# *Social Welfare Impacts of Alternative Recruitment Specifications: Implications for Pacific Whiting Management using Bioeconomic Analysis*

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Pacific whiting, *Merluccius productus*, is ecologically and commercially one of the most important fish species on the North American west coast. The stock is exploited by both the U.S., which captures approximately 75% of the allowable catch, and Canada. The stock is managed triennially in the U.S.; every three years biologists with the National Marine Fisheries Service recommend the total allowable catch for each of the upcoming three years assuming recruitment (number of age-2 fish) remains constant at the historical median. Like the gadoids, however, recruitment variation is a major component of stock dynamics for this pelagic specie; it can have a greater impact on production than either variability in mortality or growth. Consequently, fluctuations in stock abundance caused by interannual recruitment variation can significantly impact social welfare.

A fundamental principle regarding the management of renewable resources states that the sustainable yield depends on the size of the parent stock. Obviously, some minimum level of spawning stock is necessary, and maximum recruitment is limited by total fecundity, however, this relationship does not appear to be strong for Pacific whiting. There are several hypothesis regarding the source of variation in whiting recruitment, the most enduring is the effect of environmental conditions (e.g., ocean upwelling and surface temperatures). To examine the effect of alternative recruitment specifications on recommended yields and social benefits, a 3-year bioeconomic model is employed. This management-level, optimal control model integrates population dynamics, intrinsic product quality (via proximate analysis) and industry economics to develop optimal intra- and interseason harvest patterns (i.e., short-term property rights allocations). This age-structured (14 cohort) model tracks the stock over time (across months and into successive years) and between geographic regions (U.S. and Canada). In addition, the optimal temporal allocations depend on the harvest sector (onshore or at-sea) and product form (surimi, fish meal, headed and gutted, or fillet) produced.

Results of the sensitivity analysis reveals that using a constant level of recruitment can mask the importance of a large year-class. When a constant level of recruitment is changed, the change in social welfare (i.e., net present value based on a 5% real discount rate) will be proportionately equal to the change in average annual yield (MSY). If recruitment is variable, both the existence and magnitude of a large year-class can significantly impact welfare and total yield. More importantly, these figures depend on when the large cohort entered the model; for example, welfare and yields each increase by approximately 50% if a large cohort occurs in the second year, as opposed to the third, in this 3-year model. In terms of the existing management structure, these results suggest significant potential benefits from incorporating recruitment estimates. These estimates could be obtained from either (1) prediction (which is possible given the 2-year lag between spawning and recruitment) or (2) survey methods. These results were also supported using a 15-year planning horizon. In addition, discounting only affected the net present value and not the MSY (when measured in thousands of metric tons). These results are, therefore, robust to changes in the both the time horizon and use of discounting.

**Source Paper:**
Larkin, Sherry and Gilbert Sylvia. 1995. "Intraseason Product Quality and Fisheries Management: A Bioeconomic Analysis of the Pacific Whiting Fishery." Oregon State University, Department of Agriculture and Resource Economics, Corvallis.

# *Evaluating the bias and variance from fish migration in trawl estimates of abundance*

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Estimates of fish abundance from trawl surveys are typically imprecise and may often by biased because of uncontrollable factors such as fish migration. In this paper I formulate a vector-based approach for modeling the bias in area swept estimates of biomass when fish migration occurs as the survey is conducted. I evaluate the magnitude and direction of bias from fish migration in systematic transect survey designs. The effects on variability in biomass estimates of interannual variation in migration and vessel speeds are evaluated using Monte Carlo simulation. For even low fish migration velocities (<0.5m/s) bias in estimated fish biomass can be very large (>500%) in trawl surveys. Furthermore, relatively small interannual variability in fish migration rates and vessel speeds (e.g. CV=0.1 for each) can result in very large interannual error variability in biomass estimates (e.g. CV>0.5). Of the alternatives considered, designs with the least bias and variability in biomass estimates had the fastest vessel speeds along transects, shorter transects, transects aligned roughly parallel to the direction of fish migration, and the survey vessel proceeding slightly against the direction of migration as it proceeds between transects.

## *Social networks and tropical fisheries management planning*

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This presentation posed for consideration the extent to which social factors should and could be incorporated into fishery management and planning. It explored the need for an empirically grounded bio-socio-economic fishery management framework.

State-structured regulatory and market-based management measures are based largely on bioeconomic models that typically assume social atomism. That is, individual decisions and actions are assumed to be taken independently—free from the influence of social relations and organizations. However, social scientists have argued that social atomism is an analytical construct not supported by empirical evidence. Some argue that the concepts of social embeddedness and social networks (Figure 1) are more empirically valid and theoretically relevant than the more simple notion of social atomism. From this perspective, the decisions and actions of people are influenced by access to social capital and the exercise of social power (represented by the lines connecting the social actors in Figure 1). These concepts do not fit easily, if at all, into existing quantitative fishery models.

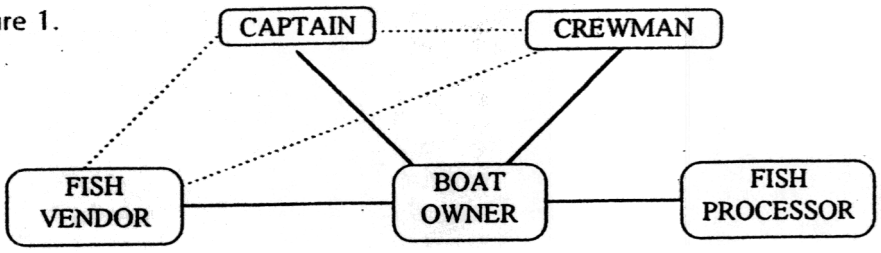
The presentation outlined the ways in which social relations and organizations may complicate the introduction of planning and management to the Barbados tropical, open access, small-scale commercial fishery for migratory pelagics. This fishery was the subject of an applied interdisciplinary research case study focused on social action.

The study revealed little empirical evidence of social atomism, although social networks with an individualistic orientation were found, especially among fishers. Formal social organizations were weakly developed partly because of this individualism, but social networks were used for cooperative purposes, particularly among small-scale buyers.

In the harvest sector, social networks influenced patterns of information exchange between fishers using different boat types and from different locations. Consequently, fishing behaviour, catches and catch rates were systematically affected. In addition to economic factors, social relations between the harvest and postharvest sectors influenced selection of target species, amounts landed and ex-vessel sales transactions. These are only a few of the complex and pervasive effects of social networks.

Knowing the characteristics of social relationships among stakeholders in the fishing industry, and between them and state officials, was invaluable for determining the most appropriate means for introducing and operating a cooperative system of fishery management planning in the case of Barbados. While integration of biological, social and economic considerations is possible in qualitative terms and in specific cases, the absence of a more formal and general integrating framework remains a serious constraint on fisheries management planning.

Figure 1.



# *The temporal signature technique in a Bayesian Framework.*

**Derek H. Ogle,**
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Temporal signatures in calcified structure growth can be used to accurately assign age to fish that have ceased to record growth. A temporal signature is a characteristic pattern of growth found on the calcified structures of all fish alive during the period of pattern formation. Skilled scale analysts have often informally identified and used temporal signatures to assign age to fish. By identifying a particular temporal signature on the calcified structure of an individual fish, the year-class of that fish can be accurately determined. The age of the fish is then the difference between the year of capture and the predicted year-class.

However, identification of the temporal signatures on the calcified structure is difficult because of the confounding effect of age on incremental width. When we quantified the temporal signature technique (Ogle et al. 1994), we removed the effect of age and constructed a series of age-corrected growth increments, called a master chronology, with a linear growth model (Weisberg 1993). The temporal signature technique can be automated by comparing the age-corrected growth increments of a fish to all possible year-classes in the master chronology. We used a minimum sum-of-squared differences to determine year-class membership of a fish (Ogle et al. 1994).

Analysts might find the temporal signature technique more useful in a Bayesian framework because (1) prior information about the sample (e.g., length or known year-class strengths) and interpretations about the scale margin (i.e., degree of resorption or number of ambiguous annuli) can be coherently incorporated into the analysis and (2) probabilities of year-class membership can be obtained. In a Bayesian analysis, methods for developing a likelihood function and expressing prior information and beliefs into a probability function are needed. In this presentation, we developed a likelihood function under the assumptions that the year-coefficients in the master chronology are normally distributed and a fish's age-corrected increments are independent. Development of the likelihood function can be easily generalized to other distributions of the year-coefficients and to simple relationships between the age-corrected increments. We chose parameters for the Beta probability function to model our prior beliefs. We concluded by using real fish to depict several possible results of this new technique.

Finally, because this technique can be used to assign age to fish, we feel that it is imperative that historical collections of scales be preserved. Historical collections can be used to develop master chronologies for which (1) very old individuals in contemporary samples can be aged and (2) age information under past environmental or management conditions can be more accurately inferred.

**References**

Ogle, D. H., G. R. Spangler, and S. M. Shroyer. 1994. Determining fish age from temporal signatures in growth increments. Canadian Journal of Fisheries and Aquatic Sciences 51(8):1721-1727.

Weisberg, S. 1993. Using hard-part increment data to estimate age and environmental effects Canadian Journal of Fisheries and Aquatic Sciences 50:1229-1237.

# *An analysis of stocking and research programs in two British Columbia lakes using a quantitative decision support model.*

**Calvin Peters,**
REM, SFU.

Freshwater fisheries are managed by the Fisheries Branch of the B.C. Ministry of the Environment. The objectives of the Fisheries Branch are to provide a wide variety of angling opportunities and to maintain CPUE, fish body size, and other components of anger success. To achieve these objectives, the Fisheries Branch sets regulations and operates an intensive stocking program using hatchery-reared rainbow trout to support recreational fisheries in many lakes around the province.

Stocking rates are linked to angler success through a series of density-dependent and size-dependent processes, including growth and vulnerability. The number of rainbow trout to stock annually in individual lakes is therefore an important policy consideration for fisheries managers in British Columbia. Excessively high or low stocking rates can result in unacceptably low catch rates for recreational anglers. Managers seeking to maximize social benefits derived from recreational fisheries thus need a way to choose among alternative stocking programs.

Stocking rates are currently set using a stocking formula that relates optimal stocking densities to lake productivity and lake size. Recently, a computer simulation model of rainbow trout population dynamics and recreational fishery processes has been developed that allows the effects of different management strategies to be simulated. The objective of my research is to use this simulation model to develop a quantitative decision-theoretic approach to setting rainbow trout stocking rates in British Columbia.
Two lakes in the interior of B.C. are used to illustrate the application of these methods.

This approach simulates the effects of different stocking rates on catch statistics given uncertainties in density-dependent growth and in size-dependent vulnerability relationships. The simulation results are then incorporated into a decision-theory framework to provide a relative ranking of different stocking rates. Rankings are assigned based on the relative ability of alternative stocking rates to optimize selected performance criteria such as CPUE and fish length. Preliminary runs of the model suggest that increases in CPUE cannot be achieved through higher stocking rates without decreasing the body size of caught fish. Resolution of this trade-off will depend on the values and objectives of fishery managers.

The decision-theory framework can also be used to quantify the value of additional research into biological and vulnerability relationships. Reducing uncertainties in these processes can lead to better-informed management decisions. Improvements in angling success that result from managing with better information thus represent the benefits of collecting additional information. These benefits will be used to evaluate alternative stocking and research programs.

## *Exploring liability in the context of pollution and the fishery*

**Richard M. Porter,**
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Liabilities represent claims against persons, corporations and things. Liability affixes responsibility and establishes `probable' prices for economic externalities. Institutional arrangements will determine the amount of externality, technical conditions will affect its existence. The assignment of liability expands the rights of others, and renders externalities pecuniary.

Torts are private wrongs, resulting from the injurious trespass of the property or rights of others. Tort is an ex post legal solution to an a priori economic problem; however, the threat of tort is sufficient to begin pricing or internalizing externalities. Were property rights well specified, liability would be equally well specified and all externalities internalized at their established prices. Wherever goods and services remain held in common, property rights, and hence liability, remain ambiguous; the unpriced externalities will bring users into conflict.

The legal history of pesticide pollution cases, clearly establishes liability for the damages to personal and private property by pollutants as the responsibility of the polluter. The tort system operates well, when private interests are damaged by nuisance. However, where pollution results in public nuisance, as in the pollution of bodies of water, so long as no private rights are adversely affected, the responsibility to prosecute the polluter remains with the Crown. The ambiguous status of rights in the fishery, implies a duty on the part of the Crown enforce any liability for pollution that deteriorates the productive capacity of the fishery.

The objective of fishery management is to manage access, not just to fish, but to the ecosystem itself. Pollution of the fishery habitat is a form of access which remains unmanaged. Conservation policies which reserve production can be used to build biomass. Such policies emphasis the regulated taking of biomass, and generally involve the gradual enclosure of the fishery. Conservation policies which are restorative, emphasis investment in the productive capacity of the ecosystem □ they expand the intrinsic growth rate of stock, and the carrying capacity of the system. Expanding fishers rights so that they represent a private interest in the biomass and the environment, will provide incentives for voluntary investments in restoration, only so long as they are protected by liability.

## *A method for determining when to declare a surplus in the Nass River sockeye salmon fishery.*

**Christina Robb,**
REM, SFU.

Inseason salmon management provides a clear example of decision making under uncertainty. Managers of salmon fisheries attempt to achieve an optimal number of fish onto the spawning grounds and thus maximise returns to the fishery. Managers must make daily decisions that affect final escapement, despite incomplete knowledge of the number of fish still to return and the response of harvesters to both salmon abundance and management decisions. A further uncertainty is the stock-recruitment relationship and hence the impact on future abundance of either not reaching or exceeding the target escapement.

I developed a decision mechanism for declaring a surplus in the Nass River sockeye salmon fishery that explicitly accounts for uncertainty in stock-recruitment parameters and for interannual variability in run size, run timing and catches. A surplus occurs when fish in excess of the escapement target escape the commercial fishery. The declaration of a surplus in the Nass permits the opening of an in-river fishery using a fishwheel. The method employs Monte Carlo simulation within a Bayesian decision theory framework. I used Bayesian statistics to place probabilities on parameter combinations of the Shepherd stock-recruitment model. Escapement and commercial catch were simulated using an empirically based relationship between run size and the ability of managers to achieve escapement goals, thus avoiding complex in-season modelling of the commercial fishery. Run timing curves were selected at random from historical data. The catchability coefficient for the fishwheel varied with daily abundance of fish passing the wheel site.

I structured the management decision rule so that a surplus is declared once a set percentage of the escapement target has been measured at the fishwheel. I assessed the performance of possible rules against four management objectives: maintain stock health, maximise catches (both commercial and "surplus"), minimise the variability in catches and improve ability to achieve management goals. Expected values of appropriate indicators were determined for rules ranging from 40 to 100% of the target escapement. Results indicate that the optimal decision depends on the relative importance of the four objectives. The Bayesian decision framework provides an appropriate avenue to communicate the implications of the management decision for each of the four objectives.

My next step is to compare the performance of the decision rules developed using this approach to decisions made using three alternative approaches to uncertainty: a deterministic model, a model that accounts for interannual variability in components but not uncertainty about the stock-recruitment relationship and a model that uses conservative estimates of all parameters. This analysis should show the potential benefits of including uncertainties in a rigorous and quantitative manner.

# *Application strategies for biophysical models of salmon migration and production in the Northeast Pacific*

**James P. Scandol,**
Fisheries Centre, UBC.

Pacific salmon (*Oncorhynchus spp.*) have complex life cycles involving both freshwater and marine phases. The marine phase is characterised by extensive feeding in the North Pacific Ocean followed by precise homing to the natal stream. The mechanisms used by the salmon to realise these migrations are not completely understood, therefore the migration route and return times of the salmon stocks are difficult to predict. Furthermore, the production of salmon (the product of salmon abundance and individual weight) is associated with biophysical oceanic conditions such as sea surface temperature and zooplankton abundance. Managers are very interested in estimates of both production and return migration route/timing.

Computer modelling techniques have the ability to easily and inexpensively explore a range of hypotheses regarding Pacific salmon migration and production. Our interdisciplinary project aims to draw together existing knowledge about salmon biology, zooplankton production and physical oceanography into a set of models that have important interpretations in salmon ecology with potential application to long and short term Pacific salmon management.

However the conclusion that published models "are applicable to management" is often a non sequitur. Management is a complex process involving historical, subjective and emotive factors. New ideas (especially those based upon computer or mathematical models) are often treated with appropriate skepticism, and many studies end up being best classified as "shelfware". We are exploring a range of strategies to facilitate model application. These include:

Scientific visualisation and gaming: The iterative loop of hypothesis formulation, hypothesis testing and then hypothesis reformulation lies at the very core of scientific investigation. However, within modelling studies, often the rate determining step is the speed at which useful information can be obtained from models (hypotheses). By constructing models which immediately display output information on computer screens, scientists have the opportunity to rapidly adjust their thinking about specific sets of ideas. In this sense the scientist "games" with the model, playing with input parameters, and getting a feel for the dynamics of the system. The same model/visualisation system might then be used to allow decision makers to gain an understanding of the system dynamics. Although the results from the model might never be used in a quantitative fashion, additional qualitative appreciation of a system is a desirable result for a modelling study and an example of model application.

Decision theoretic interpretations: Often decision processes are well established, and decisionmakers are shy of making large changes to their procedures. However results from modelling studies have the potential to improve the effectiveness of decision makers. What is required is a systematic method with which information from models can be "bled" into decision procedures so that the makers maintain a sense of control of the procedure. Bayesian methods provide one such mechanism. The application of uninformative prior probability distributions to estimates of unknown parameters should not alter the analysis than if it were performed using maximum likelihood methods. If results from (say simulation) models were be interpreted as informative prior probability distributions of specified parameters, these have the potential to change (often by reducing variance) estimates of unknown parameters using the same data. The degree of credibility that a decision maker attaches to a model can be reflected in how informative they choose to make the prior. Technical difficulties exist towards implementing such schemes, however such methods may provide another effective mechanism for applying the results of modelling studies.

# *Investigations into the Dynamics of the Pacific Razor Clam along the Washington Coast.*

**Warren Schlechte,**
CQS, UW.

Historical stock assessment data was combined with survival data collected over a three year period to assess the population dynamics of the Pacific Razor Clam. The analysis was completed in two steps: a) survival analysis, and b) recruitment analysis. The investigation began after 1983 when the Washington Department of Fisheries thought that the disease NIX might be reducing survival, and that future management should include this factor in their decision-making process.

Survival analysis of the adult population was undertaken using SURPH (Survival Under Proportional Hazards), a statistical package for analyzing survival under a proportional hazards assumption when the data are from either release-recapture or telemetry studies. The survival analysis indicated low adult survival (Probability of Yearly Survival = 0.10), especially during the summer months. The survival of adults decreased with increasing length. Survival analysis of the juveniles was undertaken using a simple regression relationship between juvenile and adult densities with data from the stock assessment. This analysis indicated that the survival of the juveniles was higher (Probability of Yearly Survival = 0.70) than that of adults. No temporal aspect of survival is possible in the juvenile stage because of the structure of the data. The decrease in adult survival during the summer months cannot be attributed to the influence of NIX.

Stock and recruitment were modelled using variations of the Ricker model, the Schaefer equation and a Stage-Structured Ricker Model. The temperature of the surrounding seawater was included as a predictor variable, with the thought that changes in seawater temperature might affect the stock-recruitment relationship. Similarly, the impact of the disease NIX was also investigated in the stock-recruitment relationship. Of the models that were investigated, many of them indicated that the inclusion of temperature would improve the statistical properties of the model. Qualitatively, for all of the models that included temperature except the Stage-Structured Ricker Model, the inclusion of temperature did little. For the Stage-Structured Ricker Model, the inclusion of temperature helped to explain the large recruitments in the early 1970's. All models indicated that a strong density-dependent relationship existed between the current density and future densities. The inclusion of NIX did not improve the fit of any of the models.

The decrease in 1983 that was observed in the population time series is adequately explained by the stock density and temperature variables. This implies that the decrease in the population in 1983 was caused by poor environmental conditions and high adult stock densities on the beach.

## *Marine mammal-fishery interactions in the Gulf of Alaska.*

**Michiyo Shima,**
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School of Fisheries, UW.

In the Gulf of Alaska ecosystem, Steller sea lion (*Eumetopias jubatus*) populations have declined dramatically in the past 2-3 decades. Due to the large-scale nature of the decline, hypotheses to explain the reduced rates of juvenile and/or adult female survival have focused on factors that potentially have widespread effects, such as disease and changes in prey resources. This study examines how Steller sea lion prey resources have changed over time and how that change may have (or is) affecting the sea lions.

In the GOA, walleye pollock (*Theragra chalcogramma*) have been the most important prey species in both number and volume since the 1970's. Our study explores how the declines may not be related to changes in abundance of pollock alone but may also be affected by changes in the availability of the prey resource. Two modeling approaches were taken to examine the timing and possible mechanisms responsible for changes in availability of pollock to juvenile sea lions that would result in the observed decline in Steller sea lions.

The first approach consisted of a simple life table model constructed to explore the timing of changes in juvenile mortality necessary to reproduce the observed decline in the sea lion population, and to project future population trends. We modeled Steller sea lion population numbers over time starting with the initial age composition in 1975 (which assumes a stable age distribution, York 1994). Successive generations of sea lions were produced based on the fecundity and mortality values (calculated from survival) taken from York (1994) with slight alterations. Sea lion numbers were fit to observed values by adjusting natural mortality of juvenile sea lions (ages 1-3) only. The adjustment was determined by minimizing the square of the difference between the observed and the expected total number of sea lions. The fecundity schedule was assumed to be constant throughout all years.

The second modeling approach explored the dependence of Steller sea lion population fluctuations on pollock numbers. The model converted the number of pollock observed into the number available to juvenile sea lions. The theoretical number of juveniles supported by the biomass of pollock was then calculated using average annual kilocalorie requirements of juvenile sea lions (Castellini 1993). The ratio of the theoretical number supported over the observed number of sea lions was used to adjust survival of the simulated juvenile sea lion population to the next generation. If this ratio was greater than one, the simulated juvenile sea lions advanced to the next age class experiencing only baseline natural mortality. That is, we assumed that if the number of juveniles theoretically supported by the available pollock was greater than the observed numbers then there were enough pollock to support juvenile sea lions. If the ratio was less than one, the juvenile survival rate was reduced by multiplying by the ratio. All adult age-classes advanced to the next year, affected only by baseline natural mortality.

The models suggest possible hypotheses about the timing and magnitude of events that would have caused changes in pollock abundance and /or distribution. Our results suggest that the observed Steller sea lion population decline could be explained by a) increased mortality of juvenile sea lions alone, due to changes in the availability of pollock to juveniles linked to shifts in the environmental conditions occurring in the late 1970's or b) the combined increased mortalities of juvenile and adult female sea lions since the mid-1980's.

# *Effects of nutrient additions to Kootenay Lake, BC on zooplankton and kokanee salmon (Oncorhynchus nerka) biomass and productivity.*

**Lisa C. Thompson,**
Fisheries Centre, UBC.

Nutrient additions to Kootenay Lake began in April 1992 in an effort to halt the decline in abundance of kokanee salmon. Kokanee are an important sport fish, and the primary food of adult Gerrard rainbow trout (*Oncorhynchus mykiss*), which often attain trophy size. Natural phosphorus loading to the lake is one-third of historical levels, following the construction of the Libby and Duncan dams, and the closure of a fertilizer plant upstream at Kimberley. Fertilizer is being added at the north end of the lake to promote a gradient of phosphorus and nitrogen concentrations, and of algal concentrations, along which the responses of zooplankton, mysid shrimp (*Mysis relicta*) and kokanee are studied. The main uncertainties to be tested are whether zooplankton will respond positively to the anticipated increases in grazeable algal abundance, and whether kokanee will respond positively to increased zooplankton abundances. Since Mysis competes with kokanee for zooplankton, potential changes in the competition between kokanee and mysids for zooplankton at different trophy levels may also be important. The monitoring program includes collection of data on: macrozooplankton species composition, density, biomass and productivity; kokanee abundance, growth, diet and fecundity; and rainbow trout abundance, size, diet and fecundity. Data from 1992 and 1993 suggest that the proportion of cladoceran zooplankton has increased in the fertilized part of the lake (Fig.1). Kokanee escapement (Fig.2), and spawner size and fecundity also increased. Fertilization and monitoring will continue through 1995 to study the effect of nutrient enhancement on at least one kokanee cohort through its entire lifespan.

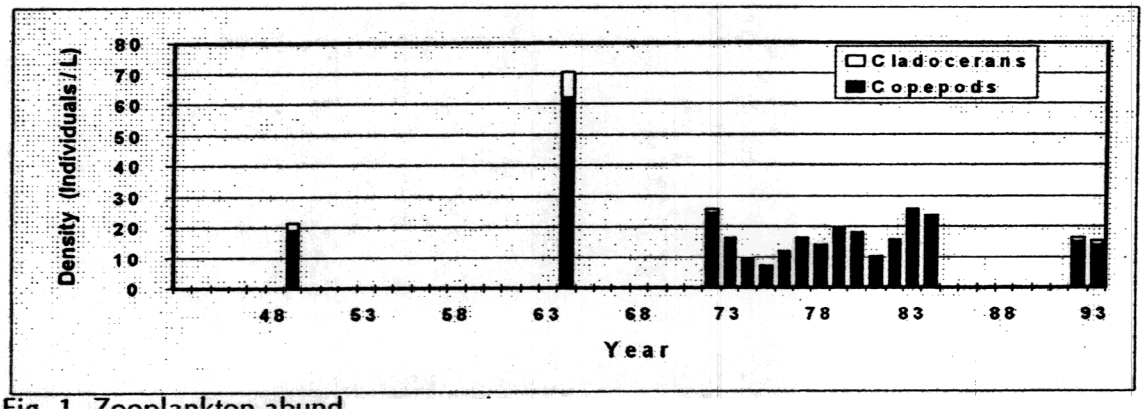


Fig. 1 Zooplankton abund

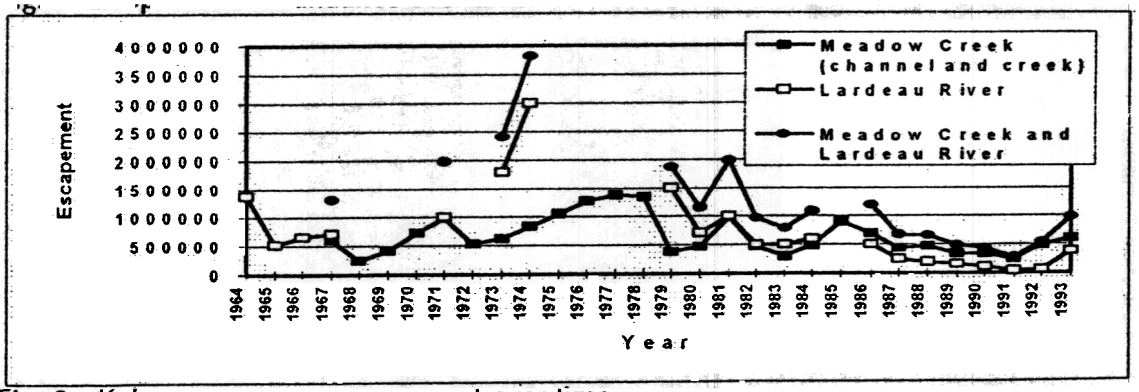


Fig. 2. Kokanee spawner escapement over time

# *Standardization of fishing effort and abundance trends of the major groundfish resources in the southern part of the East China Sea*

**Ted Tien-hsiang Tsai,**
CQS, UW.

Fishing effort data from commercial catch statistics for Taiwanese trawlers are standardized in two steps. The data are from the East China Sea from 1974-1987. In the first step, the fishing effort data are transformed from number of hauls into towing hours by an interpolation method. In the second step, the towing hour data are standardized with respect to the relative fishing power of the individual vessels. The relative fishing power of the vessels is estimated by a regression analysis that includes the two vessel classes: 100-150 and 151-250, gross registered tonnage and the two gear types: otter and pair trawls.

Using the standardized effort, catch per standard unit of effort (CPUE) is used as an index of abundance for the five major species, or associated species assemblages. The species are: sea eel (*Muraexesox cinereus*), hair tail (*Trichiurus haumela*), white croaker (*Argyrosomas macrocephalus*) and the species assemblages are: squid (*Loligo spp.*) and cuttlefish (*Sepia spp.*) The results illustrate that CPUE derived from standardized effort is a more realistic representation of variation in abundance than CPUE derived from nominal effort (Figure 1.) The individual abundances of sea eel, hair tail, white croaker, and the pooled assemblage of all of the five species show similar trends of annual decline, except the cuttlefish which do not appear to be in decline.

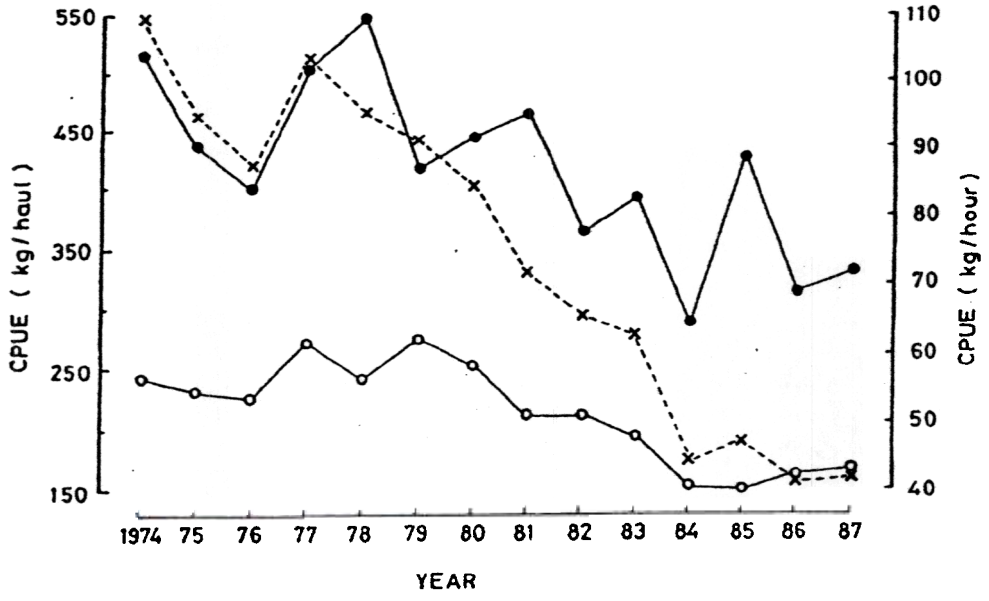


Fig. 1. Comparision among standardized CPUE (x in kg/hour) and unmodified ones (o for otter and • for pair in kg/haul) for pooled species caught by Taiwanese trawlers, which operated in the southern East China Sea.

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