

## Seasonal and Annual Changes of Oceanographic Condition during Early Ocean Life of Chum Salmon in the Coastal Waters of Okhotsk Sea, Eastern Hokkaido

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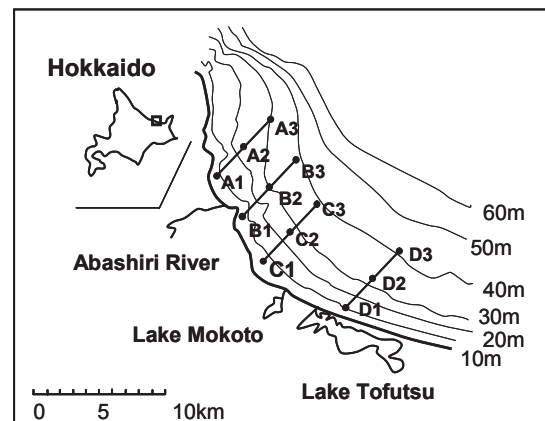
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Two different currents affect oceanographic conditions in southern part of the Okhotsk Sea along the Hokkaido coast. In winter the East Sakhalin Current characterized by low temperature and salinity flows along the Hokkaido coast with sea ice. In summer the Soya Warm Current (SWC) characterized by high temperature and salinity flows southeastward from Soya Strait along the coast. In spring, these current systems are replaced, so that the temperature, salinity and nutrients change extremely. These extreme changes in the oceanographic conditions may affect the early marine survival of juvenile chum salmon. We investigated to clarify the relationship between seasonal and annual fluctuations of oceanographic condition and early ocean life of chum salmon. Physicochemical and biological conditions were examined every 10 days from April to July in 2002–2005 at 12 stations in the coast of Abashiri Bay, eastern Hokkaido (Fig. 1). Water temperature and salinity profiles were measured by using memory STD at all stations. Water samples in each depth (0, 10, 20, 30 and 40 m) were collected with Van Dorn Bottles for nutrients and chlorophyll-a analyses at two stations off the mouth of the Abashiri River (Stations B1 and B3).

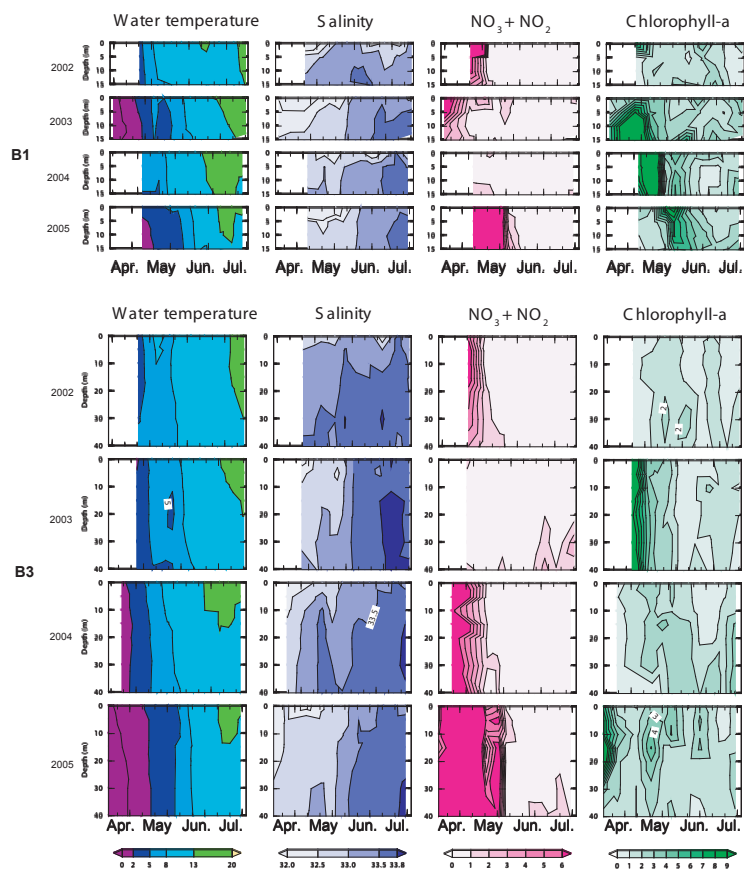
Changes in water temperature (°C), salinity (PSU), nutrient concentration ( $\text{NO}_3 + \text{NO}_2$ :  $\mu\text{g-atom/L}$ ), and chlorophyll-a concentration ( $\mu\text{g/L}$ ) at Station B1 (off 1 km) and B3 (off 7 km) are shown in Fig. 2. There were large annual fluctuations in sea surface water temperature and salinity in May, when juvenile chum salmon stayed around Stations B1 and B3. The physicochemical conditions extremely fluctuated every year owing to three seasonal environmental factors: 1) retreat timing of sea ice; 2) nutrient supplement from oceanic or terrestrial area; and 3) predominance timing of the SWC (salinity > 33.5 psu). Sea ice disappeared in late March in 2002, 2004 and 2005, but in late April in 2003 (Table 1). The maximum concentrations of chlorophyll-a (> 8  $\mu\text{g/L}$ ) were observed soon after sea ice disappearance, suggesting that retreat timing of sea ice might influence the timing of phytoplankton bloom. The high nutrient concentrations were observed after chlorophyll-a peaks except for 2003, suggesting that the nutrients were constantly supplied from another area to the bay (Fig. 3). Especially in 2005, it seemed that the Dichothermal Water (temperature < 2°C) containing high nutrient concentrations flowed into the bay from offshore areas.

From May to June, the SWC became predominant in the bay, and simultaneously “low temperature and low salinity” condition shifted to “high temperature and high salinity” condition (Fig. 4). Since the SWC is driven by a difference in sea level between the Japan Sea and Okhotsk Sea (Aota 1984), the sea level difference between Wakkanai and Abashiri is used as an index of the strength of SWC. The salinity profiles in this study indicated the predominance of SWC when the sea level difference has become to increase, although those timings were different every year. The condition shifted drastically in 2003 and 2005, but gradually in 2002 and 2004, depending upon the water temperature in April and the predominance timing of SWC. These results suggested that the early ocean life of juvenile chum salmon may be affected by annual fluctuations in the coastal oceanographic conditions between spring and summer. In the coastal waters of eastern Hokkaido, chum salmon juveniles were abundant when

Fig. 1. Map showing the study sites 1 km, 4 km, and 7 km off Abashiri coast in the Okhotsk Sea.



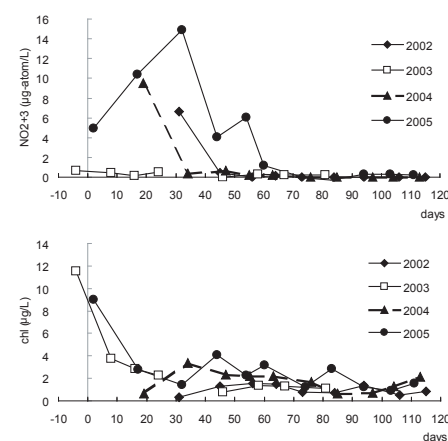
**Fig. 2.** Changes in water temperature (°C), salinity (psu), NO<sub>3</sub> + NO<sub>2</sub> concentration (µg-atom/L), and chlorophyll-a concentration(µg/L) at Station B1 and B3 between April and July in 2002–2005.



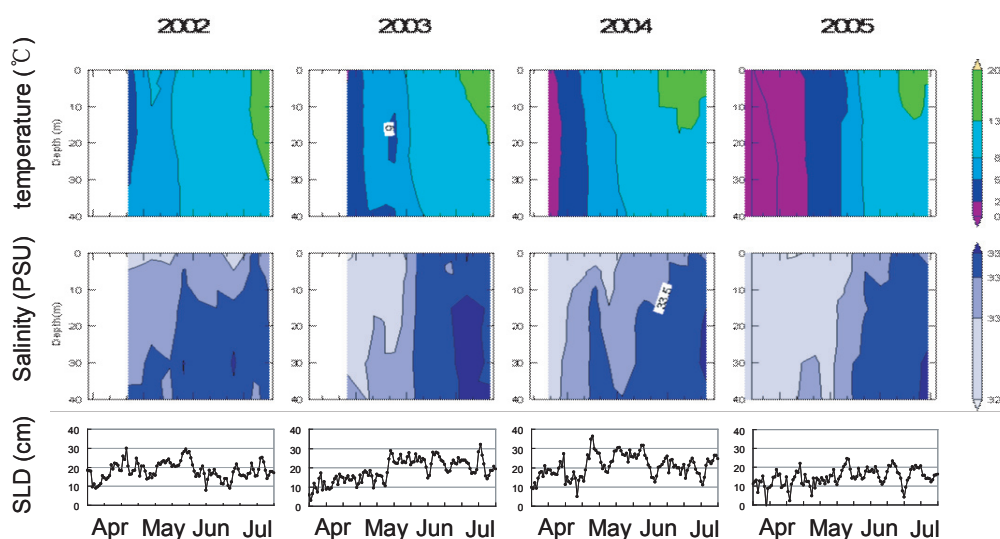
**Table 1.** Sea ice period and the last day of the sea ice period at Abashiri in 2002–2005 (data source: Japan Meteorological Agency).

year	sea ice period	the last day of the sea ice period
2002	89	25-Mar
2003	108	29-Apr
2004	54	24-Apr
2005	60	26-Mar
30 year average (1971–2000)	87	16-Apr

**Fig. 3.** Changes in NO<sub>3</sub> + NO<sub>2</sub> concentration (µg-atom/L, averaged in euphotic zone), and chlorophyll-a concentration (µg/L, averaged in euphotic zone) in time scale from the last day of the sea ice at Station B3 in 2002–2005.



**Fig. 4.** Changes in water temperature (°C and salinity (psu) at Station B3 and sea level difference between Wakkanai and Abashiri (cm) in 2002–2005.



water temperature was 8–13°C (Nagata *et al.* 2005), and the cold water zooplankton utilized by salmon juveniles was abundant when salinity was less than 33.5 psu (Asami *et al.* 2005). The duration of favorable oceanographic conditions for chum juveniles might be longer in 2002 and 2004 than in 2003 and 2005.

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