

A-565 IORI TANAKA

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Derivation of a general equation and numerical solution method for calculating chlorophyll a and pheopigments in serial oceanographic observations

When we analyze a sample containing mixed solution of chlorophyll a and pheopigments by fluorometric methods, dilution is needed for the sample containing high pigment concentration in which nonlinear relationship between fluorescence intensity and pigment concentration appears. In this study, a general equation, which can calculate the pigment concentration in the nonlinear region, was derived in order to avoid this dilution procedure. General solution of the equation through a numerical calculation method is also shown for chlorophyll a and pheopigments. Results of the calculation by general solution were verified by comparing the results to that obtained by the dilution procedure for total pigment concentrations up to 520  $\mu\text{gL}^{-1}$  using the same sample from in situ sea water collected during a spring phytoplankton bloom on the coast of the Sea of Japan.

A-566 MASAFUMI NATSUIKE, MAKOTO KANAMORI AND HIROSHI SHIMADA

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Red tide and seasonal occurrence of the harmful raphidophyte *Heterosigma akashiwo* in Hakodate Bay, Hokkaido

Seasonal sampling at the Hakodate Bay, Hokkaido, from April to November 2018 revealed the occurrence of the harmful raphidophyte, *Heterosigma akashiwo*, detected first in early July at a density of 5 cells  $\text{mL}^{-1}$ , which subsequently increased rapidly until mid-July, with the maximum density reaching 6,000 cells  $\text{mL}^{-1}$ . *H. akashiwo* was observed until August at low densities ( $< 1$  cells  $\text{mL}^{-1}$ ) and not detected from September to November. When *H. akashiwo* occurred in high density, surface water temperature ranged from 14.8° C to 18.1° C, which was reported to be the optimal growth temperature for *H. akashiwo* in culture experiments. Lower salinity ( $< 30$ ) at the surface layer, caused by precipitation, was observed in Hakodate Port when the density of *H. akashiwo* increased

rapidly. A red tide of *H. akashiwo* was observed in Hakodate Bay in mid-July 2018. Fish mortality was not reported during the occurrence of the red tide, even at the maximum cell density (113,000 cells mL<sup>-1</sup>) in the bay. Some other red tide-causing species that are lethal for fishes, such as *Fibrocapsa japonica*, were detected from July to November. Thus, continuous monitoring of harmful flagellates is important in the Hakodate Bay, to detect the occurrences of harmful red tides.

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A-567 HIROKI ASAMI, HIROFUMI HAYANO, SHUICHI MANO AND MITSUHIRO NAGATA

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Prevalence of the hemiurid trematode *Brachyphallus crenatus* in the stomach of juvenile masu salmon *Oncorhynchus masou* in the coastal waters near Cape Erimo, Hokkaido, Japan

Prevalence of the hemiurid trematode *Brachyphallus crenatus* in the stomach of the juvenile masu salmon *Oncorhynchus masou* collected in the coastal waters near Cape Erimo off the Pacific coast of Hokkaido was investigated. Juvenile salmon were sampled at two different times of the day (early morning, 5:00, and day-time, 13:00) on June 10, 1994, using set nets extending from the shore to offshore areas at three stations. A total of 127 juveniles were collected (41 individuals in the early morning and 86 individuals during the day). Most of the juveniles were captured at the shore stations. Five tagged juveniles were also found at the shore stations during the day. The fork lengths of the juveniles collected at shore were smaller than those of the juveniles caught offshore. The ratio of small juveniles (<20 cm) caught was about 50 % during the day, and about 29% in the early morning. *B. crenatus* was present in over 95% of the total juvenile salmon collected during the early morning and day. Mean intensity of occurrence was higher in the early morning than during the day for both the males and females. A positive correlation was found between the fork length and intensity of *B. crenatus*. Differences in the prevalence incidence during the two periods of the day might relate to the differences in sea entry sites or in the time spent at sea. The effectiveness of *B. crenatus* as biological tags of juvenile salmon is discussed.

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A-568 MIKIMASA JOH

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Methods of otolith microstructure analysis using free software  
(Technical report)

A-569 YOSHIYUKI TAKAYA AND HIROO GODA

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The release period of zoospores of three species of Laminariales *Agarum clathratum*, *Costaria costata* and *Alaria praelonga* off the coast of eastern Hokkaido by real-time PCR (Note)

A-570 OSAMU SHIDA

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Acoustic surveys of walleye pollock by Hokkaido Research Organization using the quantitative echo sounder (Review)

Walleye pollock is one of the most important resources of commercial fisheries in Hokkaido. Annual landings of this species are controlled by the Total Allowable Catch system in Japan. Because the annual landings have decreased since the late 1980's, more intensive studies for stock assessment, forecast of fishing conditions and developing a proposal for sustainable resource management are required for the stakeholders. In this review, I describe the history and results of acoustic surveys using a quantitative echo sounder for walleye pollock conducted by Hokkaido Research Organization to respond to such needs.

A-571 TADASHI MISAKA, NOBORU HOSHINO, MASAMICHI WATANOBE, TAKAYUKI HONMA, OSAMU SHIDA, YUKIO MIHARA, KAZUHIRO ITAYA AND HIROYA MIYAKE

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Distributional changes in the spawning population of walleye pollock *Gadus chalcogrammus* in the northern Japan Sea off Hokkaido, Japan

Analysis of annual catches in coastal fisheries and results of acoustic surveys revealed that the distribution of the walleye pollock *Gadus chalcogrammus* spawning population in the northern Japan Sea off Hokkaido shifted southward after the early 1990s and then returned northward after the late 2000s. We presumed that the distributional changes in the spawning population after 1980s have been affected by temperature changes from winter cooling, inferred from the Asian winter monsoon indices, and

by temperature increases in the Japan Sea Proper Water, in addition to the increase or decrease in population abundance. The distributional changes, varying the distance between the spawning grounds and the nursery area, seemed to exchange the major factors affecting recruitment fluctuation, as proposed in the previous studies.

A-572 MASAMICHI WATANOBE, TAKAYUKI HONMA AND TAKASHI MUTO

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Annual change of walleye pollock *Gadus chalcogrammus* distribution during the pre-spawning season off Hiyama, Hokkaido

Annual changes in abundance and distribution of walleye pollock *Gadus chalcogrammus* off Hiyama, Hokkaido was examined by acoustic surveys and hydrographic observations in December (pre-spawning season) between 2002 and 2016. In 2002, an estimated 30,000 tons of walleye pollock was extensively distributed in the coastal area of Hiyama. The abundance and distribution area reduced each year, and only about 4,000 tons of pollock were distributed off the coast of Ainuma in 2016. In addition, in recent years the time to leave to the spawning-layer is delayed due to delay in sexual maturation.