

Did a regime shift occur in 1998 around Japan? - Highlights from a symposium addressing this question

Sei-ichi Saitoh
Laboratory of Marine Environment and Resource Sensing
Hokkaido University
3-1-1, Minato-cho,
Hakodate, Japan. 041-8611
E-mail: ssaitoh@salmon.fish.hokudai.ac.jp

Kaoru Nakata
National Research Institute of Fishery Science
2-12-2 Fukuura, Kanazawa-ku,
Yokohama, Japan. 236-8648
E-mail: may31@affrc.go.jp



Sanae Chiba
Frontier Research System for Global Change
JAMSTEC
3173-25 Showa-machi, Kanazawa-ku,
Yokohama, Japan. 236-0001
E-mail: chibas@jamstec.go.jp

Akihiko Yatsu
National Research Institute of Fishery Science
2-12-2 Fukuura, Kanazawa-ku,
Yokohama, Japan. 236-8648
E-mail: yatsua@fra.affrc.go.jp



Dr. Sei-ichi Saitoh (left) is a professor at Hokkaido University. He is currently interested in the application of satellite remote sensing and Marine-GIS to fisheries oceanography and marine ecosystem studies. He is also the Co-Chairman of the PICES MONITOR Task Team since 2002.

Dr. Sanae Chiba (second from left) is part of the Ecosystem Change Research Program of FRSGC, and has been a member of the GLOBEC Focus 2 Working Group since 2003. As a zooplankton biologist, her scientific career has focused on studying the link between physical/chemical environments and lower trophic level ecosystem variability.

Dr. Kaoru Nakata (third from left) is the head of the Marine Productivity Section at the National Research Institute of Fishery Science (NRIFS). Her current work focuses on changes in that occur at lower trophic levels in both coastal and oceanic waters in relation to climate change and global warming.

Dr. Akihiko Yatsu (right most) is the head of the Population Dynamics Section at NRIFS. His current work includes stock assessment of chub mackerel, and inter-annual and inter-decadal linkages of stock abundance and marine ecosystems in the Northwest Pacific. He is also the Co-Chairman of the PICES BASS Task Team and Working Group 16 on Climate change, shifts in fish production, and fisheries management.

The Japanese Society of Fisheries Oceanography held a symposium on March 31, 2004, at the Tokyo University of Marine Science and Technology (formerly Tokyo University of Fisheries), to examine changes that occurred in waters around Japan in 1998 and determine if these changes were indicative of a regime shift. A total of 106 scientists, including journalists and university students, attended the symposium, which was convened by Drs. Sei-ichi Saitoh, Akihiko Yatsu, Kaoru Nakata and Sanae Chiba. A total of 19 oral talks were presented.

Highlights of the symposium included talks addressing how to define a regime shift (time span required for detection, alternation of dominant commercial species, onset of drastic change in the productivity of fishery stocks, etc.), regional and taxonomic differences in response to regime shifts, and the relation of the 1998 changes to ENSO and inter-annual changes. In the physics session, four speakers discussed the effect of regime shifts at scales ranging from regional (northwest Pacific and Tsushima Current region) to global.

Minobe suggested that the variation of the East Pacific pattern, which is responsible for the 1998/99 change of sea-level pressure (SLP) as shown by Minobe (2002), is likely to be related to the North Pacific SST EOF2 (known as the Victoria Pattern) proposed by Bond *et al.* (2003). Sea Surface Temperature (SST) and upper water Heat Storage (HS) increased abruptly both in the Kuroshio/Oyashio Extension region and the central North Pacific due to Rossby wave (Minobe, 2002). At the same time, Sea-Level Displacements (SLD) rose from Japan to 160°W, roughly along the Kuroshio Extension path with a tongue-like structure (Fig. 1; Minobe, 2002). This change has continued for only 4 years (1998 to mid-2002), so it is still early to decide that this phenomenon signals a regime shift.

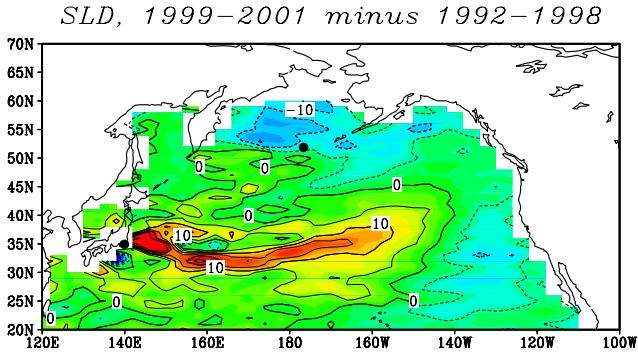


Fig. 1 Sea-Level Displacement (SLD) between 1999–2001 and 1992–1998. The contour interval is 5 cm, and the shaded areas indicate regions where SLD was larger than 10 cm (Minobe, 2002).

Yasunaka and Hanawa (2002) defined a regime shift as a “significant” and “systematic” change between the two quasi-steady states that continues for more than 5 years. They identified five regime shifts in 1925/26, 1945/46, 1957/58, 1976/77 and 1988/89. The 1998/99 change has similar characteristics to those of the previous ones, however, the Arctic Oscillation (AO) mode of the SST anomaly, which is one characteristic of a regime shift, has not continued since 1998, so we should continue analyses to determine if there was indeed a regime shift in 1998/99.

In the southern part of the Aleutian Islands in the western North Pacific, a cooling pattern of intermediate cold water was detected during 1998–2002. In the Tsushima Current region in the Japan Sea, there was no clear change in 1998/99, but a decadal change pattern was noticed. These results indicate that more data are needed to detect a signal of regime shift.

An analysis of correlations between the ENSO index and primary production estimated based on satellite images in the Pacific from 1998 to 2002, revealed that production was high during La Niña events in the equatorial eastern Pacific and off the California and Peruvian coasts, and

during El Niño events in the equatorial western Pacific and the north and south subtropical gyres (Kameda, 2003). However, changes in the primary production in the western North Pacific are not related to the ENSO event and/or to the SST shift in 1998/99. On the other hand, the primary production has increased since the winter of 2000 in the Kuroshio, Kuroshio Extension and Oyashio (Kameda *et al.*, Fig. 2). Primary production in the subarctic western North Pacific showed no consistent pattern, but was relatively high in 1999 and 2002 (Kameda *et al.*), and Yamada *et al.* reported that the primary production in the southern Japan Sea has also elevated since 2002.

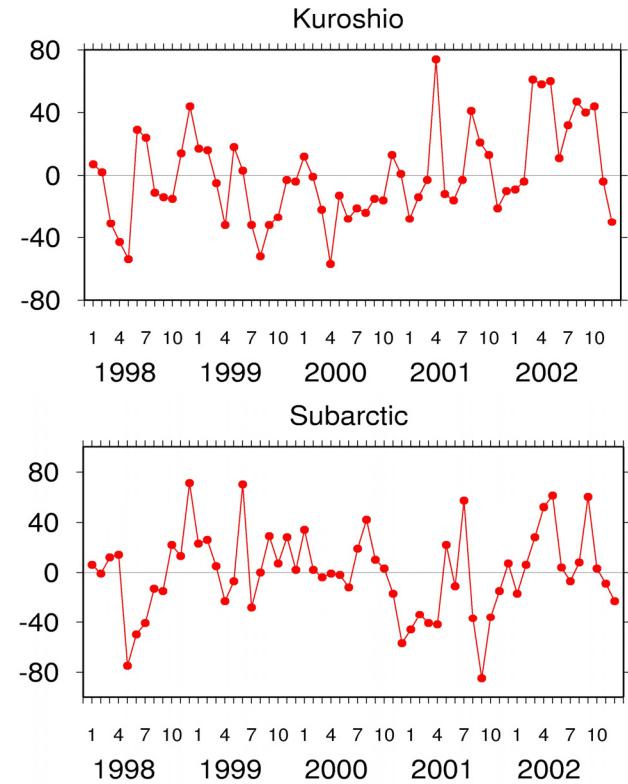


Fig. 2 Variations in primary production in the Kuroshio (upper panel) and subarctic western North Pacific (lower panel) from January 1998 to December 2002 (Kameda *et al.*).

Tadokoro *et al.* and Hidaka reported on changes that occurred in the meso-zooplankton biomass in the Oyashio and the inshore waters of the Kuroshio, respectively. In the Oyashio region, meso-zooplankton biomass in spring, which is dominated by *Neocalanus spp.*, has decreased since the early 1970s, which seems to correspond to the decrease in the mixed layer depth and the net primary production estimated from a decline of PO₄-P in the surface mixed layer from winter to spring (Ono *et al.*, 2002). In 1999, the net primary production increased to the level observed in the early 1970s (Tadokoro *et al.*, Fig. 3), though there was no evidence of an increase in the meso-zooplankton biomass. In both of the Kuroshio and

inshore water, the winter biomass of large copepods was also relatively high before the mid-1970s, but has tended to decrease since then (Nakata *et al.*, 2001). In 1999, the biomass in the Kuroshio increased to the level observed in the early 1970s, and the increase was mainly due to the increase of *Calanus sinicus* (Nakata and Hidaka, 2003). Hidaka showed that the increase in the biomass in the late 1990s was limited to the Kuroshio region, and the abundance of *C. sinicus* in the slope water was stable through the second half of the 1990s. The Kuroshio flow axis showed a somewhat more meandering path in 1999 and 2000, than in 1998, so Hidaka inferred that the difference in the biomass trends between the Kuroshio and the inshore water was due to the difference in the meandering path which probably resulted in the entrainment of slope water into the Kuroshio.

Increase in water temperature may have had a severe impact on the distribution and composition of large algal communities. Kiriyama *et al.* reported that large brown algae decreased in biomass, and warm-water species increased in biomass, along the coast of the northwestern Kyushu Island when temperature increased, especially in the late 1990s. They also demonstrated that the feeding pressure of herbivorous fishes increased with increasing temperature.

Inter-annual and inter-decadal scale variations of stock size and recruitment success of commercial fish species in Japanese and adjacent waters were reported in nine presentations, five of which examined pelagic species and three studied benthic or coastal species.

Only a few clear regime-shift-related changes were recognized in both pelagic and benthic species in 1998. For example, the recruitment success (recruits-per-spawner, RPS) of blue-fin tuna increased (Fig. 4, Inagake *et al.*), while the catch-per-unit-effort (CPUE) and/or recruitment success for other pelagic species, markedly changed in 1998, most returned to pre-1998 levels after 1999: 1) the common squid stock decreased in 1998, but recovered to an average level, and then reached a maximum in 1998–2000 for the winter and autumn cohorts (Fig. 5, Kidokoro *et al.*); 2) the anchovy stock increased in 1998, and declined after a few years in the Tsushima Current region, East China Sea and Japan Sea (Oshima); 3) RPS of sardine, mackerel and saury in the Kuroshio-Oyashio areas decreased in the late 1990s, and recovered in 2000, except for the Pacific saury, whose CPUE remained below average (Yatsu and Ueno). For benthic species, it was unclear if changes occurred in 1998. CPUE of several species gradually increased during the 1990s, and peaked in 1998–2000 along the Pacific coast of northern Honshu (willowy flounder, stone flounder, brown sole, shothole halibut, yellow goosefish; Nihira and Takahashi) and off east Hokkaido (Korean flounder, slime flounder, pointhead flounder, red halibut, octopuses; Nishimura *et al.*). This

variation might have resulted from an increase in the carrying capacity after the collapse of the sardine stock in the 1990s.

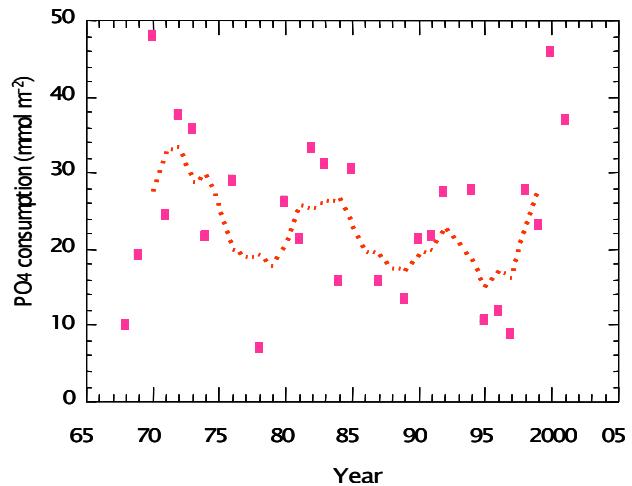


Fig. 3 Inter-annual variation of PO_4 -P consumption in the Oyashio area during February-April (Tadokoro *et al.*).

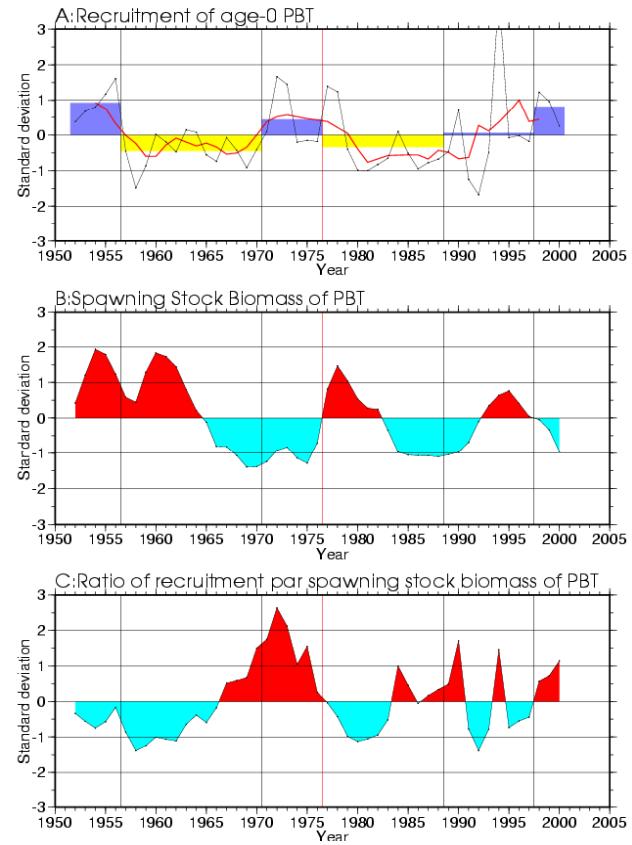


Fig. 4 Recruitment, spawning stock biomass and reproductive success (recruitment per spawner) of the Pacific stock of bluefin tuna (Inagake *et al.*). Vertical lines: regime shifts found in SST data by Hanawa and Yasunaka.

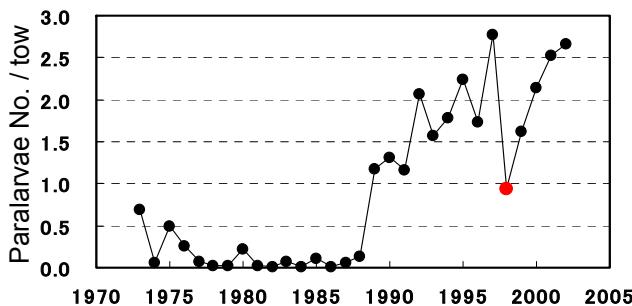


Fig. 5 CPUE of jig fishery of Japanese common squid, *Todarodes pacificus* (Kidokoro et al.). Red mark represents the 1998 data.

Some presentations examined the effects of the change in water temperature observed in 1998. In the western subarctic Pacific, the warming in 1998 resulted in a northward expansion in the distribution of the subtropical species, although overall fish abundance was constant (Yamaguchi et al.). On the other hand, the cooling after 1998 seemed to have negatively affected CPUE of willow flounder in Mutsu Bay, northern Honshu. Inagake et al. reported that the RPS values of blue-fin tuna and albacore were related to the water temperature of their spawning

grounds (and nursery ground for blue fine tuna), and found a regime-shift-related variation of RPS. However, the changes that occurred in 1998 were smaller than those that occurred during previous regime shifts.

Kidokoro et al. demonstrated that causes of the decline of common squid stock structurally differed between during the 1980s and after 1998, showing that the shift of the spawning ground that occurred in the 1980s did not occur in 1998 (Fig. 6).

The general consensus among symposium participants was that the changes that occurred in 1998 were much shorter than those that occurred during the 1976-77 regime shift. The reported changes in the higher trophic levels in 1998 might have been responses to the inter-annual or ENSO scale fluctuations in the physical and biological environments, rather than to decadal or multi-decadal scale climatic variation. The convenors concluded that more data should be collected to compare different areas in the North Pacific, and for global scale comparisons. To better compare regions and understand the links between climate and ecosystem variability, we may need to set a variety of working definitions of regime shifts using biological variables as well as physical/climatic variables.

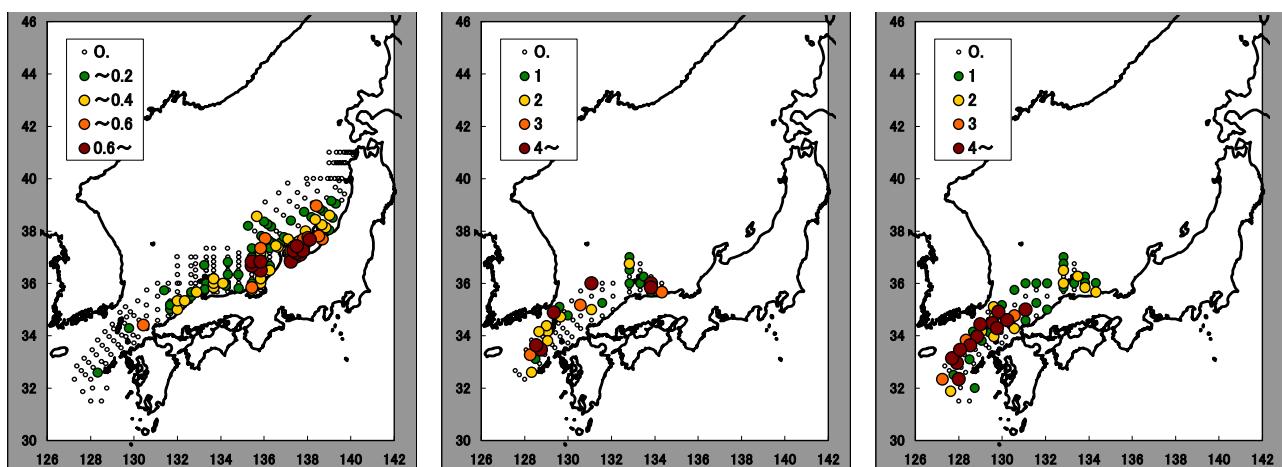


Fig. 6 Shift of spawning ground of Japanese common squid based on the larval distribution pattern (October - November) (Kidokoro et al.). Left: low stock period (average of 1981-1986), middle: high stock period (1995) and right: 1998.

References

- Kameda, T. 2003. Studies on oceanic primary production using ocean color remote sensing data. Bull. Fish. Res. Agency, 9: 118-148.
- Minobe, S. 2002. Interannual to interdecadal changes in the Bering Sea and concurrent 1998/99 changes over the North Pacific. Prog. Oceanogr., 55: 45-64.
- Nakata, K., Koyama, S. and Matsukawa, Y. 2001. Interannual variation in spring biomass and gut content composition of copepod in the Kuroshio current, 1971-89. Fish. Oceanogr., 10: 329-341.
- Nakata, K. and Hidaka, K. 2003. Decadal scale variability in the Kuroshio marine ecosystem in winter. Fish. Oceanogr., 12: 234-244.
- Ono, T., Tadokoro, K., Midorikawa, T., Nishioka J. and Saino, T. 2002. Multi-decadal decrease of net community production in western subarctic North Pacific. Geophys. Res. Lett., 29: 271-274.
- Yasunaka, S. and Hanawa, K. 2002. Regime shifts found in the Northern hemisphere SST field. J. Meteor. Soc. Japan, 80: 119-135.