Chapter 36C. North Pacific Ocean

Contributors: Thomas Therriault (Convenor), Chul Park and Jake Rice (Co-Lead members and editors for Part VI Biodiversity)

1. Introduction

The Pacific is the largest division of the World Ocean, at over 165 million km^2, extending from the Arctic Ocean in the north to the Southern Ocean in the south (Figure 1). Along the western margin are several seas. The Strait of Malacca joins the Pacific and the Indian Oceans to the west, and the Drake Passage and the Strait of Magellan link the Pacific with the Atlantic Ocean to the east. To the north, the Bering Strait connects the Pacific with the Arctic Ocean (International Hydrographic Organization, 1953). The Pacific Ocean is further subdivided into the North Pacific and South Pacific; the equator represents the dividing line. The North Pacific includes the deepest (and, until recently, the least explored) place on Earth, the Mariana Trench, which extends to almost 11 km below the ocean's surface, although the average depth of the North Pacific is much less at approximately 4.3 km. Thus, the North Pacific encompasses a wide variety of ecosystems, ranging from tropical to arctic/sub-arctic with a wide diversity of species and habitats. Further, t

areas of the North Pacific. For example, Japan has established a programme to track community-structure changes at 1,000 monitoring sites (both terrestrial and marine) and many countries around the North Pacific conduct stock assessments for major commercial species, but higher-level synthesis remains a gap. Furthermore, coastal systems are under different pressures in different parts of the basin, which will only complicate higher-level synthesis of status and trends.

2.1 Biodiversity status and trends

2.1.1 Primary producers

Climatic variability continues to increase in the North Pacific Ocean, especially in the eastern part of the basin, where both extreme warm and cool events have occurred in the Gulf of Alaska, the California Current and equatorial waters in recent years (Sydeman et al., 2013). At finer spatial scales, eddies and current meanders are important determinants of ecosystem productivity. For example, in the Gulf of Alaska region, eddies influence nutrients, phytoplankton, and even higher trophic levels (Ream et al., 2005). In the California Current, chlorophyll concentrations have increased (Kahru et al., 2009), but this has resulted in a shift to a community more dominated by dinoflagellates, at least in Monterey Bay, that has resulted in significant ecosystem changes, including impacts at higher trophic levels. In the Kuroshio Current region, the species composition time-series is limited, hence it is not possible to identify trends in biomass, but the dominant taxa have been highly variable with a obvious diatom spike in 2004, possibly due to the meandering of this current (Sugisaki et al., 2010; Figure 2

One of the most significant biological changes in the North Pacific is the explosion of gelatinous macrozooplankton in the western portion of the basin, especially the Yellow Sea, where medium to large jellyfish have become overly abundant in recent years and have resulted in increased reports of impacts (Purcell et al., 2007; Figure 3

2.1.4 Higher trophic levels

McKinnell et al. (2010) provide the only intra-basin comparison of changes in key fish and invertebrate stocks between 1992–2002 and 2003–2008. In this study many taxa in the Sea of Okhotsk and Oyashio regions increased and many in the California Current, Yellow Sea, and East China Sea decreased (Table 1). In addition to changes in abundance, distributional shifts occurred, related at least in part to changing ocean conditions; these shifts can have ecological and economic consequences on ocean services (e.g., Mueter and Litzow, 2008).

In the eastern North Pacific, a mid-water trawl survey for the California Current system provides evidence that the forage fish community of this ecosystem tends to alternate between a less productive warm community and a more productive cool community in response to widely recognized regime shifts in oceanic conditions (NOAA's Southwest Fisheries Science Center (SWFSC) in Bograd et al., 2010). Similarly, on the western side of the basin in the Kuroshio-Oyashio system, where a strong latitudinal gradient in

demersal species (e.g., pollock, flatfish, crab), some rockfish may have experienced population declines at regional or sub-regional scales.

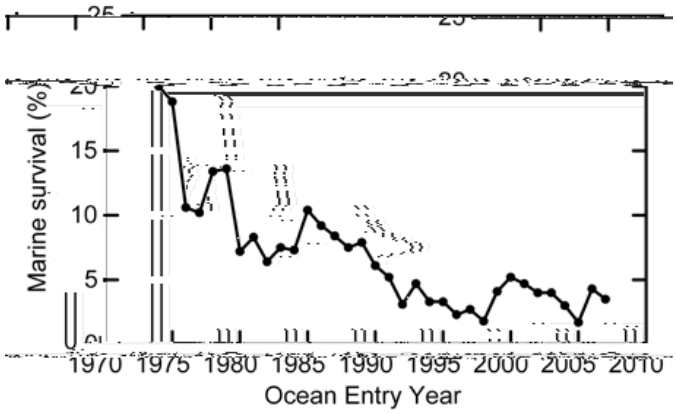


Figure 6. Average marine survival of up to 45 coho salmon (O. kisutch) stocks in the northern California Current region by year of ocean entry (from Bograd et al., 2010).

For Pacific salmon spawning in Canadian waters, the Canadian Department of Fisheries and Oceans has provided outlooks since 2002. IiÉ•öá á Û À E öá* À w @Ð < Ù \ y2 - ãN:

population, community, and ecosystem processes (Ruiz et al., 1997). Additional, cumulative consequences of these invasions should be expected.

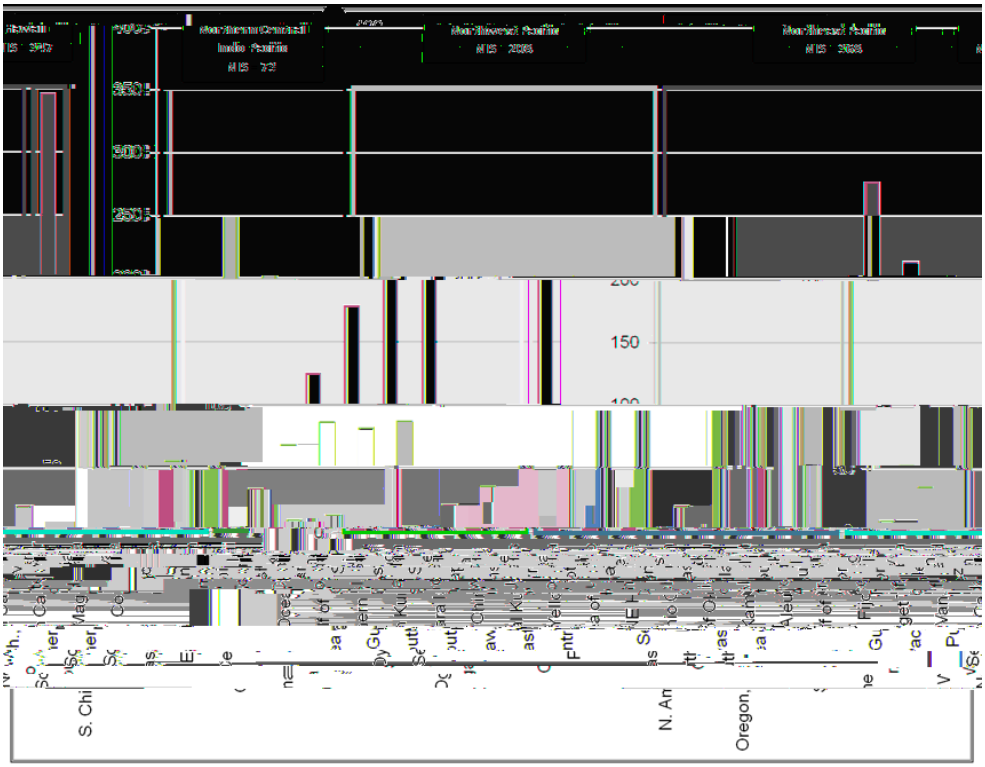


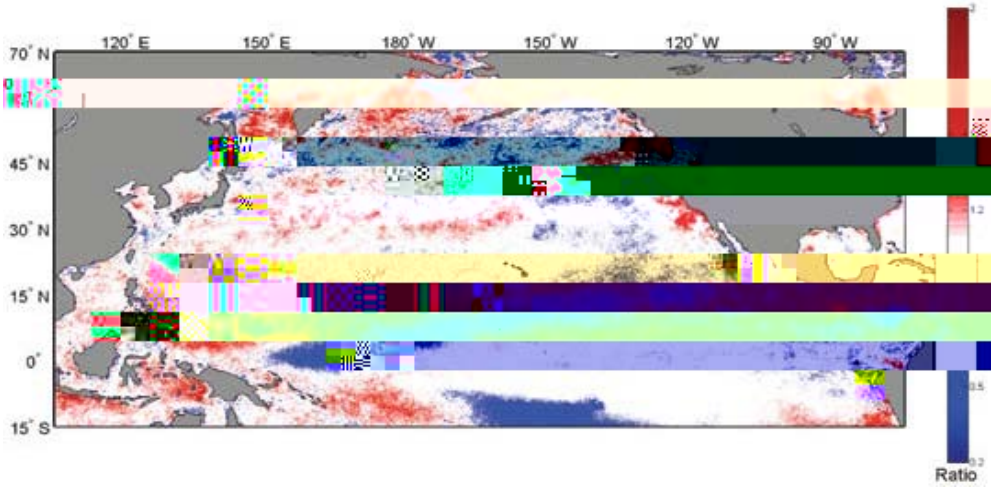
Figure 8. Number of non-indigenous species in central/northern North Pacific marine ecoregions (from Lee II and Reusser, 2012).

Other major stressors in the North Pacific include hypoxia, habitat destruction, pollution, and overfishing. However, none of these have been quantified at the scale of the North Pacific. Ocean acidification has dramatically impacted some calcifying organisms such as pteropods (Orr et al., 2005). Hypoxia has not only increased in the Yellow Sea, but continues to be a major pressure on coastal ecosystems in the eastern North Pacific, including off Oregon, with lethal consequences for benthic species.

fishing down the food chain. In addition, Hutchings (2000) has shown that most stocks are very slow to recover from overfishing, and this has consequences for ecosystem services and can adversely affect

Also, Schroeder and Love (2002), who compared rockfish assemblages among three differently fished areas, showed large differences in fish density, size structure, and species composition. Only the protected area had both higher density and larger fish and greater species composition.

chlorophyll decreased in parts of the eastern North Pacific (the exception of the


70° N
45° N
30° N
15° N
0°
15° S
120° E
150° E
180° W
150° W
120° W
90° W
Ratio

[redacted]

threats remain. No additional entirely oceanic organisms are known to be designated as being at risk for the North Pacific.

3.2 Major pressures in the oceanic area and major groups affected by the pressures

It appears

Other specific areas in the North Pacific include the Mariana Trench and deep-sea hydrothermal vents. The Mariana Trench is unique in being the deepest location known on Earth. Relatively few studies exist, most characterize or describe the unique bacterial communities inhabiting this environment. Globally, hydrothermal vents are relatively rare and a unique geological feature associated with the spreading of tectonic plates. These sites support chemosynthetically driven ecosystems that support a diverse array of unique organisms (see Chapter 45).

5. Special conservation status issues

5.1 Taxonomic groups

Corals are often identified as a taxonomic group requiring special conservation consideration. In the North Pacific, approximately 30 percent of the world's coral reefs are located in Southeast Asia. Wilkinson et al. (1993) suggest that more than half are already destroyed and being destroyed by sedimentation, overexploitation (including by dynamite and chemicals), and pollution. In addition to these warm-water corals, a growing number of cold-water corals and sponges also should be considered (e.g., Stone and Shotwell, 2007). Both warm- and cold-water corals are covered in more detail in Chapters 43 and 42, respectively.

Pacific salmon (*Oncorhynchus* species) are ecologically, commercially, and culturally important around the North Pacific. As anadromous species they require both freshwater and marine habitats for their continued survival and productivity but increased human activities have reduced productive habitat (in both freshwater and

hydrothermal vents, seamounts, large river deltas, kelp forests, mangroves, and coastal lagoons

	Flatfishes		
			Crabs

Table3. Trends in the numbers or productivity of planktivorous species of marine birds and baleen whales. [CA= California, USA; BC=British Columbia, Canada; PRBO= Point Reyes Bird Observatory in California, K = carrying capacity] (from McKinnell et al., 2010)

Location	Species	Metric	Dates used	Trend	Reference
California Current					
Farallon Is., CA	Cassin's auklet	Population trend	1998 - 2008	No trend	PRBO - pers. comm.
Farallon Is., CA	Cassin's auklet	Productivity	2002 - 2008	Down	PRBO - pers. comm.
California & Oregon	Blue whale	Population trend	1991 - 2008	Up <3% y^{-1}	Calambokidis 2009
California, Oregon & Washington	Blue whale	Popu505.68 76.92 29.039 Td (u505.68 76.92 29.039 Td (u505.68 76.92 Tm ( )Tj ET EMC /F			

Table 4a. Piscivorous species in the North Pacific [PRBO= Point Reyes Bird Observatory in California, USA; K= carrying capacity; CA= California, USA; WA= Washington State, USA; BC= British Columbia

S6.1(i)-0.9(a)-4Ues

Table4b. Piscivorous species in the eastern Bering Sea and Aleutian Islands (from McKinnell et al., 2010)

Location	Species	Metric	Dates Used	Trend	Reference
St. Paul Is., E Bering	Black-legged kittiwake	Population trend	1999 - 2008	No trend	Dragpo, pers. comm.
St. Paul Is., E. Bering	Common murre	Population trend	1999 - 2008	No trend	Dragpo, pers. comm.
St. George Is., E. Bering	Black-legged kittiwake	Population trend	1999 - 2008	No trend	Dragpo, pers. comm.
St. George Is., E. Bering	Common murre	Population trend	1999 - 2008	No trend	Drago

Table 4c. Piscivorous species in the western Pacific, including western Bering Sea, Sea of Okhotsk, Oyashio, and Yellow Sea (from McKinnell et al., 2010)

Location	Species	Metric	Dates Used	Trend	Reference
E. Kamchatka	Steller sea lion	Non-pup count	2001 – 2008	No trend	Burkanov et al. 2009
Commander Islands	Steller sea lion	Non-pup count	2000 - 2008	No trend	Burkanov et al. 2009
Commander Islands	Northern fur seal	Pup production	1972 - 76 vs. 2002 - 06	No trend	Olesiuk 2009
Kuril Islands	Northern fur seal	Pup production	1972 - 76 vs. 2002 - 06	Up, 3% y^{-1}	Olesiuk 2009
Robben Is., Okhotsk	Northern fur seal	Pup production	1972 - 76 vs. 2002 - 06	No trend	Olesiuk 2009
Kuril Islands	Steller sea lion	Non-pup count	2000 – 2007	Up	Burkanov et al. 2009
N. Okhotsk					

96 Tm ( )Tj 95.04 526.2 Q

Beaugrand, G., Edwards, M., and Legendre, L. (2010). Marine biodiversity, ecosystem functioning, and carbon cycles. Proceedings of the National Academy of Sciences of the United States of America 107, 10120–10124.

Behrenfeld, M.J., and Falkowski, P.G. (1997). Photosynthetic rates derived from satellite based chlorophyll concentration. Limnology and Oceanography 42, 1–20.

Boerger, C.M., Lattin, G.L., Moore, S.L., and Moore, C.J. (2010). Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. Marine Pollution Bulletin 60, 2275–2278.

Bograd, S.J., Castro, C.G., Di Lorenzo, E., Palacios, D.M., Bailey, H., Gilly, W., and Chavez, F.P. (2008). Oxygen declines and the shoaling of the hypoxic boundary in the California Current. Geophysical Research Letters 35, L12607.

Bograd, S.J., Sydeman, W.J., Barlow, J., Booth, A., Brodeur, R.D., Calambokidis, J., Chavez, F., Crawford, W.R., Di Lorenzo, E., Durazo, R., Emmett, R., Field, J., Gaxiola-Castro, G., Gilly, W., Goericke, R., Hildebrand, J., Irvine, J.E., Kahru, M., Koslow, J.A., Lavaniegos, B., Lowry, M., Mackas, D.L., Manzano-Sarabia, M., McKinnell, S.M., Mitchell, B.G., Munger, L., Perry, R., Peterson, W.T., Ralston, S., Schweigert, J., Suntsov, A., Tanasichuk, R., Thomas, A.C., Whitney, F. (2010). Status and trends of the California Current region, 2003–2008, pp. 106–141 In McKinnell, S.M. and Dagg, M.J. (eds.) Marine Ecosystems of the North Pacific Ocean, 2003–2008. PICES Special Publication 4, 393 p.

Caihua, M.A., Kui, Y., Meizhao, Z., Fengqi, L., and Dagang, C. (2008). A preliminary study on the diversity of fish species and marine fish faunas of the South China Sea. Oceanic and Coastal Sciences Research 7(2), 2–11.

CBD (Convention on Biological Diversity) (2014). Report of the North Pacific regional workshop to facilitate the description of ecologically or biologically significant marine areas. UNEP/CBD/RW/EBSA/NP/1/4. 187 pp.

Chelton, D.A., Bernal, P.A., and McGowan, J.R. (1982). Large-scale interannual physical and biological interaction in the California Current. Journal of Marine Research 40, 1095–1125.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R., and Pauly, D. (2009). Projecting global marine biodiversity impacts under climate change scenarios. Fish and Fisheries 10, 235–251.

Cheung, W.W.L., and Sadovy, Y. (2004). Retrospective evaluation of data-limited fisheries: a case from Hong Kong. Reviews in Fish Biology and Fisheries 14, 181–206.

Chiba, S., Hirawake, T., Ishizaki, S., Ito, S., Kamiya, H., Kaeriyma, M., Kuwata, A., Midorikawa, T., Minobe, S., Okamoto, S., Okazaki, Y., Ono, T., Saito, H., Saitoh, S., Sasano, D., Tadokoro, K., Takahashi, K., Takatani, Y., Tanabe, Y., Wada, Y., Watanabe, Y.W., Watanuki, Y., Yamamura, O., Yamashita, N., and Yatsu, A. (2010). Status and trends of the Oyashio region, 2002–2008, pp. 300–32Tak S4(e)-0.003]TJ 0 Tc 03 Tc -0.00 0

Dagg, M.J. (

Tegner, M.J., and Warner, R.R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. Science, 293, 629-637.

Jia, X., Li, Z., Li, C. Qiu, Y., and Gan, J. (2004). The ecosystem and fisheries in the commercial zone and the continental shelf of the South China Sea. Science

Mackas, D.L., and Galbraith, M. (2002). Zooplankton community composition along the

Ono, T., Midorikawa, T., Watanabe, Y.W., Tadokoro, K., and Saino, T. (2001). Temporal increases of phosphate and apparent oxygen utilization in the subsurface waters of western subarctic Pacific from 1968 to 1998. Geophysical Research Letters 28, 3285-3288.

Orr, J.C., Fabry, V.J., Aumont, O., Bopp, L., Doney, S.C., Feely, R.A., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F., Key, R.M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R.G., Plattner, G.-K., Rodgers, K.B., Sabine, C.L., Sarmiento, J.L., Schlitzer, R., Slater, R.D., Totterdell, I.J., Weirig, M.-F., Yamanaka, Y., and Yool, A. (2005). Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437, 681-686.

Ovetz, R. (2007). The bottom line: An investigation of the economic, cultural and social costs of high seas industrial longline fishing in the Pacific and the benefits of conservation. Marine Policy 31, 217-228.

Pang, L., and Pauly, D. (2001). Chinese marine capture fisheries from 1950 to the late 1990s: the hopes, the plans and the data. In Watson, R. Pang, L., and Pauly, D. (eds.), The Marine Fisheries of China: Development and Reported Catches. Fisheries Centre Research Report 9(2), 1-27.

PICES (2004). Marine ecosystems of the North Pacific. PICES Special Publication 1, 280p.

Pitcher, T.J., Morato, T., Hart, P.J.B., Clark, M.R., Haggan, N., and Santos, R.S. (eds.) (2007). Seamounts, Fisheries and Conservation. Blackwell Publishing, 527 pp.

Polovina, J., Howell, E., Kobayashi, D., and Seki, M. (2001). The transition zone chlorophyll front, a dynamic global feature defining migration and forage habitat for marine resources. Progress in Oceanography 49, 469-483.

Polovina, J.J., Balazs, G.H., Howell, E.A., Parker, D.M., Seki, M.P., and Dutton, P.H. (2004). Forage and migration habitat of loggerhead (Caretta caretta) and olive ridley (Lepidochelys olivacea) sea turtles in the central North Pacific Ocean. Fisheries Oceanography 13, 36-