X-25 Sea of Japan / East Sea: LME #50

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The Sea of Japan/East Sea LME is bordered by China, Japan, North Korea, South Korea and the Russian Far East. This LME has a mean depth of 1,350 m, a surface area of about 984,000 km^2, of which 0.40% is protected, and contains 0.25% of the world's sea mounts and 10 major estuaries (Sea Around Us 2007). Narrow straits connect the LME to the Sea of Okhotsk, the North Pacific and the East China Sea, with the Korean Strait accounting for 97% of the total annual water exchange (Baklanov *et al*. 2002). Flowing southwest along the Far East's coast of Russia is the cold Primorskii (Liman) Current (Dobrovol'sky & Zalogin 1982). This LME spans both subtropical and temperate climatic zones and climate is the primary driving force of biomass change. Monsoon atmospheric circulation mainly determines the sea climate. A book chapter and report on this LME have been published by Terazaki (1999) and made available electronically by UNEP (2006).

I. Productivity

The Sea of Japan/ East Sea LME is a Class II, moderate productive ecosystem (150-300 $gCm^{-2}y^{-1}$). Considerable variation in the composition, distribution and abundance of the plankton community has been recorded and associated with environmental variability (Terazaki 1999). Diatom blooms occur primarily in the spring and a subsurface chlorophyll maximum is sometimes found in the deeper layers, particularly in spring and winter. The zooplankton community has low diversity in terms of number of taxonomic groups and species, with five zooplankton groups accounting for over 99% of the biomass: copepods, which are the most abundant, euphausiids, chaetognaths, amphipods and mysids. At a depth of 0-5 m in open and semi-closed bays there are widespread communities of species such as blade kelp (*Laminaria hyperborean*) and Irish moss (*Chondrus crispus)*, with biomass up to 12 kgm^{-2}. Tropical, sub-tropical and arctic animals occur in the LME, with the coastal fauna and flora consisting of a higher percentage of sub-tropical species.

Oceanic fronts (Belkin et al. 2009; Belkin and Cornillon, 2003): The Subarctic (Subpolar) Front (SAF) crosses the Japan (East) Sea zonally from west to east and then extends meridionally northward into the Gulf of Tartar (Tatarskiy Zaliv) (Figure X-25.1). From satellite data, three tributaries of this front have been identified in the western part of the sea. This major front divides the Japan Sea/East Sea LME into two parts, northern and southern, with different oceanographic regimes. The Liman Current Front (LCF) extends along the coast of the Russian province, Primorskii Krai, in the northwestern part of the Japan/East Sea. Small and meso-scale fronts are generated near Laperouse Strait and in the southern part of the Gulf of Tartar owing to vigorous tidal mixing and the influx of Okhotsk Sea waters.

Sea of Japan / East Sea LME SST (Belkin 2009)
Linear SST trend since 1957: 0.82°C.
Linear SST trend since 1982: 1.09°C.

Since 1957, the Japan Sea/ East Sea LME experienced at least one regime shift, between 1986 and 1990 (Figure X-25.2). The last cold year of 1986 saw the all-time minimum SST of 12.0°C. Then, SST rose by >1.5°C in 4 years, a regional manifestation

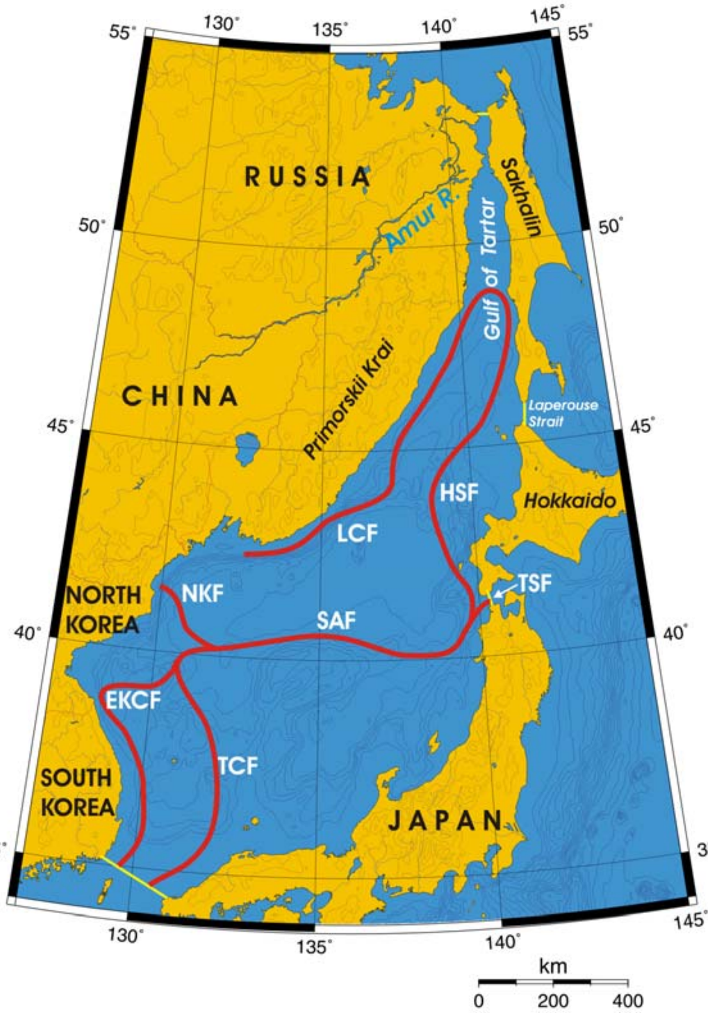

Figure X-25.1. Fronts of the Sea of Japan/ East Sea LME. EKCF, East Korea Current Front; HSF, Hokkaido-Sakhalin Front; LCF, Liman Current Front; NKF, North Korea Front; SAF, Subarctic (Subpolar) Front; TCF, Tsushima Current Front; TSF, Tsugaru Strait Front. Yellow line, LME boundary. After Belkin et al.(2009) and Belkin and Cornillon (2003).

of the trans-Pacific regime shift of the late 1980s (Hare and Mantua, 2000) that profoundly affected the Japan Sea/East Sea ecosystem (e.g. Zhang et al., 2007). The all-time maximum of 1998 caused by the El Niño 1997-98 saw SST>14°C, which was >2°C above the all-time minimum of 1986. Interannual variability in the Japan Sea is substantial, with a magnitude of 1°C. Thermal histories of the Japan Sea/ East Sea and Kuroshio are similar since the Kuroshio's main branch, Tsushima Current, flows across the Japan Sea.

Using 1°×1° resolution SST data from 1950-1998 compiled by the Japan Meteorological Agency, Hong et al. (2001) found a strong correlation between SST and ENSO (El Niño Southern Oscillation) events and showed that SST anomalies in the Japan Sea occurred simultaneously with development of ENSO events in the Tropical Pacific. From a similar time period of 1951-1996, Park and Oh (2000) found SSTs in the East Asian Marginal Seas (EAMS) lagging ENSO events in the eastern Equatorial Pacific. The phase lag between SST anomalies in the EAMS and ENSO was found to depend on the variability scale: 5-9 months for 2- to 3-year periods, and 18-22 months for 6-year oscillations.

Significant spatial contrasts were found between the northern and southern parts of the Japan Sea/ East Sea: a cooling in 1965-66 was confined to the southern part, whereas its northern part experienced a sudden warming (Park and Oh, 2000). These contrasts can be explained by the existence of a major front that separates the northern and southern part of the Japan Sea/ East Sea (e.g. Belkin and Cornillon, 2003).

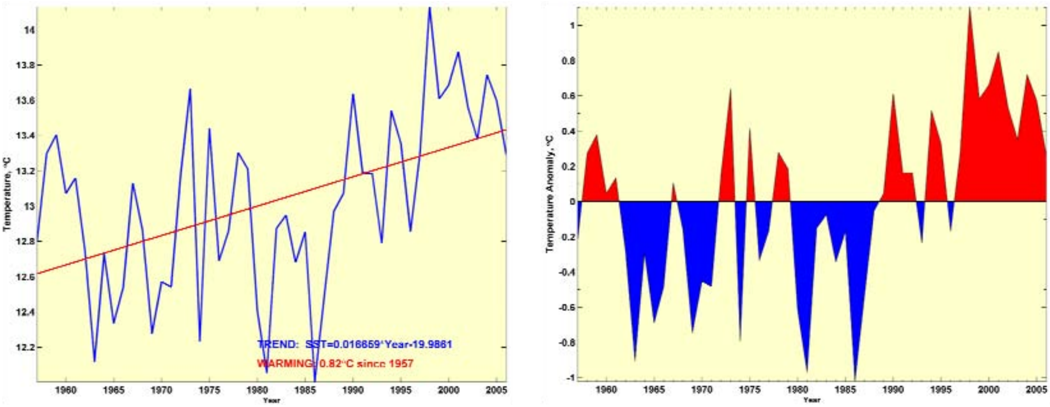

Figure X-25.2. Sea of Japan/ East Sea LME annual mean SST (left) and SST anomaly (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

***Sea of Japan/ East Sea LME Chlorophyll and Primary Productivity*:** The Sea of Japan/ East Sea LME is a Class II, moderately productive ecosystem (150-300 gCm^{-2}y^{-1}).

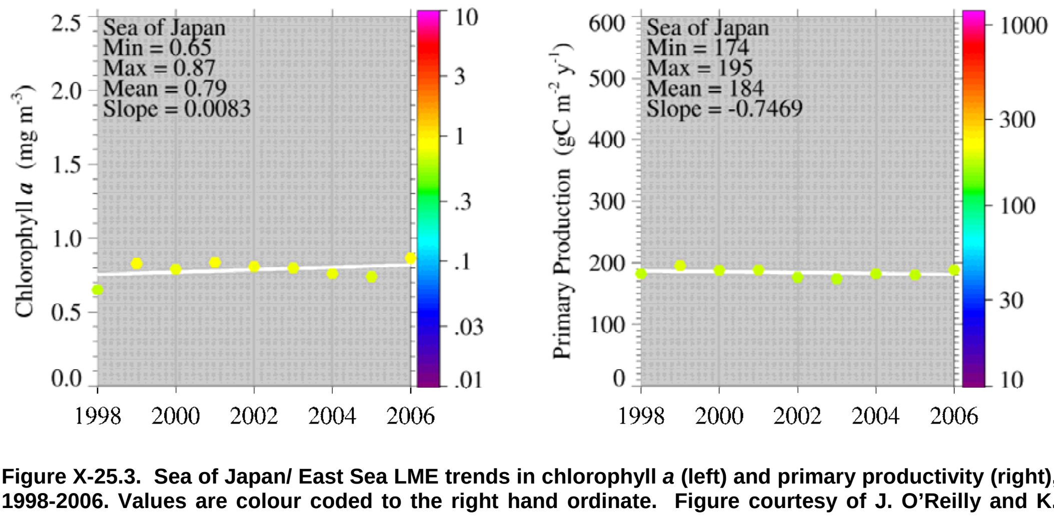

Figure X-25.3. Sea of Japan/ East Sea LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II.   Fish and Fisheries

Marine fisheries are an important economic sector for the countries bordering the Sea of Japan/East Sea LME. Both cold and warm-water fish occur in the LME, with salmon, Alaska pollock, sea urchin, sea cucumber, crab and shrimp being the most valuable species. There is a strong correlation between high catches of some species, such as mackerel and the meandering of the Tsushima Current (Terazaki 1999). Long-term fluctuations of South American pilchard *Sardinops sagax*, accompanied by noticeable geographic shifts in its spawning and nursery grounds have been observed, but no relationship has been found between high pilchard catches and the Tsushima Current. Catches of anchovy, round herring, yellowtail, scad and squid have also fluctuated over the past few decades. Total reported landings in the LME reached 2.2 million tonnes in 1984 but have since declined to around 1 million tonnes in 2004 (Figure X-25.4). The fluctuation in the landings can be attributed mainly to the high reported landings of South American pilchard, which accounted for 30% of the total landings in the mid to late 1980s. The value of the reported landings also rose steadily to over US$4.6 billion (in 2000 US dollars) in 1979, due to the high value commanded by chub mackerel (Figure X-25.5).

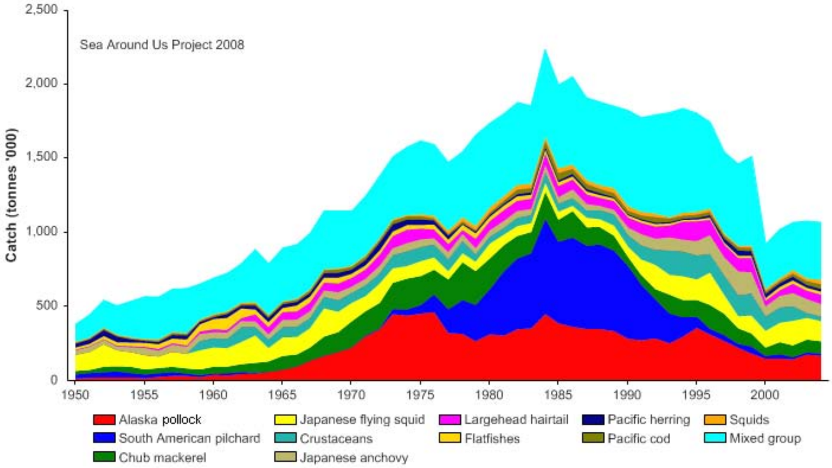

Figure X-25.4. Total reported landings in the Sea of Japan LME by species (Sea Around Us 2007)

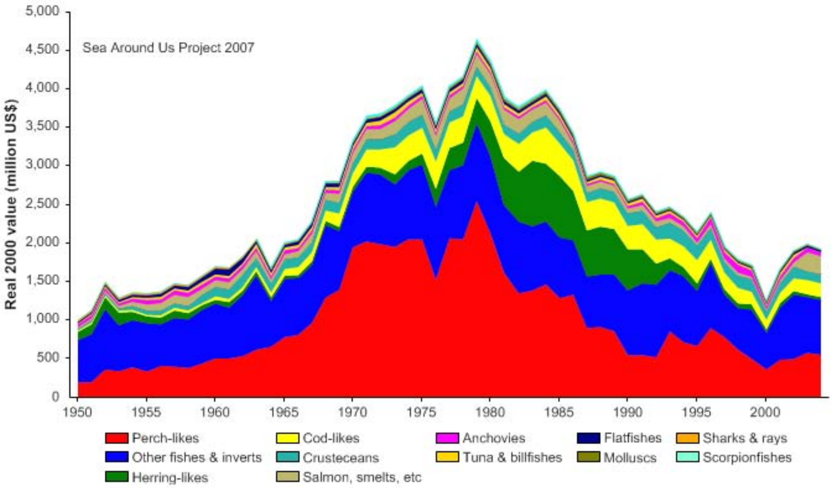

Figure X-25.5. Value of reported landings in the Sea of Japan LME by commercial groups (Sea Around Us 2007)

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached 50% of the observed primary production in the 1990s but has since declined in recent years (Figure X-25.6). This extremely high PPR may be a result of over-reporting by China in its landings statistics (Watson & Pauly 2001). China, Japan and Russia account for the largest share of the ecological footprint in the LME, though the size of the Chinese footprint must be questioned.

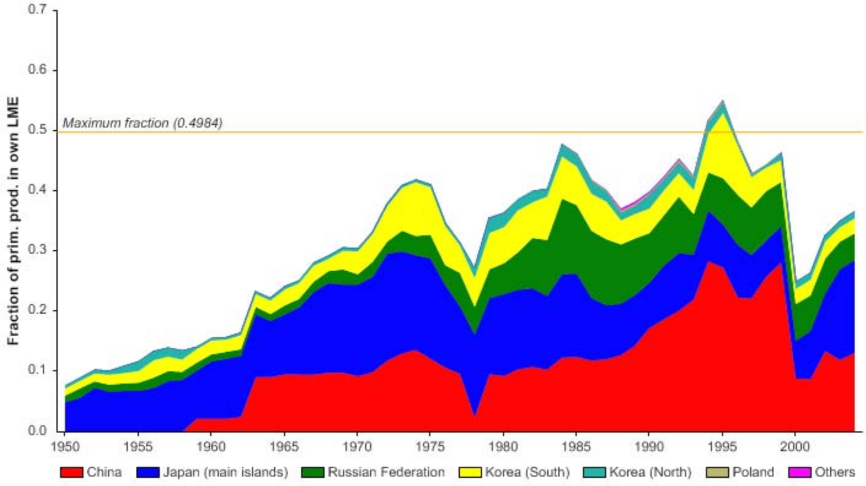

Figure X-25.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Sea of Japan /East Sea LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of the reported landings (i.e. the MTI; Pauly & Watson 2005) shows a large fluctuation, reflecting the cyclic nature in the relative abundance, and hence the landings, of the low-trophic South American pilchard in the LME (Figure X-25.7 top); the FiB index shows a period of expansion in the 1950s and 1960s, after which the index levels off, indicating that the decrease in the mean trophic level resulting from the high proportion of reported landings of South American pilchard in the 1980s was compensated for by its large volume of landings (Figure X-25.7 bottom).

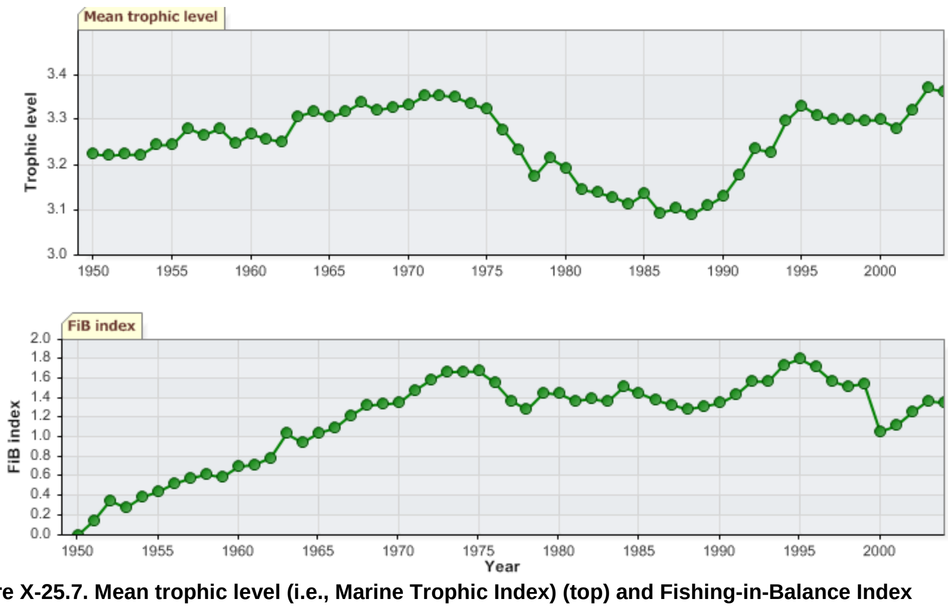

Figure X-25.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Sea of Japan LME/ East Sea LME (Sea Around Us 2007).

The Stock-Catch Status Plot indicates that the number of collapsed and overexploited stocks in the LME has been rapidly increasing, to 80% of the commercially exploited stocks (Figure X-25.8, top), with almost half of the reported landings still supplied by fully exploited stocks (Figure X-25.8, bottom).

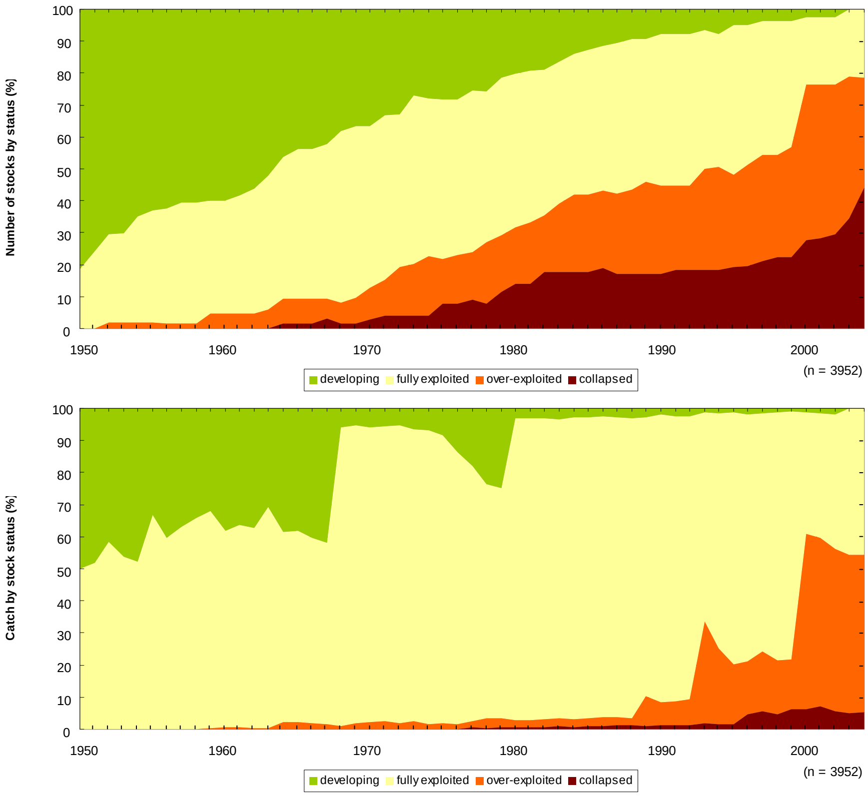

Figure X-25.8. Stock-Catch Status Plots for the Sea of Japan/ East Sea LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

Catches of fish and invertebrates beyond MSY have resulted in severe overexploitation of several of the major species in this LME (UNEP 2006). For instance, overfishing of the Pacific herring in Peter the Great Bay (Zaliv Petra Velikogo in Russian; off Vladivostok) led to the closure of this fishery. Illegal and unreported fishing is a major concern, and leads to uncertainties in the status of the fish stocks. In addition, hundreds of Russian, Japanese, Chinese and Taiwanese unregistered fishing vessels as well as flag of convenience ships operate in this LME. Current ongoing efforts to modernise the fishing industry in the Russian Far East and ambitious regional and national government programmes to increase Russian fish harvests over the next decade will put increased pressure on the fish stocks (UNEP 2006). These efforts, coupled with inadequate monitoring and enforcement due to funding shortfalls, could result in overfishing of some other species such as pollock (Baklanov *et al*. 2003). In recent years, the fishing industry has been working on ways to switch from a "fish-catching" to a mariculture mode. Facilities such as the Toyama Prefectural Fish Breeding Centre and others are conducting research on the growing and releasing of juvenile prawns, red seabream, flounder and other fish.

III. Pollution and Ecosystem Health

***Pollution*:** Pollution standards have improved the quality of coastal waters (UNEP 2006). Pollution is mainly due to effluents from industries as well as human settlements, run-off from land (including agricultural areas) and atmospheric fallout. Microbiological pollution is often a problem arising from inadequate treatment of the large volume of wastewater generated by human populations. Eutrophication and harmful algal blooms are a serious problem in some parts of the LME, particularly because of their harmful effects on fisheries (Taylor & Trainer 2002).

Chemical pollution is of concern in industrial areas, with heavy metal pollution being prevalent. In cities and settlements in the Russian Far East, the maximum permitted concentrations of lead were exceeded in several places such as in Rudnaya Pristan' (literally Ore Wharf; 514 km north of Vladivostok, on the coast), where the annual average level of lead is twice as high as in other areas (Kachur & Tkalin 2000). Rudnaya Pristan' was cited by the Blacksmith Institute as one of the most polluted places in the world. The concentrations of detergents, petroleum hydrocarbons and heavy metals are high in coastal lagoons. In the northern region from the Zolotoy Cape to Povorotny Cape (on the Russian Far East's coast of the Sea of Japan/East Sea) there are several local sources of pollution in coastal waters, largely from ore-mining and ore-chemical production. Pollutants include large quantities of lead, copper, zinc, cadmium, arsenic and boron in dissolved as well as suspended forms (UNEP 2006). Some coastal lagoons in the southern areas of the LME show relatively high turbidity as a result of increased coastal erosion. Solid waste often litters beaches and damage fishing nets. The proportion of plastic material in solid waste has increased sharply in recent times, accounting for more than 80% of the total waste volume (UNEP 2006). Oil pollution is a significant problem along the major shipping routes. Increasing numbers of accidents have occurred in recent years and spills have caused high mortality of sea birds and contamination of seashores. Oil from open ocean sources constitutes only 10% - 20% of all oceanic oil pollution, while coastal and land-based pollution constitutes 80% - 90%.

Habitat and community modification: Overall, habitat and community modification are found to be slight, although there has been moderate loss of certain habitats and severe modification in the littoral belts in the southern areas (UNEP 2006). Excessive land reclamation and coastal development have led to the destruction of some mangrove areas and have harmed coral reefs in the southern Sea of Japan/East Sea LME. Increased volumes of industrial and sanitary wastewater in the coastal zone as well as run-off from agricultural lands have caused the modification of some benthic communities. In the last decade, the bottom communities in the Peter the Great Gulf have shown visible changes. For instance, there has been a progressive reduction of some species of benthos as well as plankton and an increase in populations of some species of polychaetes, sea-lettuce and other organisms that are pollution indicators. Degradation of seagrass beds in Amur Bay has led to shrinkage of the spawning grounds of the Pacific herring (UNEP 2006). In the last 25 years there has been a reduction in the density of macrobenthos, notably autotrophic species, with a growing quantity of heterotrophic species. Areas occupied by bivalves resistant to pollution and silting are expanding as a result of the industrial development of this bay.

The environmental and ecological disturbances resulting from growing economic development will continue to threaten the health of the Sea of Japan LME (UNEP 2006). On the other hand, improvements in waste treatment and construction of new and efficient treatment facilities will help to reduce some of the negative impacts of economic growth.

IV. Socioeconomic Conditions

The Sea of Japan/East Sea LME region has an increasingly urban coastal population. The people are particularly dependent on the sea for their food and livelihoods. Important economic activities in the coastal and marine areas include port operations, shipping, fisheries, seafood processing and mining.

The overexploitation of fish and other living resources has resulted in reduced economic returns and loss of employment (UNEP 2006). Downstream fisheries and coastal communities, which are highly dependent on fisheries, are also seriously affected by overexploitation. Eutrophication, chemical pollution and spills have severe effects on local fisheries, aquaculture and recreation. Heavy metals, nitrogen compounds and other hazardous substances cause allergies, poisoning, chronic inflammations as well as infectious diseases. In some local areas in these coastal waters cannot be used for recreation due to the large volume of wastewater discharge.

V. Governance

The countries bordering the Sea of Japan/ East Sea LME are involved in several regional programmes such as NOWPAP (see the East China Sea LME) and organisations such as PICES (see the East China Sea LME). All countries are members of the 10-nation Working Group for the Western Pacific, which was established by UNESCO to plan and coordinate multilateral ocean science programmes. China, Japan and South Korea have ratified the 1982 UN Law of the Sea Convention (UNCLOS) and proclaimed their respective EEZs in the late 1990s. All the countries are members of the International Maritime Organisation (IMO) and have acceded to MARPOL. China, Japan and Russia are parties to the 1972 London Dumping Convention.

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