Qualitative texture characteristic of herring (*Clupea pallasi pallasi*) pre-larvae developed from the natural and artificial spawning-grounds in Severnaya Bay (Peter the Great Bay)

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Some authors consider the frequency of morphologically deformed herring larvae to be indicative of the quality of spawning substrate. The relative frequency of normal and deformed larvae in recently hatched herring eggs from natural and artificial spawning grounds has been determined in Severnaya Bay. The maximal quantity (94%) of well-developed larvae hatched from roe was from artificial spawning substrate but was only 25% or less from the natural seagrass substrate (*Zostera marina*). The deformed larvae from natural substrates included the absence of a yolk sac (4.2%) or high water content (16.6%). The principal deformities of larvae from artificial substrates were curvature of the spine (8%) and irregular head and tail parts (5% and 10%). Approximately 50% of larvae with spinal curvature recovered about one day after hatching.

Pacific Herring: Common Factors Have Opposite Impacts in Adjacent Ecosystems

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Pacific hake are the dominant resident species in the Strait of Georgia (Beamish and McFarlane, 1999) and off the west coast of Vancouver Island in summer (Ware and McFarlane, 1995) – Figure 1. In the La Perouse Bank area, Pacific hake are a large migratory population. During the 1960s, 1970s and 1980s, they spawned off Baja, California during the winter and migrated north to summer feeding grounds (Francis, 1983). Prior to 1990, approximately 25 to 30% of the mature biomass moved into Canadian waters. Since the early 1990s a much larger percentage of the stock (approximately 40%) was present in the Canadian zone.

The fishery for Pacific herring dominated catches in the Strait of Georgia and off the west coast of Vancouver Island from the early 1950s until the mid-1960s (Schweigert and Fort, 1999). The fishery collapsed in the mid-1960s and was closed from 1967 to 1971. It re-opened in 1972 and has been largely regulated by market demands.

Herring are now abundant in the Strait of Georgia and at low levels off the west coast of Vancouver Island (Fig. 2). Predation on herring by hake off the west coast of Vancouver Island increased in direct relation to the increased northward migration of Pacific hake (Ware and McFarlane, 1995). However, hake in the Strait of Georgia reduced their predation on herring despite having a high biomass (Table 1). After 1989, there was a shift to higher mean sea surface temperatures in both areas (Fig. 3) that was part of a large scale shift in climate/ocean conditions as seen in the change in the pattern of the Aleutian Low. Off the west coast of Vancouver Island the high percentage of herring in the diet of hake (approximately 37% annually) is clear evidence of the preference of hake for herring as a prey (Table 2). This preference for herring and the large biomass of hake has been shown to be the principle cause of the low abundance of herring in this area (Ware and McFarlane, 1995).

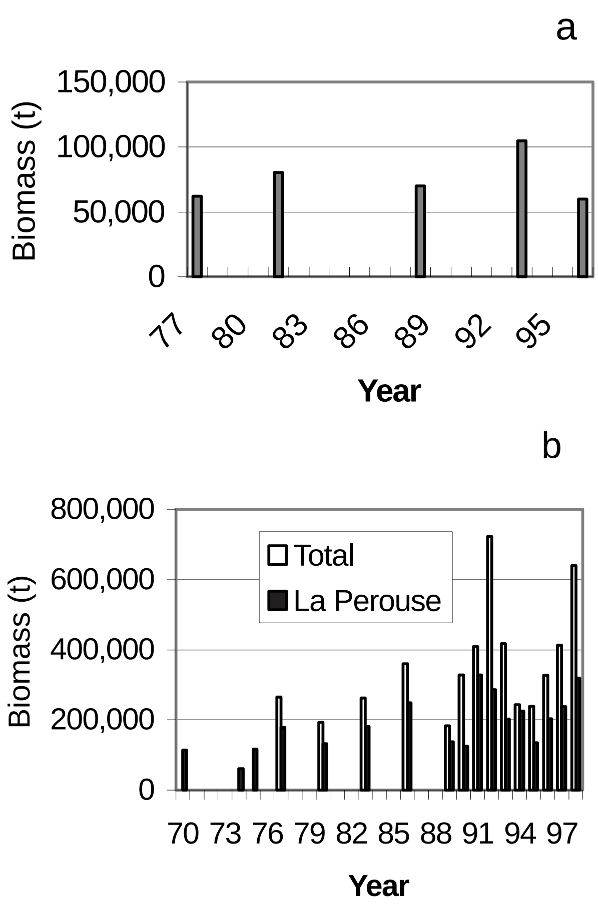


Fig. 1 Biomass estimates (t) of Pacific hake in a) the Strait of Georgia and b) the La Perouse area.

In the Strait of Georgia, hake preference for herring as a prey declined as a consequence of smaller individual size. Our observations of the elimination of herring in the diet of hake in the 1990s is consistent with observations of Tanasichuk et al. (1991), that hake smaller than 40 cm prey almost exclusively on euphausiids and not on herring.

Table 1 Percentage of herring (volume) in the diet of hake from the Strait of Georgia.

Year	Month	Number sampled	% herring in diet
1974	February	601	10.0
1975	Jan-May	3293	23.3
1976	Jan-May	2552	9.9
1981	Feb-May	2072	5.7
1983	Feb and April	2597	30.3
1985	March	607	2.1
1995	Feb-April	572	0.0
1996	Feb-Mar; Oct-Nov	570	0.0
1997	February; Sept-Oct	447	0.0
1998	Feb-March; Sept	307	0.0

Table 2 Percentage of herring (volume) in the diet of hake from the west coast of Vancouver Island (La Perouse).

Year	Month	Number sampled	% herring in diet
1983	July-August	1377	57.0
1985	A	820	40.0
1986	A	2386	9.2
1987	A	1824	28.0
1988	A	3219	58.7
1989	A	1148	11.8
1990	A	998	30.5
1991	A	1105	25.8
1992	A	1663	36.2
1993	A	953	58.5
1994	A	907	18.6
1995	A	916	39.2
1996	A	836	26.8
1997	A	462	17.3

The temperature increases were measures of the ecosystem change but clearly cannot be directly related to the herring abundance trends in the two areas. Thus, the increased temperature in the Strait of Georgia was not associated with a reduction in herring abundance as reported for the west coast of Vancouver. Instead it was associated with improved survival of hake. It is the improved survival that increased their numbers, reduced individual growth, and eliminated predation on herring.

A lesson from this study is that it is the nature of the "reorganization" of the ecosystem after a regime shift that determines the impacts on the population dynamics of a species. A measure of the change, such as temperature, is only one factor affecting the dynamics of populations. The opposite response of herring in the two ecosystems to the climate changes of 1977 and 1989 in adjacent ecosystems, even though the temperature response was similar, indicates that single physical factors need to be related to the dynamics of ecosystems and not just to the observed effect on a single species. It also means that once we see indications that climate/ocean conditions are changing we need to monitor the direction of the new ecosystem organization and adapt our management strategies to this new reality.

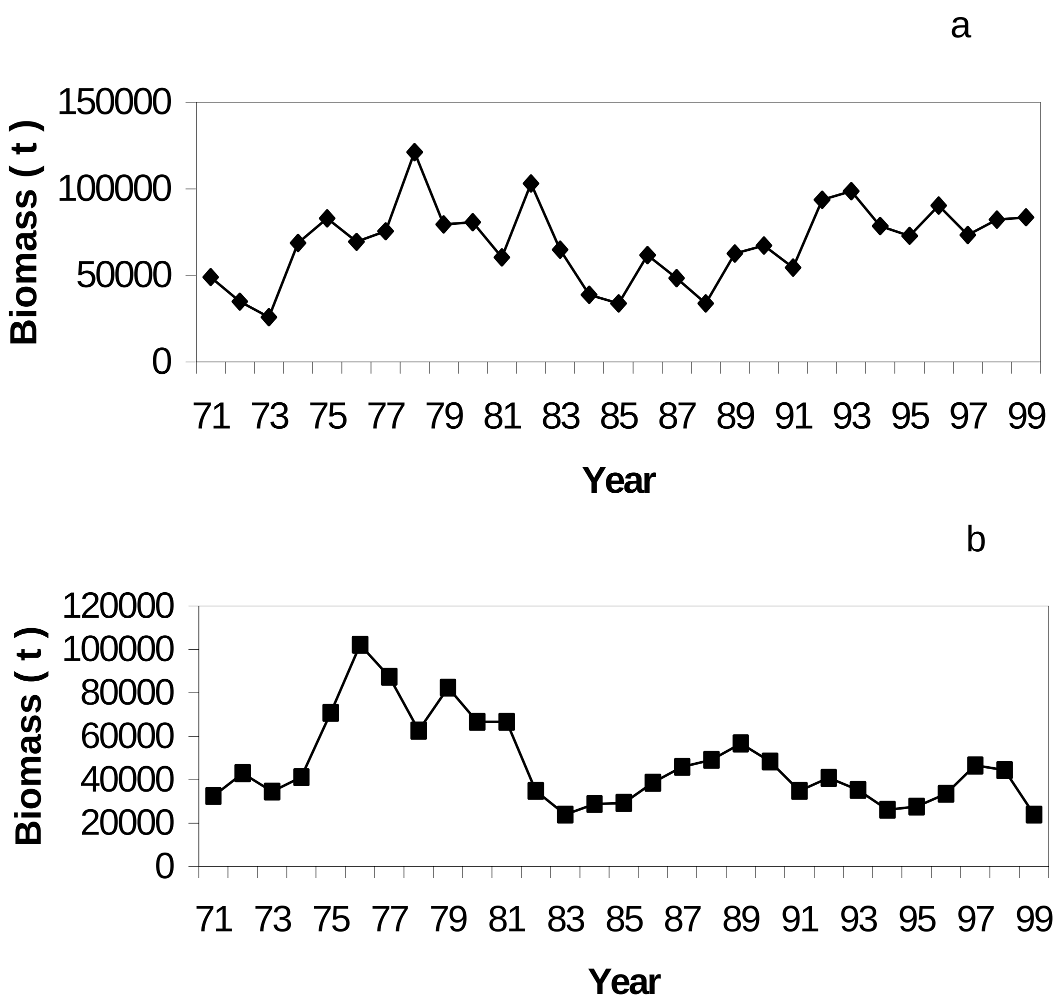
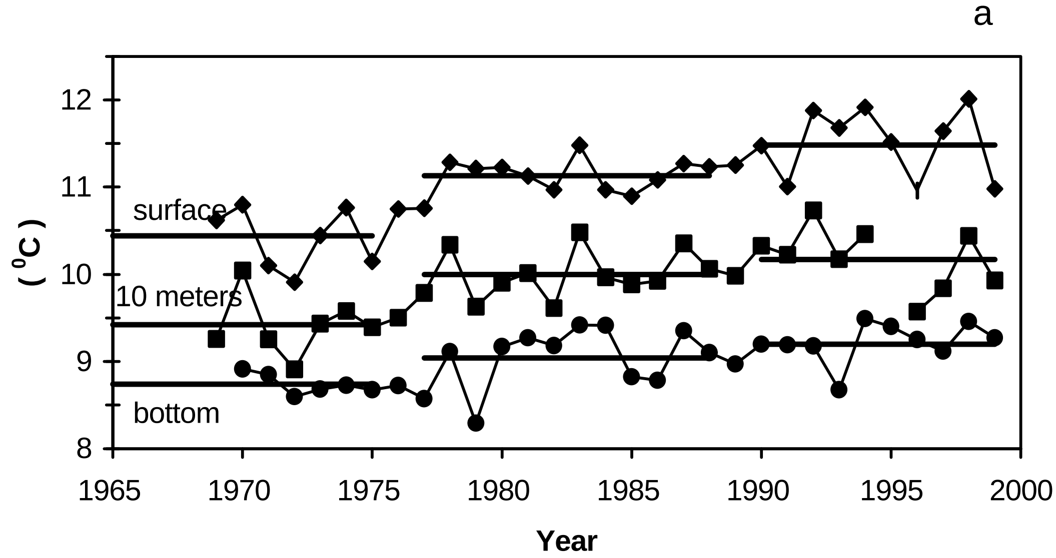


Fig. 2 Biomass estimates (t) of Pacific herring in a) the Strait of Georgia and b) the west coast of Vancouver Island.



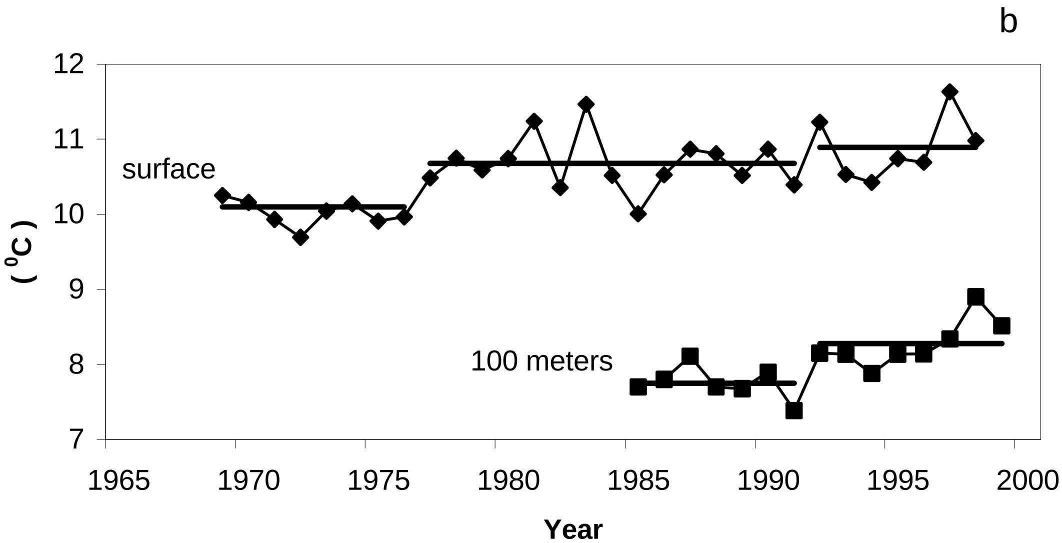


Fig. 3 The average annual sea water temperature at a) surface, 10 m, and bottom in the Strait of Georgia and b) surface and 100 m off the west coast of Vancouver Island. Solid horizontal lines indicate average temperature for regime.

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Long-term fluctuation of the catch of Pacific herring in Northern Japan

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Several spawning grounds of Pacific herring have been observed in the waters of Northern Japan. These spawners are genetically isolated from each other and these populations are classified into the following four types: (I): lagoon-small migration type, (II): oceanic-wide migration type, (III): oceanic-small migration type and (IV): intermediate type between I and II. The Hokkaido-Sakhalin population is one of the oceanic-wide migration type (II) and Mangoku-ura population belongs to type III (Kobayashi, 1993).

Hokkaido-Sakhalin population

Catch and catch at age data for the Hokkaido-Sakhalin population are available since 1878. The annual catch was over 400,000 t from the late 19th century to early in the 20th century, with a historical peak of 970,000 t in 1897 (Fig. 1). However, the population has steadily declined thereafter with continual fluctuation, accompanied with the disappearance of spawning grounds from south to north in the west coast of Hokkaido. In 1955 the spawning ground completely disappeared from the coast of Hokkaido.

Studies of year-class strength, spawner-recruit relationship and observations of oceanographic events led to a hypothesis that the factors controlling the year-class abundance of Hokkaido-Sakhalin population relate to the variations in the spring-summer oceanographic environmental condition. This hypothesis has been tested by examining the data incorporated into a spawner-recruit pattern, for example, sea water temperature and food organism, obtained from spawning-nursery ground. Oceanographic data for the west coast of Hokkaido area is limited, with data from some locations available. Water temperature data for the west coast of