	neg.	1
Long–Range Sonarcomm	0.02	5	$300	0.1	10
Laser Comm	0.2	50	$3,750	0.4	20,000
Trailing Antenna	0.06	15	$150		

Range is in miles.

VLF: Any of the radiomodules can be designated as very−low frequency capable. It has a longer rangeunderwater (see p. 00), but datalinks are not possible and even two−way voicecommunication is problematic. The radio works normally out of the water.Multiply VSP, weight, and cost by ¥10.

Sensors

Unless otherwise noted all sensors require a line of sight andmust have a facing chosen at installation. Sensors may be mounted in smallturrets (p. 00) to give 180° or 360° coverage. Most sensors cannot seeover the horizon.

PESA: PassiveElectromagnetic Sensor Arrays combine a passive millimetric−band radar,thermograph, and low−light imager. They provide the advantages of Infravision(p. B237) and Night Vision (p. B22). They have a magnification capability equalto their range in miles (or 1¥, whichever is greater).

Ladar: Tunable ladars(LAser Detection And Ranging) are difficult to confuse or jam, but they arehighly degraded by turbid water and do not detect objects beyond the air/waterboundary with any great success.

Radar: A conventionalradar system. Can be spotted by radar detectors at twice its range.

Low−Resolution Imaging Radar (LRIR): A low−frequency millimetric radar, able to determinea target's general shape and outline.

High−Resolution Imaging Radar (HRIR): This uses millimetric radar frequencies, allowingresolution approaching human vision. It cannot resolve flat details or color.

AESA: ActiveElectromagnetic Sensor Arrays are capable of switching between radar and laserimaging (ladar) functions. Halve range (−2 Scan) when operating in ladar orLRIR mode. In HRIR mode range is 1/50 normal (−10 Scan), with each"mile" actually representing 35 yards. It can switch to a "lowprobability intercept" radar mode as well; halve range (−2 Scan) but itcan only be detected at 1.5 times the radar's (halved) range.

Sensor Suites

Navigational Lights: Allvessels are assumed to have a number of small navigational lights that canilluminate a 3−foot area out to 135 feet and can be seen 2,700 feet away. Theyreduce fog penalties by half.

Searchlight: This projectsa bright beam of visible light, illuminating a 30−foor radius out to 5 miles.The searchlight itself is visible for 10 miles.

Simple PESA Array: This isa band of four PESAs arranged around the ship.

Simple Sonar Array: Thisis a set of five active/passive sonars with the no−targeting and flat arrayoptions. One is mounted on the bottom and the rest are spaced around the hull.When active, these systems can create a detailed map of the surrounding seabedand locate nearby objects. In busy harbors they will map out the locations ofother sonar−equipped vessels and note the location of sonar beacons. Thissystem provides a +2 to Navigation rolls close to shore or shoals.

Light Sensor Suite: Asmall PESA and low–res imaging radar in one package, suitable for most civilianvessels or as a periscope sensor on submersibles. The PESA has a 12–mile rangewith Scan 17, and the AESA has a 4.5–mile range with Scan 15.

Medium Sensor Suite: Anupgraded set of sensors, designed for light combat vehicles and some scientificmissions. The PESA has a 36–mile range with Scan 20, and the AESA has a 45–milerange with Scan 21.

Heavy Sensor Suite: Aheavy set of sensors intended for combat vessels. The PESA has a 100–mile rangewith Scan 23, and the AESA has a 225–mile range with Scan 25.

*Individual Sensors:*Sensors can also be bought individually. Ladars and low–res imaging radars(LRIRs) have the same statistics.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**	**Range**	**Scan**
Searchlight	0.2	50	$2,500	5		
Simple PESA Array	neg.	0.2	$80	neg.	1.5	12
Simple Sonar Array	0.04	15	$750	1.25	0.1	5
Light Sensor Suite	0.04	10	$22,770	1.1	*	*
Medium Sensor Suite	0.4	93	$216,180	11.25	*	*
Heavy Sensor Suite	7	706	$1,362,500	126.56	*	*
Individual Sensors						
Small AESA	0.03	7.5	$12,500	1.25	5	15
Medium AESA	0.3	75	$125,000	12.5	50	21
Large AESA	3	750	M$1.25	125	500	27
Small PESA	0.05	12.5	$50,000	neg.	25	19
Medium PESA	0.9	112.5	$450,000	neg.	75	22
Large PESA	5	1,250	M$5	neg.	250	25

Small Ladar or LRIR	0.05	12	$15,000	3	6	15
Medium Ladar or LRIR	0.5	120	$150,000	30	60	21
Large Ladar or LRIR	5	1,250	$625,000	312.5	250	25
Small Radar	0.02	5	$2,500	1.25	5	15
Medium Radar	0.2	50	$25,000	12.5	50	21
Large Radar	0.6	250	$75,000	37.5	250	25

No Targeting: AESA,Ladar/LRIR and radars are available in versions that cannot be used fortargeting. Multiply VSP, weight, and cost by ¥0.5.

Air/Surface Search: Radarscan be optimized for ground or air search, at the expense of the other.Multiply cost by ¥0.5.

Sonar

Sonar detects targets by emitting a beam of sound using *transducers* and measuring the time it takes for the echoes toreturn. Active sonar can determine range, size, and speed of a moving object aswell as the shape of stationary objects and the ocean floor. Repeated pulsescan determine the general shape, and course of a moving object.

The basic sonar system is a three–dimensional array withhydrophones and transducers built into the skin, providing 360° coverage they are multifrequency systems, designed to cause as little impact onsea life as possible. They are active–only systems, and cannot effectivelyfunction in a passive (listening) mode. A number of options are available forsonar:

Active/Passive: The sonarcan switch to a passive hydrophone mode. Listening range is double that of theactive range (+2 Scan).

Passive: The sonar cannotoperate actively. It can determine approximate distance, course, elevation, andspeed to a target but not size or shape. It is not accurate enough to aimdirect–fire weapons. The power requirement becomes negligible and range isdoubled (+2 Scan). Also see *sonar detector*, p. 00.

Flat: Sonar systems thatonly cover a single hemisphere (forward or rear) are more compact and lessexpensive.

No Targeting: The sonarcannot be used for targeting (even TMA, p. 00). Not compatible with the passiveoption.

New Technology: The sonaruses cutting–edge multifrequency adaptive technology that can range fromlow–frequency, long–range scans to high–frequency sonar imaging, and do it fastenough to form a broad sensor composite of the surrounding area. New sonars arealso more compact, taking advantage of the latest in distributed computing andsignal analysis.

Module Type	VSP	Wt.	Cost	Power	Range	Scan
Tiny Sonar	0.08	20	$2,000	1	0.5	9
Small Sonar	0.16	40	$4,000	1	1	11
Medium Sonar	4	1,000	$100,000	50	5	15
Large Sonar	16	4,000	$400,000	200	10	17
Massive Sonar	64	16,000	$1,600,000	800	20	19
Immense Sonar	144	36,000	$3,600,000	1,800	30	20

Options

Active/Passive	¥1.5	¥1.5	¥1.5	¥1
Flat	¥0.5	¥0.5	¥0.5	0.5
No Targeting	¥1	¥1	¥0.5	¥0.25
New Technology	¥0.5	¥0.5	¥4	¥1

Navigation

These modules help the vehicle find its position. A magneticcompass is free, but useless on worlds without a strong magnetic field (e.g.,Mars). All computers come with Global Positioning System (GPS) hardware andsoftware for free.

Precision Navigation: Thisis a system of gyroscopic compasses, star–tracking devices, andradio–navigation systems that can be used on planets without a GPS network.When using dead reckoning the instruments give +5 to all Navigation rolls.

*Inertial Navigation System:*A sophisticated gyroscopic system that allows a vehicle to keep track of itslocation as it travels. It is accurate to within 1' per 10 miles traveled, butwill correct any drift when it encounters known landmarks or a navigationalrelay.

IFF: "Identify Friendor Foe," a specialized transceiver used to recognize vehicles that havebeen detected but not identified. IFFs mostly appear on military vessels. RadioIFF systems have the same range as a long–range radio (10,000 miles) but inmost cases it is set at a lower power (300 miles). Sonar–based systems have arange of 100 miles, but practical considerations reduce this to 1 mile in mostcases.

Transponder: A civilianIFF system that lacks the capability of interrogating other systems andcontains only a limited amount of information. Transponders are used to locatevessels and can be set to broadcast an emergency signal.

Module Type	VSP	Wt.	Cost	Power
Precision Navigation	0.08	20	$5,000	neg.
INS	0.04	10	$12,500	neg.
IFF	0.02	5	$1,000	neg.
Transponder	0.01	2.5	$500	neg.

Countermeasures

Decoy Dischargers: A smallmortar or tube that can fire decoy munitions. In air they can conceivably fire300'.

Laser/Radar Detector: Thissensor automatically warns of any radar emissions or if a laser targets theship. It can also determine the range and bearing of a radar or radar jammer(out to twice the radar's range or 20 times a jammer's usual range) as well asthe make and model of the system and its current operating mode (if anappropriate database is available).

Sonar Detector: Aspecialized hydrophone and signal analysis system that detects active sonartransmissions (at up to four times the active sonar range) and provides a roughbearing and range to the source. Note that a passive sonar can detect an activesonar at twice the active sonar's range, without this module. Halve detectionranges for new sonars.

Area Jammer: This deviceprojects a signal that interferes with radio and radar, subtracting its jamrating from any rolls to detect with radar or communicate with radio byeveryone in the area (friend or foe). Area jammers have Jam 10 and a range of50 miles.

Sonar Jammer: The aquaticversion of the area jammer, it interferes with sonar systems to a radius of 40miles with Jam 8. Sonar jammers are rarely used because of bad publicity andthe fact that the area they are launched in becomes a tempting target.Individuals with Ultrasonic or Subsonic hearing within the radius of effect ofa sonar jammer must make a HT−8 roll each hour to avoid disorientation (−2 onall tasks) and are effectively deaf. Sonar Vision within the radius is at −8.

Module Type	VSP	Wt.	Cost	Power
Decoy Dischargers	0.2	20	$100	0
Decoy Reload	0.1	10	*	0
Laser/Radar Detector	0.06	15	$1,500	neg.
Sonar Detector	0.01	2.5	$250	neg.

Area/Sonar Jammer	0.8	200	$40,000	1,000

* $10 for a smoke discharger, $20 for chaff/radar jammer, $50 forsonar decoy.

Manipulators

A vehicle may have arms, designed for manipulating externalobjects. Unlike most modules, arms do not usually occupy VSP in the vehicle;they are attached to the outside. A vehicle may have as many arms as desired,but the total weight of all arms may not exceed half the ship's hull weight.The vehicle face each arm is attached to must be specified. Arms are made withcarbon composite, extra–heavy frames with smart structure. They are notconsidered to be armored or have any surface options (such as sealing), but canbe given those options just like a subassembly.

Type	**Area**	**Wt.**	**Cost**	**Power**	**HP**	**Size**	**Reach**
ST 10 Arm	1	6	$11,000	0.05	12	–4	1
ST 100 Arm	5	45	$85,000	0.5	60	–2	2

Reach is the arm's reachin yards. Each arm may also contract to half this length.

Retractable: Ifretractable, a ST 10 manipulator requires 0.01 VSP of internal space; 0.1 VSPfor the ST 100 arm.

Small–Craft Storage

Dry docks and bays have two forms of module. The Base module foreach must be used to start a new bay or dock, but each Base module may beexpanded with any number of Add–On modules of the same type. All Base moduleshold 40 VSP of small craft. All Add–On modules hold 20 VSP each.

Dry Dock: A floodablehangar lets watercraft dock inside; it takes 5 seconds per VSP of capacity tofill or empty. The hangar must be pressurized to empty a flooded hangar at depth,this takes 20 seconds ¥ VSP ¥ difference in pressure (in atmospheres).This is rarely done due to the time required. Increase the vehicle weight by250 lbs. ¥ filled VSP.

Hangar Bay: A large bayfor storing smaller vehicles. Craft in the hangar bay have access to fuelstores and can recharge from the ship's power system. Includes any necessaryelevators or ramps to a flight deck (see p. 00).

Vehicle Bay: A vehicle bayis a specialized hangar built to hold a specific vehicle type very snugly. Ifthe vehicle is manned it can be accessed directly through a small door. Thecraft then exits through a small hangar door. There is not enough room formaintenance or vehicle recovery. The craft can usually be transferred from thebay to a nearby hangar or back again. "Reloadable" bays can bereloaded from inside the mother vehicle, taking a time 400/VSP seconds.

External Cradle: Shipsoften attach smaller craft or pods to their sides or decks. The cradle includesa winch or boom for launching or recovering the mounted object. This generallytakes a minute and matching speeds. In bad conditions (rushed docking, roughseas, low visibility, etc.) the GM may require control rolls to prevent acollision or recovery mishap. Items on cradles are outside the vehicle and canbe targeted separately. Each module holds 1.25 tons of vehicle.

Module Type VSP Wt. Cost Power

Dry Dock Base 80 2,000 $5,000

Dry Dock Add−On 40

Hangar Bay Base 60 2,000 $5,000

Hangar Bay Add−On 30

Vehicle Bay Base 42 1,000 $3,000

Vehicle Bay Add−On 21

Reloadable ¥1 ¥2 ¥2

External Cradle 1 250 $2,500

Miscellaneous Equipment

These are other modules that may be installed in or on vehicles.

Arrestor Hook: Retractablenanoweave wire or net system that can snag an arrestor hook. On a successfulcatch the landing vehicle is slowed by 80 mph.

Safety: A fire−suppressionsystem that senses fires and floods the burning compartment with inert gas toextinguish them. A compact (and less−effective) version is also available.

Bilge Pump: Bilge pumpsremove 90 lbs. of water each minute from a ship. Large vessels often mountseveral pumps in case of an emergency.

Crane: Used to lift andmove heavy cargo. Requires an operator with Professional Skill (CraneOperation). Each module provides 6' of height and one ton lifting capacity.

Hall: A furnished roomthat can comfortably accommodate 10 people. Usable as a restaurant, bar,conference room, etc.

Small Galley: A small areafor cooking and presenting meals for vessels that lack bunks or cabins. Onlyone person can work in a small galley at a time.

Full Galley: A completekitchen with all the amenities. Even vessels with cabins will sometimes haveone or more full galleys as they add +2 to Cooking skill. Up to three peoplecan work in a full galley at once.

Stage: Usable forbriefings, dancing, plays, nightclub acts, act. Includes a sophisticated soundand light system.

Launch Catapult: Thiselectromagnetic catapult accelerates any aircraft under 75 tons to 20 mphalmost instantly.

Minifacturing Workshop: Aworkshop with a 3D printer, plus appropriate tools and spare parts for usingthe Armory, Electronics, Engineer, and Mechanic skills. Up to three people canuse it at once, and it gives +2 to skill. A compact minifacturing workshop isalso available; it can only be used by one person at a time.

Science Lab: As per the *Laboratory* habitat module, p. 00.

Winch: A motorized winch.It can lift one ton (ST 100) at up to 12' per second, or tow much greaterweights.

Cyberdoc: A robotic medic.Cyberdocs are treated as crew, not part of the vehicle. See p. TS122.

Surgery: A well–equippedsurgery, including a gyrostabilized operating table, diagnosis table, and EMU.One person may be operated on at a time. A variant surgery module is availablefor veterinary medicine. The differences are minor, and it can be used for workon humans at –2 to skill (and vice–versa).

Airlock: As per the *Airlock* habitat module, p. 00.

*Fuel Electrolysis System:*This converts water into hydrogen and liquid oxygen. It can be useful forvehicles with turbines or fuel cells (p. 00). Each electrolysis module canprocess 40 gallons of water per hour, producing 63 gallons of hydrogen and 30gallons of oxygen.

Provisions: Food anddrink, plus storage facilities. The space occupied by provisions will usuallybe part of the cargo bay. Two sets of statistics are listed; the"Provisions w/FLS" line should be used if the vehicle has a full lifesystem.

Cargo: Five cubic feet ofcargo space. Multiple cargo modules can be combined to form one large cargohold. Cargo modules with fractional spaces are also possible.

Open Cargo: Ten cubic feetof cargo space, in an open cargo bed on the top deck, with partial sideprotection and no overhead cover. Otherwise identical to a *Cargo* module.

Ballast Tanks: Floodabletanks that allow a submersible to adjust its buoyancy. Submersibles should have10% to 20% of their volume as ballast for proper operation.

Empty Space: Any spaceleft over after all modules have been selected is simply empty space otherwise known as "bilge" space. This space serves a valuable safetyfunction if the vessel is flooded

Module Type VSP Wt. Cost Power

Arrestor Hook	1	100	$1,000	0
Safety	0.8	200	$5,000	0
Bilge Pump	2	200	$500	1
Compact Safety	0.2	50	$500	0
Crane	4	1,000	$4,000	1
Hall	200	80	$500	0.1
Galley	10	100	$50	
Full Galley	80	3,000	$1,900	1
Stage	200	250	$1,000	0.1
Launch Catapult	160	40,000	$200,000	500
Minifacturing Workshop	250	30,000	$170,000	1
Compact Minifacturing Workshop	100	10,500	$55,000	0.5
Science Lab	200	20,000	$1,000,000	3
Winch	1	25	$1,000	0.5
Surgery	50	280	$50,000	0.5
Airlock	10	500	$1,000	neg.
Fuel Electrolysis System	1	100	$5,000	560
Provisions	0.05	[12]	[$6]	
Provisions w/FLS	0.01	[2]	[$6]	
Cargo	1	[100]	$0	0
Open Cargo	1	[200]	$0	0
Ballast Tanks	1	0	$0	0

Empty Space var. 0 $0 0

Step 7: Weaponry

The following weapons are commonly available. All guns are fullystabilized, allowing fire while moving, and come in casemate mounts if placedin the body, or universal mounts if in a turret. Weapons are assumed to faceforward out of the body or turret. If installed to face in a differentdirection, specify this.

55mm Emag: Short barreledcannon that can engage a wide variety of targets.

100mm Emag: A longbarreled, rapid–fire railgun used for shore bombardment and low–intensity navalfire support.

150mm Emag: Larger navalrailgun with a very–long barrel, primarily used to launch drone warheads (0.2cf).

Warheads: Various warheadsthat can be installed for self–destruct or attack purposes. A depth charge issimply a warhead mounted on a hardpoint.

Torpedoes: These arerobotic unmanned submersibles, launched from vehicle bays. Two torpedo typesare listed on pp. 00–00. Additional torpedoes can be built using theconstruction system.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**
55mm Emag	10.5	2,615	$345,000	800kW
300 rds. HEMP	0.5	[240]	[$6,000]	
300 rds. MBC	0.5	[240]	[$3,000*]	
100mm Emag	86.4	21,600	M$2.9	20,000kW
100 rds. HEMP	1	[500]	[$12,000]	
100 rds. MBC	1	[500]	[$6,000*]	
150mm Emag	259.2	64,800	M$8.6	85,000kW
25 rds. HEMP	1	[425]	[$10,000]	
25 rds. MBC	1	[425]	[$5,000*]	
100mm Warhead	neg.	[1.3]	[$20**]	
250mm Warhead	0.1	[20.8]	[$310**]	

300mm Warhead	0.2	[36]	[$540**]
400mm Warhead	0.5	[85.3]	[$1,280**]
600mm Warhead	1.7	[288]	[$4,320**]

Ammo Options: * Plus costof doses of chemical (or microbots). The smart ammo options from p. TS157 mayalso be applied to vehicular weapons. Simply multiply the ammo module costs bythe given multiplier.

Warheads: ** Multiply byany cost multiplier for warhead type.

Step 8: Surface Features

Fin Stabilizers: Thissystem uses a gyroscope and small retractable fins to control a ship's roll inrough seas. It does not work to full effect unless the vessel is moving, but issmaller than large, rigid fins.

Flight Deck: This makespart of the top deck into a runway with a length equal to 3 ¥ the squareroot of the area assigned to it. Half of the deck must be clear to performtakeoffs and landings.

Landing Pad: An open areaon the deck for landing VTOL aircraft.

Camouflage Paint: Asuitable paint job can make a vehicle harder to spot, giving −2 to Visionrolls. This is the simplest concealment feature. An especially gaudy paint jobcosts the same but has the opposite effect!

Chameleon System: Thiscombines liquid crystal skin with sensors that scan the surroundings, andchange the skin to match. It gives a −6 (−3 if moving) to be visually spottedor hit, or detected by ladar. Optionally, the sensors may be turned off, andthe skin may be set to any programmed color scheme.

Sound Baffling: This masksthe vessel's sound emissions, usually through the use of anechoic tiles,aerogel, active sound cancellation, and judicious planning before construction.Civilian vessels often have some level of sound baffling for aesthetic and legalreason. All give a penalty to be detected by passive sonar: *basic* −5, *radical* −10, *extreme* −20. Halvethe penalty against active sonar.

Emission Cloaking: Thismasks the vehicle's heat, magnetic, and millimetric emissions. It imposes apenalty on rolls to detect the vehicle with non−optical passive sensors. *basic* −5, *radical* −10.

Module Type	**VSP**	**Wt.**	**Cost**	**Power**
Fin Stabilizers	0	0.01	$0.2	neg.
Flight Deck	0	0.1	$1	0

Landing Pad	0	0.05	$0.5	0
Camouflage Paint	0	0	$0.1	0
Chameleon System	0	0.5	$100	0
Basic Sound Baffling	0	0.5	$25	0
Radical Sound Baffling	0	1	$250	0
Extreme Sound Baffling	0	2	$2,500	0
Basic Emissions Cloaking	0	1	$150	0
Radical Emissions Cloaking	0	2	$1,500	0

Except for the flight deck and landing pad, multiply weight andcost by the total area of the vehicle.

(((START BOX)))

Bubble Generators

A bubble generator is a set of components that increase theefficiency of cavitation bubble formation and maintenance. A bubble generatoris rated for its "bubble factor" that is used for performancecalculations (p. 00). The system weighs 1 lb. ¥ cube root of total area(minus the area of retracted components) ¥ bubble factor. The system doesnot take any space but costs $25 per lb. New advanced bubble generators weighhalf as much, but cost $50 per lb. They require either weight /10 gallons of HOfuel or 200 kW ¥ weight.

For example, a Large Waterbike with no subassemblies hasan area of 60 sf. A bubble factor 6 new electric generator would weigh 11.74lbs., costs $587, and requires 2,348 kW.

(((END BOX)))

Step 8: General Statistics

Passive Defense

This depends on DR. DR 1 gives PD 1, DR 2–4 gives PD 2, DR 5–15gives PD 3, and DR 16+ gives PD 4.

Weight

Empty Weight (EWt): Thesum of all components with their weight not listed in brackets.

Payload: This is the totalof all components with their weight listed in brackets, plus 200 lbs. per humancrew or passenger, plus the weight of any carried craft or cybershell crew,plus any fuel or consumables. Per gallon, fuel is:

Fuel	**Wt.**	**Cost**	**Fire**
Alcohol	5.8	$0.5	10
HO Rocket Fuel	2.1	$0.1	13
Hydrogen	0.58	$0.1	13
Jet Fuel (Kerosene)	6.5	$3	13
Liquid Oxygen	9.6	$0.1	13
Metallic Dust	18.4	$2	
Synthetic Gas	6	$5	11

Loaded Weight (LWt): Sumof empty weight and payload. It is usually simpler to list it in tons (loadedweight/2,000).

Flotation Rating

Flotation Rating is the maximum weight of the vessel before itsinks. In pounds it equals hull VSP ¥ 375 in water (¥ 210 in liquidethane). If the ship's weight exceeds this figure it will sink. Submersiblesuse the sum of body, superstructure, and turret VSP for maximum flotationrating.

Submersibles

Submersibles must be able to achieve negative buoyancy (i.e.sink) in order to dive. The *minimum*flotation rating of the ship is found by reducing the flotation rating by 62.5lbs. per cf used for ballast tanks. If the submersible has too high a minimumflotation rating to sink, add more ballast.

*Submerged Weight:*Submerged weight is either the flotation rating or the loaded weight, whicheveris greater. Note that submersibles with a loaded weight more then theirflotation, or those with a loaded weight less then their minimum flotationrating, will need to calculate their hydrodynamic stall speed, as they willsink or float without dynamic lift.

Volume

Volume in cf is (hull VSP ¥ 6) + (subassembly total VSP ¥5).

Arms: Each ST 10 arm adds0.06 cf, or 0.6 cf for each ST 100 arm.

For example, a Medium Boat hull (20 VSP) with a hydrofoil (4VSP) and a 2 VSP subassembly has a total volume of (20 ¥ 6) + ([6 + 2]¥ 5) = 160 cf.

Cost

This is the sum of all component prices not listed in brackets.Those prices in brackets and fuel are the payload price, which are not listedamong the vehicle's primary statistics, but should be mentioned in the generaldescription.

Structural Strength (HT)

This is a measure of structural robustness. The heavier a ship iscompared to its structural strength, the more strain it puts on its systems. Aship may have a low HT and many hit points. HT is calculated as follows:

Structural HT = (200 ¥ hull hit points / loaded weight) +5

If the vehicle has hardpoints, use the weight with hardpointsloaded do not calculate two different values. If the vehicle has aracing engine, reduce HT by −1. The maximum allowed HT is 12 (11 if a racingengine). Round HT to the nearest whole number.

Maintenance Interval

This is the period of time a vessel can safely operate betweenmaintenance checks and overhauls. The formula is:

Maintenance interval in hours = 20,000 / (square root ofvehicle cost)

Round to 2 places. If the vessel has a smart hull andsubassemblies then double the Maintenance interval. See p. TS189 for rules onfailing to perform proper maintenance.

Step 9: Performance

Water Performance

Before determining performance it should be determined if thevessel is primarily a *surface vessel* ora *submersible*.

Hydrodynamic Drag

This is based on the wetted area of the vessel, which largelyconforms with its loaded weight in pounds

Hdr = [(cube root of loaded weight) squared] / Hl

*Hydrodynamic Lines (Hl):*This is 15 for fine lines, 10 if average lines, 5 if mediocre or submarinelines (either type), or 1 for no hydrodynamic lines.

Round to the nearest whole number.

(((START BOX)))

Towing

The towing rule applies for any submerged vehicle with open crewstations or harness, or a surface vessel towing a submerged operator. Calculatethe drag separately for each exposed passenger or crewmember; aquatic–adaptedcharacters have a drag divisor of 10. Thus, an average human (200 lbs.) willadd 6 to drag and an average dolphin (500 lbs.) adds 1. If a vehicle is towinganother vehicle add the hydrodynamic drags together.

(((END BOX)))

Water Speed (wSpeed)

First determine the total aquatic motive thrust (Ath) used by thevehicle. Then use the following formula:

WSpeed = [cube root of (Ath/Hdr)] ¥ 6

Round to the nearest mph if speed is under 20 mph, otherwiseround to the nearest 5 mph.

Planing: If Ath is atleast [(Hl ¥ 5) + 5]% of loaded weight the vessel can skim over the water.Multiply top speed by 2.

Hydrofoils: If a vesselwith hydrofoils (p. 00) has a surface top speed of 20 + (hull area / 100) mphor more after accounting for planing it can rise up on its foils. Multiply topspeed by 1.5.

Water Acceleration (wAccel)

wAccel = (Ath / loaded weight) ¥ 20

Round to the nearest tenth of a mph/s if the result is under 1mph/s; if 1–5 mph/s round to the nearest mph/s; if above 5 mph/s round to thenearest 5 mph/s.

Water Maneuver Rating (wMR) and Water Stability Rating (wSR)

Hull		**Volume**	**wMR**	**wSR**
Small Waterbike	Small Boat	upto 20 VSP	0.75	4
Medium Boat	Medium Runabout	20.2–200 VSP	0.5	5
Large Runabout	Medium Cutter	200.2–2,000 VSP	0.25	6
Medium Cutter	Medium Ship	2,000.2–20,000VSP	0.1	6
Large Ship	Medium Arcoblock	20,000.2–200,000VSP	0.05	7

Large Arcoblock	over200,000 VSP	0.02	8

wMR: Shift one category upfor each of the following: computerized controls, responsive structure, and findrive. Once the topmost column is reached add +0.25 to wMR for each remainingoption.

wSR: Reduce by −1 foraverage hydrodynamic lines, −2 for fine or submarine lines. Add +1 forcomputerized controls and +1 for fin stabilizers. Minimum wSR is 1.

(((START BOX)))

Hydrofoils

To better represent the maneuverability of hydrofoil craftuse the foil's volume to determine wMR and wSR when it has risen out of thewater. Only modifiers for computerized controls and responsive structure affectthese values.

(((END BOX)))

Water Deceleration (wDecel)

The base safe deceleration possible on water in mph per secondis:

100 ¥ (wMR / Hl)

Maximum wDecel is 10 mph/s. The vehicle may add half its wAccelto water deceleration, rounding up, but show the increased deceleration inparentheses.

Draft

This is the minimum depth of water, in feet, in which the vesselmay travel without running aground.

Draft = [(cube root of loaded weight) / 15] ¥ Hld

Hydrodynamic Draft Factor (Hld): Is 1 if no hydrodynamic lines, 1.1 if mediocre, 1.2 if average, 1.3 iffine, 2 if either submarine lines.

Underwater Performance

Hydrodynamic Stall Speed

This is the minimum speed the vessel must be travelling at inorder to maintain neutral buoyancy, otherwise it will either sink or begin torise. If the result is positive the vessel will sink if it moves slower thenthe listed speed; if the result is a negative number the absolute value is thespeed necessary to keep from floating to the surface.

Hydrodynamic Stall Speed = [(Submerged weight   flotation rating) / lift area] ¥ 0.05

Submerged weight and *flotationrating* are in lbs.

Lift area is 10% of thehull's surface area, 15% if it is also a lifting body. Add the surface area ofany wings.

Underwater Deceleration (uDecel), Underwater Stability Rating(uSR), and Underwater Maneuver Rating (uMR)

Use the water statistics (wDecel, wSR, wMR) for these.

Underwater Drag (HdrS)

This is based on the submerged weight of the vessel.

HdrS = [(cube root of submerged weight – lift) squared] / Ls

Submarine Lines (Ls): Thisis 20 if advanced submarine lines, 10 if submarine lines, 4 if fine lines, 3 ifaverage lines, 2 if mediocre lines, or 1 if the vessel lacks hydrodymaniclines.

Underwater Top Speed (uSpeed)

USpeed = [cube root of (Sth / HdrS)] ¥ 6

Round to the nearest mph.

Draft

The *base draft* of thesubmersible is the cube root of the ship's submerged weight.

*Actual Submerged Draft:*Divide the base draft by 5. This is the draft used for performancecalculations.

Safe Draft: This is theminimum operating depth at which the vessel can operate while submerged. Dividethe base draft by 3.

Round to the nearest inch.

Crush Depth

This is how deep the vessel can dive in a liquid withoutpressurized areas being crushed. Pressurized areas include any body orsubassembly that contains crew positions, passenger seats or accommodations. Tofind the maximum pressure a vehicle can withstand use this formula:

Pressure = 1 + 3 ¥ (DR + 10) ¥ Frame Modifier ¥Shape Modifier / (Size Modifier ¥ 34)

Size Modifier is the hullor subassembly's Size Modifier, minimum 1.

Frame Modifier is 0.25 ifextra–light, 0.5 if light, 1 if medium, 2 if heavy, 4 if extra–heavy.

Shape Modifier is 24 forspherical hull, 6 for structures with the submersible option, and 3 otherwise.

To convert pressures to depths use this formula:

Depth (feet) = 34 ¥ (Pressure – Atmosphere) / (Gravity¥ Density)

Atmosphere, *Gravity*, and *Density* are defined in the box *Calculating Pressure* (p. 00).

To get yards, divide by 3; to get miles, divide by 5,280.

Test Depth: Mostsubmersibles operate well within safety limits, not exceeding a test depth. Tofind test depth, divide the maximum pressure by 2 and convert to a depth.

Pressure Hulls: If thereare multiple pressurized sections calculate their crush and test depthsindividually.

Supercavitation Performance

Supercavitating Top Speed (cSpeed)

cSpeed = [square root of (cThrust / HdrS)] ¥ 6

cThrust includes only thethrust of engines that will function during supercavitation. Round to thenearest 5 mph.

Supercavitating Threshold (cThresh)

This is the minimum underwater speed the vehicle must reach toinitiate supercavitation.

cThresh = [square root of (submerged draft + 11 – B) ¥175]

B is the bubble factor ifthe vessel is using a bubble generator (p. 00).

Supercavitating Depth (cDepth)

This is the shallowest depth, in yards, that a vessel caninitiate supercavitation. If the result is less then safe submerged draft, orless than zero, the vehicle can t supercavitate.

cDepth = [(uSpeed squared / 175) – 11 + B]

Supercavitating Floor (cFloor)

This is the maximum depth, in yards, at which the vehicle can *maintain* supercavitation.

cFloor = [(cSpeed squared / 175) – 11 + B]

This value may be greater than cThresh, indicating the vehiclemay dive to a greater depth once it has managed to initiate supercavitation. Ifit is less than cThresh, supercavitation is actually slowing the vehicle!

(((START BOX)))

Offworld Supercavitation

The cDepth and cFloor statistics assume Earth normalconditions. On other worlds, adjust the depths as follows:

adjusted depth = [34 ¥ (1 – Atmosphere) + depth] /(Gravity ¥ Density)

Atmosphere, *Gravity*, and *Density* are defined in the box *Calculating Pressure* (p. 00).

(((END BOX)))

Supercavitating Acceleration (cAccel)

cAccel = [(cThrust / Lwt.) ¥ 20]

Round to the nearest whole number.

Supercavitating Maneuver Rating (cMR)

As per wMR (p. 00), but shift *down* two rows and ignore the flexibody modifier.

Supercavitating Stability Rating (cSR)

As per wSR (p. 00), but shift *up* two rows, subtracting –1 for each row above the top, and then subtractan additional –1. Reduce by –1 for mechanical controls. Add +1 for extendedwings.

Supercavitating Deceleration (cDecel)

cDecel = [cMR ¥ 4]

A vessel may decelerate at this rate safely via controlledcollapse of the supercavity. In crash deceleration, cDecel in mph/s is equal to(current speed – cThresh) ¥ cMR. A control roll is required, at –1 per (cMR¥ 50) mph/s over ordinary cDecel.