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Implications of variation in euphausiid productivity for the growth, production and resilience of Pacific herring (*Clupea pallasi*) from the southwest coast of Vancouver Island

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This presentation includes the results of a number of studies which collectively suggest that the recent order of magnitude reduction in euphausiid production along the southwest coast of Vancouver Island depressed the productivity and resilience of the West Coast Vancouver Island (WCVI) herring (*Clupea pallasi*) population.

We have been studying the oceanography of the southwest coast of Vancouver Island since 1985 to learn how the ocean affects fish productivity there. Results of diet analyses show that euphausiids are the dominant prey of the more abundant pelagic fish species and that herring feed on them exclusively. We have also been monitoring the species and size composition of prey. Tanasichuk (1999) showed that Pacific hake (*Merluccius productus*), the dominant planktivore, selects larger (>17 mm) euphausiids of one species (*Thysanoessa spinifera*) regardless of how euphausiid biomass varies. WCVI herring select the same prey. Euphausiid population biology and productivity along the WCVI have been monitored since 1991 (Tanasichuk 1998). Figure 38 shows that herring and hake prey biomass has varied by an order of magnitude over the last 10 years. The same degree of prey variation has also occurred for coho salmon (*Oncorhynchus kisutch*).

The effect on herring productivity and resilience appears to operate through influencing growth. Tanasichuk (1997) examined the effect of variations in year-class strength and oceanographic conditions on the size of recruit herring and the growth rates of adult fish. At that time, data were available to 1996 only. He suggested that the 1993 year-class was an outlier because this year-class was the first to be subjected to low *T. spinifera* biomass over its first three years of life. All subsequent year-classes have been outliers, over a period when *T. spinifera* biomass remained depressed (Fig. 39). This dataset suggests that the compensatory population-

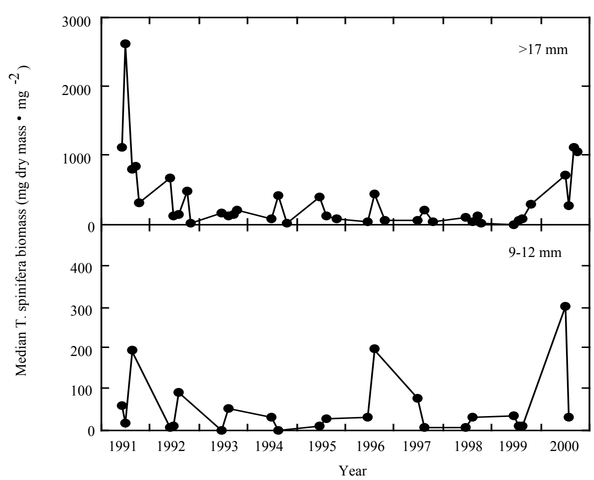

Fig. 38 Median biomass (mg dry mass/mg^2) of key prey for Pacific herring and Pacific hake (>17 mm *T. spinifera*) and coho salmon (9-12 mm *T. spinifera*) over the summer feeding period.

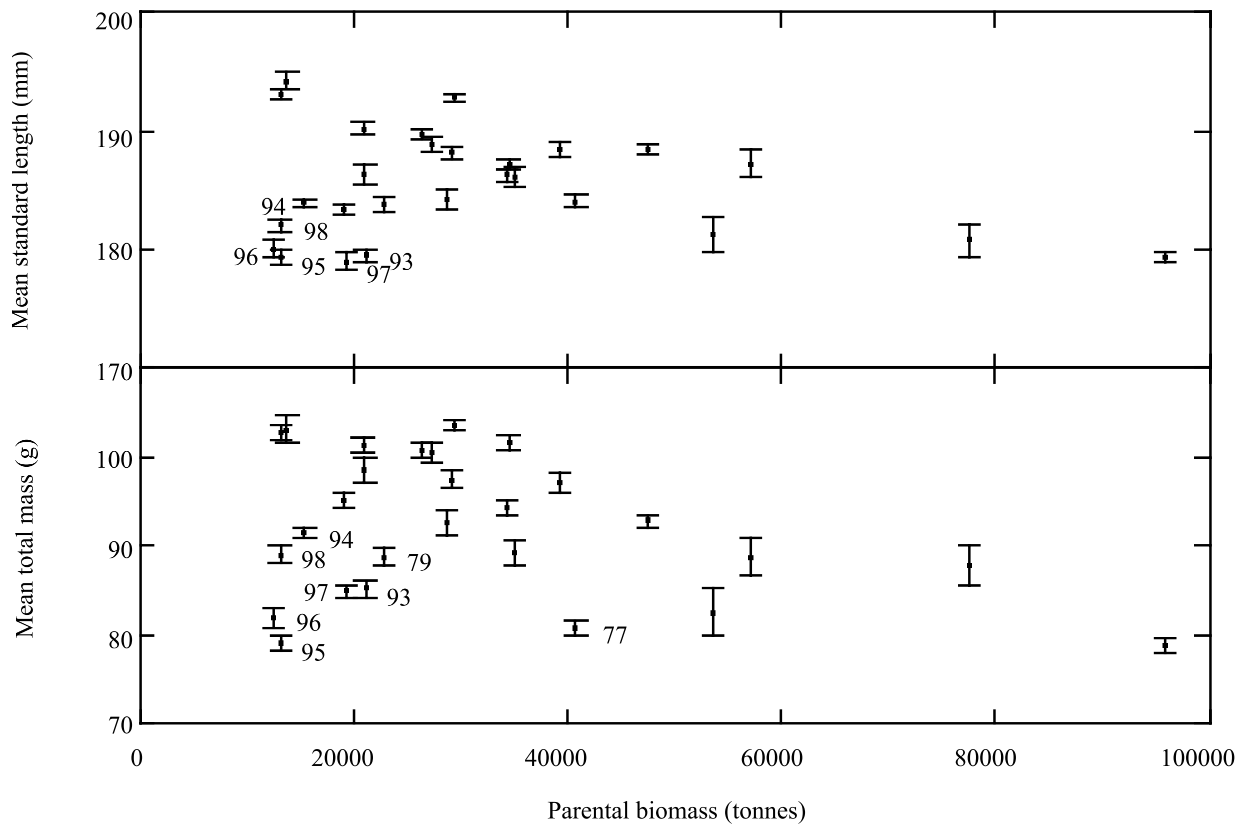

Fig. 39 Scatterplot of mean standard length- and total mass-at-age 3 for WCVI herring. Error bars are 95% confidence limits. Plot labels indicate year-class.

regulating mechanism of density-dependent recruit size has been disrupted by low euphausiid biomasses since 1993. Tanasichuk (1997) concluded that adult growth rates were influenced mainly by size at the beginning of the growth period. Because adult growth rates are affected mostly be initial size, the effect of low euphausiid biomass would persist over the entire life of the year-class. It appears that mortality and size-specific surplus energy allocation to ovarian production have not varied. Tanasichuk (2000) reported that age-specific natural mortality rates of adult herring vary as a function of age alone. Unpublished results showed that there has been no inter-annual variability in mass-specific ripe ovarian mass.

Growth suppression had a large effect on ovarian (=egg) production, and presumably resilience, that is the population's potential to increase or sustain biomass through recruitment. We calculated ovarian production for all ages for each year since 1982, when Fisheries and Oceans Canada started measuring ovarian mass. Annual estimates of observed mean mass-at-age were used to calculate ovarian production; this includes the observed mass-at-age over the time when growth appeared to be suppressed. "Non-suppressed" mass-at-age 3 was then estimated using the regression in Tanasichuk (1997) which describes recruit mass as a function of parental biomass. These estimates of recruit mass, and the regressions describing variations in adult growth rates in mass, were used to estimate what the mass of older fish of a year-class should have been in subsequent years. Figure 40 shows the effect of small recruit size on growth in subsequent years. Figure 41 demonstrates the effect on reduced growth on ovarian production. It would have been reduced by 20% as a consequence of growth suppression of recruit fish and its effect of subsequent adult size. However, after considering further that reduced egg production in 1996-98 could have reduced the number of spawners produced by these year-classes, the suppression of reproduction could have become compounded. Calculations showed that egg production would have consequently been reduced by 40%, presumably a 40% reduction in resilience, in other words a 40% reduction in potential recruitment.

These results have implications for evaluating growth in herring and the concept of the precautionary approach. Recruit size and subsequent adult growth are affected by year-class strength and food availability during the pre-recruit phase. We show an effect of food which complicates the interpretation of size-at-age trends. The precautionary approach (target- and limit reference points) implicitly assumes that fish population productivity and the ability to re-build are constant over time. These results show that assumption is invalid.

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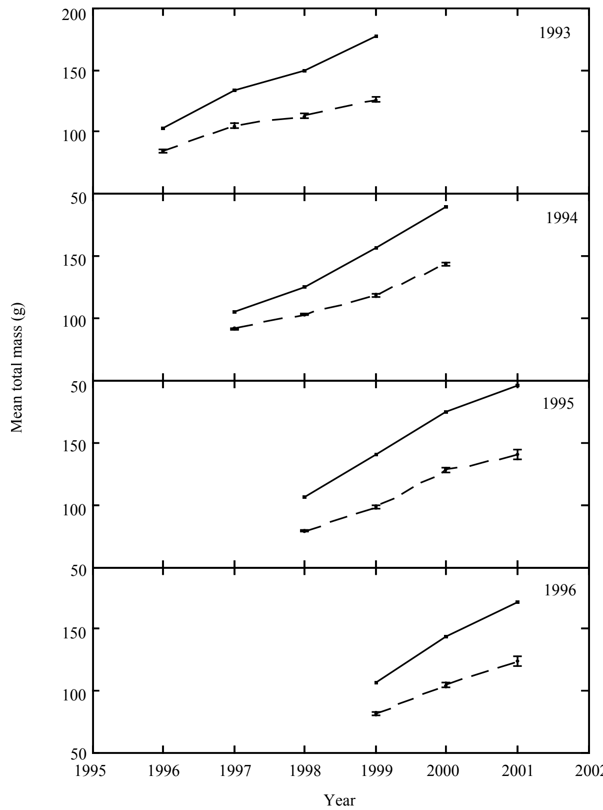

Fig. 40 Mass-at-age trajectories for WCVI herring. Dotted line – observed. Solid line - estimates from growth regressions in Tanasichuk (1997). Error bars are 95% confidence limits. Year-class is indicated in the upper right of each panel.

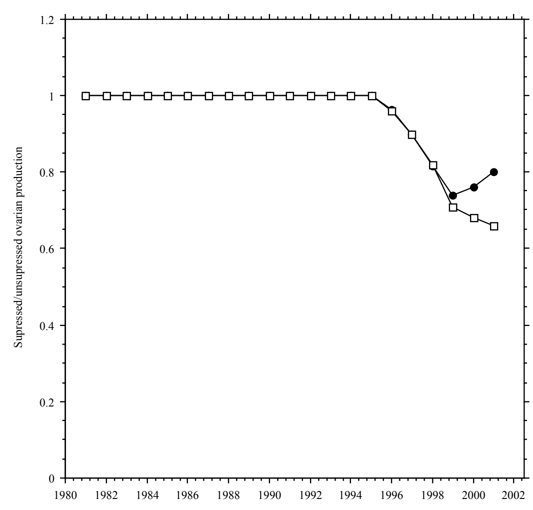

Fig. 41 Suppression of ovarian production due to growth (solid circle) and growth plus recruitment depression (open square).