XI-31 Chukchi Sea: LME #54

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The Chukchi Sea LME is a high-latitude system situated off Russia's East Siberian coast and the northwestern coast of Alaska. This LME is a relatively shallow marginal sea with a surface area of 776,643 km^2 , of which 5.4% is protected (Sea Around Us 2007), and an extensive continental shelf. According to the Atlas of the Oceans (USSR Navy, 1980), the Chukchi Sea alone has the surface area of 595,000 km^2, water volume of 42,000 km^3, and total water catchment area of 261,500 km^2. Total river runoff is less than 100 km^3. An arctic climate and major seasonal and annual changes in ocean climate, in particular the annual formation and deformation of sea ice, characterise this LME. The ice-free zone of the summer is about 150-200 km wide, the position of the ice edge being determined by northward flowing streams of Pacific water through the Bering Straits (Muench 1990). The ice cover of the Arctic Seas plays an important role in the Earth's climate formation. Additional descriptions of the Chukchi Sea LME are found in Carleton Ray & Hayden (1993) and UNEP (2005).

I. Productivity

Primary production from in situ data varies between 150-300 $gCm^{-2}yr^{-1}$, while maximum concentration of zooplankton can be as high as 1300 mg m^{-3} (Lukianova 2005; Vetrov and Romankevich 2004). Benthos biomass in this LME is higher than elsewhere in the Arctic, up to 500 g m^{-2} (Lukianova 2005). The total biomass of this LME is 120 million tonnes, while the annual production is 4.1 million tonnes of carbon (Vetrov and Romankevich 2004). Most of the nutrients come from the Pacific water, although upwelling of nutrient-rich bottom water, such as in Lancaster Sound, also creates favourable conditions for phytoplankton growth. The annual formation and melting of sea ice influence the productivity of this LME by releasing nutrients to the melt water. In addition, seasonal faunal shifts between winter and summer (e.g., salmon, migratory birds and mammals) have been described (Carleton Ray & Hayden 1993). In this volume, the Barents Sea LME chapter presents additional information on the biodiversity and food web Arctic Seas.

Oceanic fronts: Five fronts are found within this LME (Belkin *et al.* 2003; Belkin *et al*. 2009) (Figure XI-31.1). The Kotzebue Sound Front (KSF) bounds the northward Bering inflow. Low-salinity Bering Sea waters flow around Chukotka northwestward along the Chukotka Front (CF) toward Herald Valley. The Siberian Coastal Current/Front (SCCF) enters the Chukchi Sea through Long Strait, rounds Wrangel Island and continues northward via Herald Valley. The Herald Shoal Front (HSF) is situated over the steep southern slope of the namesake shoal. A stable front extends along Barrow Canyon (BCF).

Chukchi Sea LME SST (after Belkin 2009)(Figure XI-31.2)
Linear SST trend since 1957: 0.58°C.
Linear SST trend since 1982: 0.70°C.

The long-term warming of the Chukchi Sea over the last 50 years was modulated by strong interannual variability, with a magnitude of about 0.5-1.0°C, as well as decadal variability and at least one regime shift. Two regimes can be distinguished: (1) overall cooling until 1983; (2) overall warming since 1983. The long-term warming accelerated

after the all-time minimum of -1.0°C in 1983, and by 2005 SST reached 0.3°C, a 1.3°C increase over 22 years. Even though the Chukchi Sea is affected by warm water influx from the Bering Sea through the Bering Strait, this influx apparently is not critical for the Chukchi Sea thermal regime. This is evidenced by the lack of Chukchi Sea manifestation of the 1976-77 North Pacific regime shift, which was quite abrupt in the Bering Sea, in both East and West Bering Sea LMEs. The impact of the Bering Sea inflow is two-fold, since this inflow consists of two components, eastern and western, with potentially different thermal signatures (Weingartner et al. 2005; Woodgate *et al.* 2006).

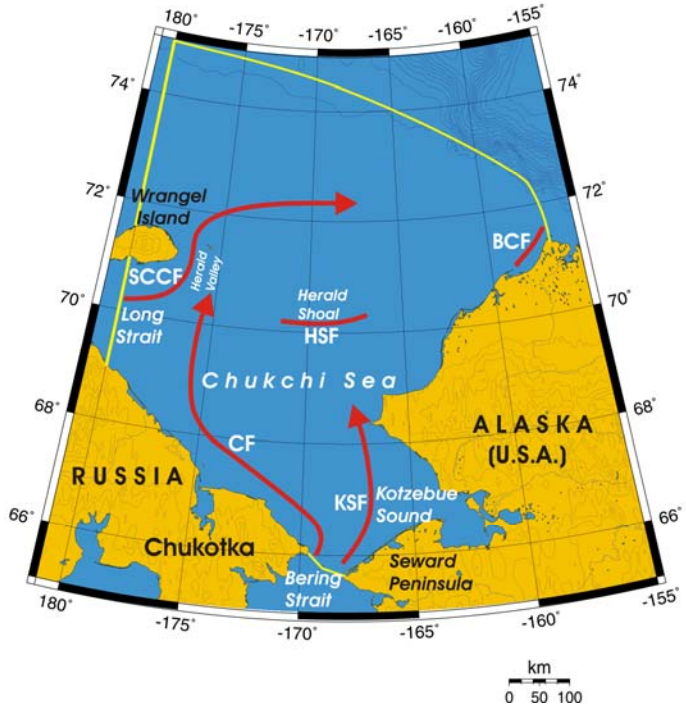

Figure XI-31.1. Fronts of the Chukchi Sea LME. BCF, Barrow Canyon Front; CF, Chukotka Front; HSF, Herald Shoal Front; KSF, Kotzebue Sound Front; SCCF, Siberian Coastal Current Front. Yellow line, LME boundary. After Belkin *et al.*, 2003; Belkin *et al.*, 2009).

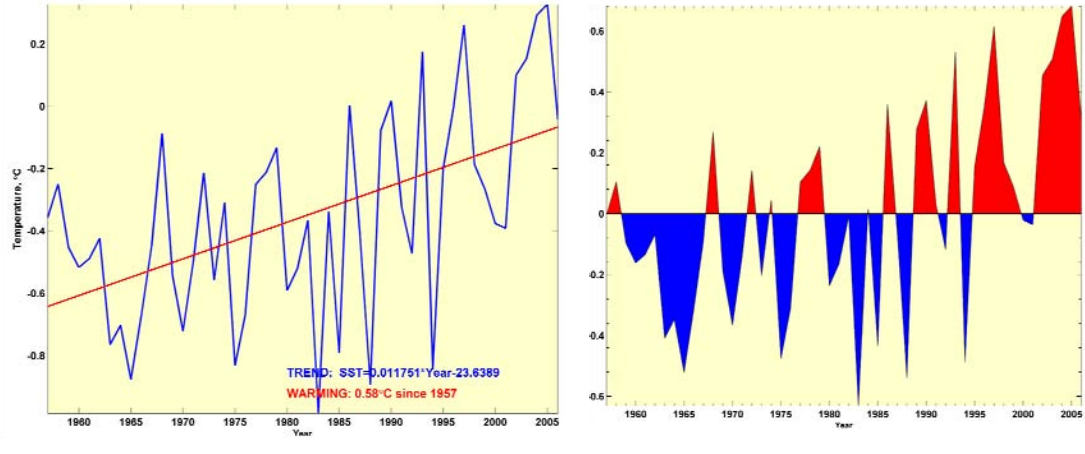

Figure XI-31.2. Chukchi Sea LME Mean Annual Sea Surface Temperature (SST; left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

Chukchi Sea LME Chlorophyll and Primary Productivity: The Chukchi Sea LME is considered a Class II, moderately high productivity ecosystem (150-300 $gCm^{-2}yr^{-1}$).

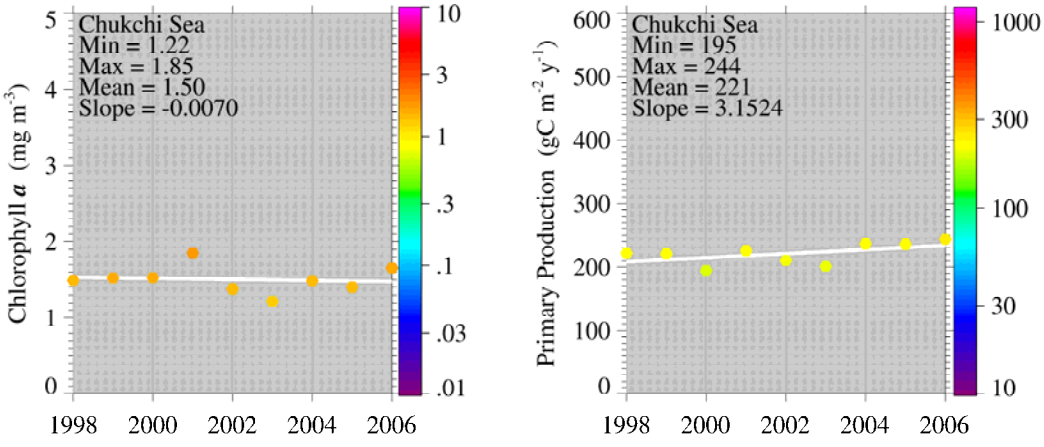

Figure XI-31.3. Chukchi Sea LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

Key marine species in this LME are salmon (*Oncorhynchus* spp.), herring (*Clupea pallasii pallasii*), walrus (*Odobenus rosmarus*), seals, whales (Greenland whale, blue whale, killer whale, beluga/belukha whale, and humpback whale being most common) and various species of waterfowl. Total annual catch shows dramatic oscillations on the scale of two-to-three years (Figure XI-31.4). Some of these oscillations are probably due to the impact of varying ice and weather regimes, whereas others may have been caused by the internal dynamics of this ecosystem. The key subsistence marine species are likely to undergo shifts in range and abundance due to climate change. The central and eastern Arctic Seas do not have a significant fishing industry, except near coastal areas. There is no evidence of overfishing in this LME (UNEP 2005).

As salmon extends its range into the Arctic, and walleye pollock into the northern Bering Sea, "the North Pacific Fishery Management Council has begun to develop an Arctic Fishery Management Plan that will provide a framework for future commercial fishing in the Chukchi Sea. Presently, the precautionary approach keeps the fishery closed while scientific data can be collected and assessed." (Alaska Climate Impact Assessment Commission 2008, p.21).

Very scarce data are available from the Russian part of the Chukchi Sea, which is only sparsely populated. Pauly & Swartz (2007) estimated a fish catch of 100 tonnes per year for the period 1950-2004, consisting overwhelmingly of salmonids. Catch figures are not transferred to FAO.

Salmonids also dominate the catches from the Alaskan part of the Chukchi Sea, i.e., taken north of Cape Prince of Wales on the Seward Peninsula, which are collected from commercial, subsistence and sport fisheries by Alaska's Department of Fish and Game.

The catches from the Alaskan Chukchi Sea were assembled by S. Booth and D. Zeller (Sea Around Us Project, unpublished data), and added to the catch estimate from the

Russian part of the Chukchi Sea. This resulted in Figure XI-31.4. As can be seen, the overall catch from the Chukchi Sea fluctuates between 500 tonnes and 3,000 tonnes and consists predominantly of salmonids.

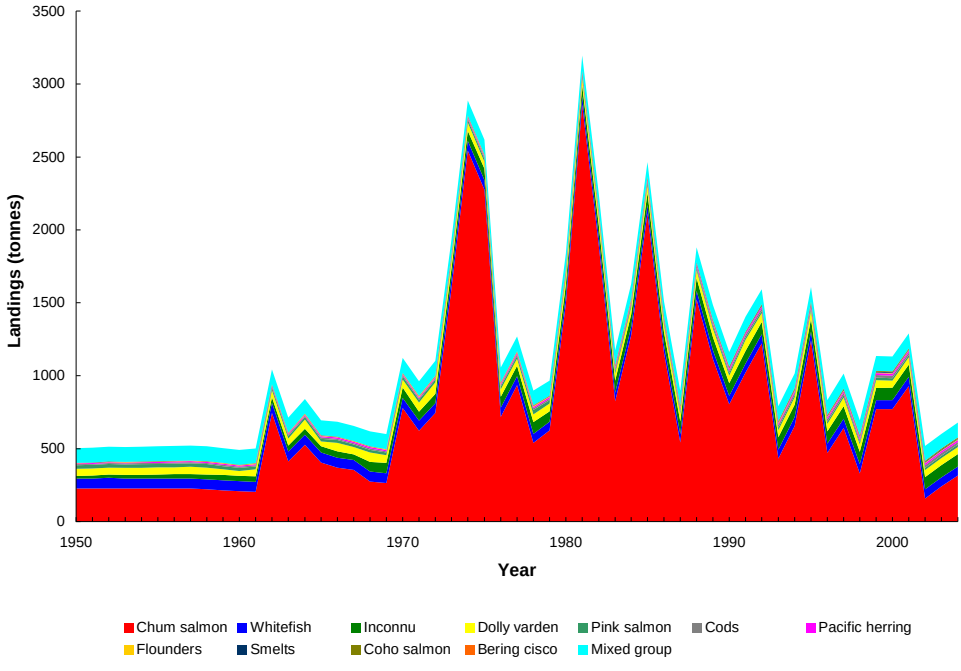

Figure XI-31.4. Total estimated catches (subsistence fisheries) in the Chukchi Sea LME (Sea Around us 2007)

Due the tentative nature of these catch estimates, no indicators based on these data will be presented (but see Sea Around Us 2007).

III. Pollution and Ecosystem Health

Pollution: Pollution in the Chukchi Sea LME is generally slight and attributed mainly to chemicals and oil spills (UNEP 2005). In spite of the considerable remoteness from major economic activities, heavy metals, aromatic and chlorinated hydrocarbons, as well as new contaminants (endosulfan, bromoform, dibromomethane, etc.) have been discovered over the last few years in the Chukchi Sea LME. According to the data of the Arctic Monitoring Regional Centre, a broad spectrum of trace metals was found in the surface waters of the Chukchi Sea (GOIN 1996a-d, Roshydromet 1997-2002).

The distribution of organic pollutants in this LME has become increasingly pronounced over the past decade (Izrael & Tsyban 1992, 2000, Tsyban 1999, Roshydromet 2001). Great concern is caused by pollution of the Chukchi shelf by PCBs. Although their atmospheric content decreased in 1993 compared to 1988, the concentrations of these toxicants in the LME waters remained unchanged. The PCB content of the bottom sediments has doubled between 1988 and 1993 (Hinckley *et al*. 1992, Izrael & Tsyban 2000). This fact is indicative of accumulations of organochlorines in the Chukchi Sea LME. It is noteworthy that the long residence times of these compounds (several decades) in the marine environment determines their active circulation along food webs and accumulation in hydrobionts, including trade organisms. At present, it is believed

that hexachlorocyclohexanes (HCHs) rank among the most widespread chlorinated pesticides in the Arctic seas (Bidleman *et al*. 1995). For example, the HCH content of water samples from the Chukchi Sea LME exceeds that of other chlorinated hydrocarbons such as PCBs and DDT.

A serious concern arises from prospecting and production of oil and gas on the Chukchi shelf. Exploration and industrial drilling impact the pelagic and bottom systems in a number of ways, including the hazardous consequences of seismic prospecting and pollution of water and bottom sediments by drilling fluids and slurries, oil, copper and other metals pollution. In all the components of the Chukchi Sea ecosystem, benzo(a)pyrene, an indicator of carcinogenic PAHs, has been found. The coefficients of benzo(a)pyrene accumulation in particulate matter and in biota proved to be high (Izrael & Tsyban 1992, Tsyban 1999, Izrael & Tsyban 2000, Roshydromet 1997-2002). Contaminants are endangering marine mammals such as walruses and whales (Reynolds III *et al.* 2005).

Habitat and community modification: The coastal areas of the Chukchi Sea LME are thought to be in relatively pristine condition due to the sparse human population and the region's general remoteness. There are no records of serious habitat loss in the region, but there is evidence of localised degradation of some habitats. Habitat and community modification were assessed as slight and mainly attributed to pollution (UNEP 2005).

Climate change is expected to have a profound ecological impact in the Arctic LMEs. The Arctic climate is warming rapidly and much larger changes are expected (ACIA 2004). Species ranges are projected to shift northward on both land and sea, bringing new species into the Arctic while severely limiting some species currently present, leading to the possible extinction of some species. Salmon, herring, walrus, seals and whales are likely to undergo shifts in range and abundance. On the other hand, some arctic marine fisheries are likely to become more productive (ACIA 2004). A major issue is the thinning polar ice pack. Ice and climate records show climate warming occurring in the southern section of the LME. Climate change and receding sea ice are affecting the distribution, migration patterns and abundance of some wildlife species.

At present the transboundary waters of the Chukchi Sea LME are in relatively healthy condition (UNEP 2005). This may change, however, as a result of the rapid development of the oil and gas industry on the Arctic shelf, the increased volume of oil and gas transport as well as the accidental introduction of alien species with ship ballast water. Management and development of the Chukchi Sea LME must take account of the impacts of climate change.

IV. Socioeconomic Conditions

The coastal zone of the LME is mostly inhabited by indigenous peoples, most of whom live in rural areas. Economic activity focuses on fisheries and the exploitation of petroleum and natural gas. Contaminant levels in some Arctic indigenous groups can be 10 - 20 times higher than in most temperate regions (AMAP 1997). Heavy metals, PAHs and other persistent toxic substances have a strong mutation effect in humans. The potential impact of rapid climate change could put the native human communities at risk. The impact of recent climate warming is reflected in marine hunting data. This has improved conditions for native hunting of walrus but has adversely impacted other human activities (Mulvaney 1998). For instance, when sea ice is forming late, certain types of hunting are delayed or may not take place at all. On the other hand, when sea ice melts too quickly in the spring, it greatly decreases the length of the hunting season. There have been substantial shifts in native hunting practices, subsistence activities and the consumption of marine products on the Chukchi Peninsula during the last decade. The

growth of poverty and unemployment in the coastal areas of the Russian Arctic seas is closely connected with the destruction of natural systems and the loss of traditional types of natural resource management.

V. Governance

The Chukchi Sea LME is bordered by Russia and the U.S. Any consultative framework to manage the marine resources of the Arctic LMEs requires attention to the culture and economy of indigenous peoples. Stakeholders in the Chukchi Sea LME include the Inuit Circumpolar Conference and the Council of Elders of the Chukchi of Arctic Russia. In September 1996, eight Arctic countries signed the Ottawa Declaration, under which the Arctic Council Board, an international forum of the Arctic countries, was created. This Board is an instrument for addressing Arctic pollution problems, in particular, those related to sustainable development and Arctic environment protection.

The protection of nature in the Arctic, including of the Chukchi Sea LME, is regulated by several international agreements and conventions. See the Barents Sea LME (Chapter XIII-36) for more information on Arctic governance. GEF is supporting two projects in the region. One project supports a National Plan of Action in the Russian Federation for the Protection of the Arctic Marine Environment from Anthropogenic Pollution (Phase 1). This project focuses on pre-investment studies of identified priority hot spots with known significant transboundary consequences, with additional activities to include necessary support through the development of legal, institutional and economic measures. The other project, 'Integrated Ecosystem Approach to Enhance Biodiversity Conservation and Minimise Habitat Fragmentation in Three Selected Model Areas in the Russian Arctic', will develop and implement integrated ecosystem management strategies in the Russian Arctic and strengthen stakeholder capacity in sustainable biodiversity management. Chapter XIII-36, Barents Sea LME, presents additional information on Arctic governance.

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