THE IMPORTANCE OF EUPHAUSIIDS TO A BRITISH COLUMBIAN COASTAL MARINE ECOSYSTEM

R. W. Tanasichuk, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B. C.

The Department of Fisheries and Oceans began an intensive study of the La Perouse Bank area, off the lower west coast of Vancouver Island, in 1985. The aim was to understand how interannual variations in ocean climate influence commercially important fish species using the area. The impetus for the work was the detrimental effect that the 1982-83 ENSO (El Nino Southern Oscillation) event had on the lower west coast Vancouver Island herring stock. The benefit of the study would be managing fish stocks in the context of the biological consequences of changes in the ocean.

The La Perouse Bank area is extremely productive. Fig. 1 shows fish yield for the La Perouse area and for major fishing zones in the northern hemisphere. It is second only to Georges Bank in yield per unit area. The Bank area is relatively small, about 10,000 km^2, and therefore has a considerably smaller absolute catch. Most of the commercially exploited biomass is pelagic. The most important species are Pacific hake (*Merluccius productus*) and Pacific herring (*Clupea pallasi*). There were important fisheries for pilchard (*Sardinops sagax*) during the 1930's and 40's and for dogfish (*Squalus acanthias*).

The La Perouse Project has three components. Physical oceanographic studies examine seasonal and interannual variations in ocean circulation. The data come from many STD casts made at pre-defined sampling sites and from moorings. Biological oceanographic studies monitor changes in zooplankton community composition and productivity. Vertical net tows are made at some of the STD locations. The aim of the fisheries oceanographic component is to understand the trophic interactions of the various fish species and how they can be affected by climate change. Fish are collected during research cruises every August. Data collected include distribution and abundance, growth and feeding.

Results of the fisheries oceanographic work show that Pacific hake is by far the dominant pelagic fish species. Mean annual biomasses are 198,000, 40,000 and 70,000 tonnes for hake, herring and dogfish respectively. Hake use the La Perouse area for summer feeding. They spawn off Baja California and then migrate northward to feed off the west coast of Vancouver Island between June and October. The biomass of hake in Canadian waters is a positive function of sea temperature. Ware and McFarlane (1995) reported that a 1° C increase in sea temperature results in a 174,000 tonne increase in hake biomass. Therefore, sea temperature variations influence hake prey strongly by affecting hake biomass.

Fish diet analyses (Table 1) show that euphausiids are the most important prey item for pelagic fish in the La Perouse Bank area. Euphausiids account for 88, 100 and 56 % of the ration for hake, herring and dogfish respectively. Hake appear so dedicated to euphausiids as food that euphausiids distributions determine those for hake. Plots of commercial tow locations show that the main concentrations of hake are near shore early in the summer and move progressively offshore (Tanasichuk et al. 1991). This is presumably because hake graze down euphausiids over time. Ware and McFarlane (1995) present a figure (Fig. 6) showing the overlap of hake and euphausiids distributions

in summer

The obvious importance of euphausiids to fish productivity in the La Perouse ecosystem led me to begin a detailed investigation of the influence of interannual variation in sea temperature on the biology and productivity of euphausiids (Tanasichuk, this volume). I began by collecting hake stomachs during the 1989 and 1990 commercial fisheries to see if hake preferred one euphausiid species. Euphausiids were identified to species and measured. Hake fed exclusively on *Thysanoessa spinifera*, the more near shore species, early in the summer when the daily ration was highest (Fig. 2). In August, when fish began moving offshore, *Euphausia pacifica* became more important. Therefore, *T. spinifera* is much more important as prey because it is the only euphausiid taken when feeding is most intense. Length frequency histograms of euphausiids show that hake fed on adults exclusively until late October when young-of-the-year entered the diet.

The preliminary results of my euphausiid work in Barkley Sound show that abundance and productivity changed markedly during and after the 1992-93 ENSO's. Presumably this is due mainly to a large increase in predator biomass during the events. The warmer water resulted in a large influx of hake as well as mackerel (*Scomber japonicus*, *Trachurus symmetricus*) and pilchard to the lower west coast of Vancouver Island. Changes in euphausiids in Barkley Sound may reflect those offshore because Summers (1993) suggested that they are part of the lower west coast Vancouver Island population.

There appears to have been a major impact on herring at least. We have had difficulty finding significant concentrations of herring on the bank areas over the last several years. This suggests that herring vacated them in search of food. Movement of herring off the banks probably increases the risk of them being eaten by hake and Ware (1991) found an inverse relationship between hake and herring biomasses. The 1992 and 1993 year-classes were weak and the biomass of herring is at a low level.

References:

Summers, P. L. 1993. Life history, growth and aging in *Thysanoessa spinifera*. M. Sc. thesis. University of Victoria, Victoria, B. C. 210p.

Tanasichuk, R. W. , D. M. Ware, W. Shaw and G. A. McFarlane. 1991. Variations in diet, daily ration and feeding periodicity of Pacific hake (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) off the lower west coast of Vancouver Island. Can. J. Fish. Aquat. Sci. 48:2118-2128.

Ware, D. M. 1991. Climate, predators and prey: Behaviour of a linked oscillating system. p. 279-291. *In:* T. Kawasaki et al. (eds.) Long-term variability of pelagic fish populations and their environment. Pergammon Press. Tokyo. 402p.

Ware, D. M. and G. A. McFarlane. 1995. Climate-induced changes in Pacific hake (*Merluccius productus*) abundance and pelagic community interactions in the Vancouver Island upwelling system. p. 509-521. *In*: R. J. Beamish (ed.) Climate change and northern fish populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

Table 1 Estimated summer rations (tonnes) of dominant predators around La Perouse Bank.

		Prey	
Predator	Euphausiids	Herring	Hake
Hake	183,000	17,000	0
Herring	65,000	0	0
Dogfish	20,000	7,000	7,000
Total	268,000	24,000	7,000

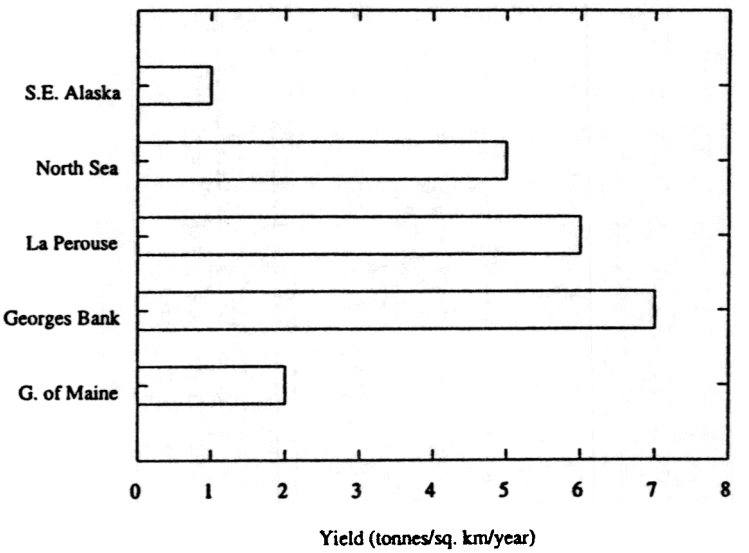

Figure . Average fisheries yield from major fishing grounds in the Northern Hemisphere.

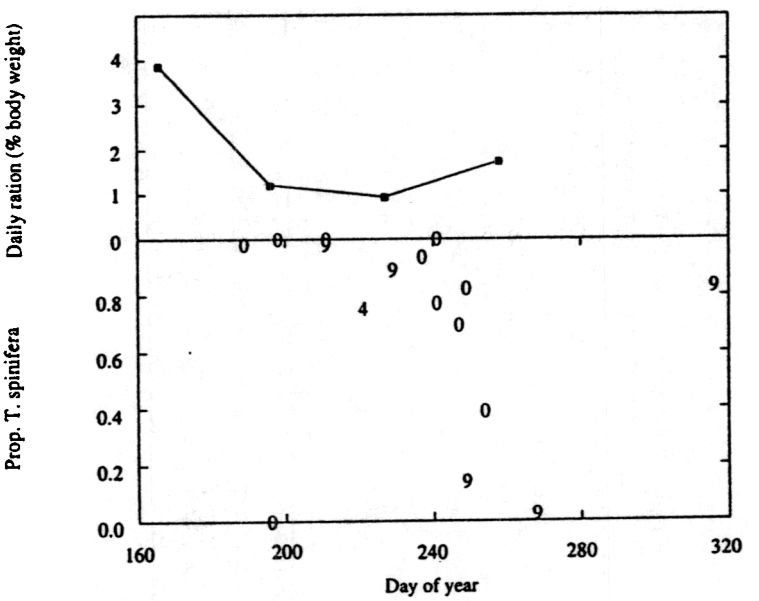

Figure 2. Seasonal variation in hake daily ration and proportion of hake euphausiid ration accounted for by T. spinifera. 9-1989. 0-1990. 4-1994.

THE INFLUENCE OF INTER-ANNUAL VARIATIONS IN SEA TEMPERATURE ON THE POPULATION BIOLOGY AND PRODUCTIVITY OF EUPHAUSIIDS IN BARKLEY SOUND, CANADA

R. W. Tanasichuk, Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B. C.

Euphausiids are the main link between lower trophic levels and fish in many marine ecosystems. Numerous studies are examining the effect of interannual variations in ocean climate on fish populations. However, there has been little work on the influence of variations in the ocean on the biology and production of euphausiids. My work on euphausiids in Barkley Sound stems from how important euphausiids are to energy flow through the La Perouse ecosystem. It is important to understand how variations in ocean climate affect the ecosystem's key fish prey item. The goal of the work is to describe the influences of sea temperature variations on the growth, reproduction, mortality, surplus energy and ultimately production characteristics of *Thysanoessa spinifera* and *Euphausia pacifica*. I hoped for a significant warming or cooling during the study which began in 1991. There were El Nino Southern Oscillation (ENSO) events in 1992 and 1993. Annual sea surface temperature anomalies since suggest that the ocean cooled in 1994 and was as warm in 1995 as it was in 1993. Monthly anomalies show that, for both years, anomalously cool winters were followed by unusually warm summers. This would mean that summer sea temperatures were warmer than the annual anomalies would suggest. I present preliminary results of the euphausiid study here.

I have been sampling euphausiids in Barkley Sound since March 1991. I chose Barkley Sound because it can be sampled conveniently using a small boat virtually all through the year, and it is next to the La Perouse area. Summers (1993) provides reasons for accepting that euphausiid samples in the Sound describe euphausiids in the La Perouse Project study area. I collected animals during 36 cruises so far. There are 4 sampling stations which collectively reflect the bathymetric and circulation characteristics of the Sound. Cruises were made nine times annually between March 1991 and 1994 to define accurately the seasonal growth, reproduction and mortality patterns. Since then, I collected samples five times a year to monitor interannual variations. The work will continue until at least March 1997.

I collected samples at night using obliquely towed bongo nets which traveled to within 10 meters of the bottom. Animals from one cod-end were examined fresh. Individuals were identified to species, measured, weighed, sexed and identified to maturity stage (immature - no secondary sexual characteristics; males - petasma and with or without spermatophores; females - thelycum and unfertilized, fertilized, gravid). These animals were then preserved for surplus energy analyses when the hepatopancreas and gonad were weighed. The entire sample from the other cod-end was preserved. This sample was size-fractionated using sieves to separate adults and sub-adults. All adult-sized animals (>10 mm total length) were identified to species, counted and measured. Individuals from sub-samples were weighed, sexed and their maturity described (immature - no secondary sexual characters; male - petasma and with or without spermatophores; female - thelycum and unfertilized or fertilized). Samples of sub-adults were split using a Folsom splitter. Eggs and nauplii were counted and measured. Calyptopis and furcillia larva were identified to species, stage, counted

and measured. I used MULTIFAN (Multiple Length Frequency ANalyser, Otter Research Ltd., Nanaimo, B. C.) to segregate adult length frequency distributions. These distributions were assigned to cohorts based on the assumptions that the number of animals within a cohort decreases exponentially with time and there is no increase in length over winter. (My success in developing cohort-specific growth and mortality trends suggests two possibilities. First, Barkley Sound euphausiids are discrete populations. Second, they are, as Summers (1993) suggested, part of the lower west coast Vancouver Island populations and therefore in- and out- migration have little effect on the biological characteristics of the animals collected in Barkley Sound.) Larvae were assigned to cohorts using stage durations Summers (1993) reported for T. *spinifera* and Ross (1981) described for *E. pacifica*. By knowing the stage and the time required to develop to it, I could: 1) back-calculate to spawning time and 2) decide how sampling time coincided with spawning time. Larval and adult cohort assignments were linked using the growth and mortality assumptions.

I described abundance as number of animals per square meter. The volume of water filtered was measured with a flowmeter. Number of adults was estimated as (no. animals in each cohort/m^3 filtered) x 2 x wire out because euphausiids were collected during the descent and ascent of the net. I multiplied the number of larvae by 1/Folsom split size to estimate number in each sample. Numbers of adults and larvae were summed over cohorts for each sampling event. Abundances can be converted to per m^3 considering an average of 110 m of wire out over time and between sampling stations.

Adult and larval production was estimated as the sum of daily biomass changes between sampling events for each cohort. Production was considered to be larval if the initial length was less than 10 mm. I assumed that changes in weight occurred exponentially over time. Daily production of animals that survived between sampling periods was added to that for animals which would not survive to the next sampling but had not died yet. I estimated "animals yet to die" using the cohort-specific natural mortality function. The number of animals yet to die= N_t-N_o - (sum of daily mortalities based on the derivative of the mortality function). Production of adults and larvae were summed over cohorts. Daily production (mg wet weight x m^{-2} x day^{-1}) was estimated by dividing the sum of the biomass change by the number of days between sampling periods.

Abundance and daily production estimates for *T. spinifera* are plotted in Figs.1 and 2 respectively, and mean annual biomass and total annual production estimates are presented in Table 1. Adult abundance dropped in early 1992 but increased substantially later because of the appearance of a strong cohort. It then dropped and has been low since mid-1993. Larval abundance in 1993 and 1994 was negligible and the high larval abundance early in 1995, which was not produced by a high adult abundance, has not generated many adults. *T. spinifera* sub-adult abundance has remained very low since 1992. The peak in *T. spinifera* sub-adult abundance in 1995 generated no production because mortality was so high. Adult daily production rates have been low since 1993. In general, mean annual biomass and annual production dropped steadily from the peak observed in 1991 for adults and 1992 for larvae. Adult P:B ratios have remained fairly constant in contrast with those for larvae.

Abundance and production trends for *E. pacifica* are different. It produced relatively strong cohorts in 1992 and 1993. This

species became dominant but abundance has declined to or below pre-ENSO levels. Larval production by the strong cohorts in 1992 and 1993 was high. There has been no larval production since. The peak in sub-adult production in 1993 was not followed by one for adults. *E. pacifica* adult productivity has been low since mid-1994. Mean annual biomass increased in 1991 and fell in 1994. Larval P:B ratios are similar to those for *T. spinifera*. P:B ratios for adults were considerable more variable for *E. pacifica* and in general were lower.

To conclude, euphausiid abundance and productivity in Barkley Sound changed dramatically during and after the 1992 and 1993 ENSO events. I suggest that this began as a consequence of an increase Pacific hake (*Merluccius productus*) predation and the appearance of mackerel (*Scomber japonicus*, *Trachurus symmetricus*) which feed intensively on euphausiids (B. Hargreaves, DFO, Nanaimo, B. C. pers.comm.). Based on the data in Table 1, larval biomass and production in 1994 were 88 and 82% respectively lower than in 1991; for adults, biomass and production were 64 and 56% lower respectively. Preliminary results for the March 1995 - February 1996 sampling year suggest that euphausiid abundance and productivity will be at least as low. I am just beginning the detailed examination of euphausiid population biology which is designed to explain the variations in euphausiid production. Changes in euphausiid abundance and productivity that I described would likely have importance consequences for the fish resources of the lower west coast of Vancouver Island.

References:

Ross, R. M. 1981. Laboratory culture and development of *Euphausia pacifica*. Limno. Ocean. 26:235-246.

Summers, P. L. 1993. Life history, growth and aging in *Thysanoessa spinifera*. M. Sc. thesis. University of Victoria, Victoria, B. C. 210p.

Table 1. Mean biomass (mg wet weight x m^{-2}), total production (mg wet weight x m^{-2} x $year^{-1}$) and P:B ratios for *T. spinifera* and *E. pacifica*. Values are calculated for March-February.

	Larval			Adult			Weighted
Year	Biomass	Production	P:B	Biomass	Production	P:B	P:B
				T. spinifera			
91-92	952	22506	24	13985	14638	1.04	2.48
92-93	1162	66014	57	6083	11505	1.89	10.69
93-94	670	8898	13	2639	3759	1.41	3.82
94-95	101	1307	13	2649	3572	1.35	1.77
				E. pacifica			
91-92	342	8178	24	7202	3297	0.46	1.52
92-93	1137	48215	42	11118	21561	1.94	5.69
93-94	837	62359	75	19416	-406	-0.02	3.06
94-95	131	2378	18	6685	2868	0.43	0.77

DISCUSSION PAPER

Three Components Leading to an Assessment of the Potential Yield of British Columbia Krill Stocks: A Fishery Manager's Point of View (an ad hoc workshop session).

Jim Morrison, Department of Fisheries and Oceans.

The second day of the workshop concluded with a discussion of information needs, ecological impacts, and industry/ economic factors pertaining to the potential increased yield of British Columbia (B.C.) and the Gulf of St. Lawrence Canadian krill stocks (preceding section).

Approaching this matter from the admittedly different point of view of a fishery manager working from within a government mandated framework, the three components for discussion were identified to be fundamental questions, implementation process and the economics of the process (not the fishery) leading to quota re-evaluation.

A. Fundamental Questions·

These are not questions that are biologically fundamental, but instead are fundamental to the process of establishing surveys which industry has proposed in this workshop as a mean to acquire greater harvest opportunities.

1. Described as the first and last question of this series, as a result of the workshop sessions over the last 2 days, does industry still want to pursue the process of requesting quota increases based on surveys. Another workshop participant has identified political opportunities to seek quota increases. It was noted that a response to this question may depend on the subsequent questions identified in this session which would indicate the possible complexity of the process.

2. What is the minimum information required to convince fishery managers to reconsider the present quota limits? In B.C. this was suggested to be information which would clearly establish or strongly suggest that the increased harvest of krill is not a threat to salmon and herring stocks which are the most important harvestable stocks in B.C. waters.

3. Do we need to use a model to establish this lack of threat, and if so, which model? The 3 models which had been discussed in the course of the workshop were A.) the CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) model used in Antarctica, B.) the Ecopath II model which has been described by Drs. Daniel Pauly and Astrid Jarre-Teichmann in this workshop, and C.) an euphausiid predator model previously used by DFO (Department of Fisheries and Oceans) to set the original B.C. coastal krill quota (which has not been reviewed in this workshop).

The suggestion was made that if the goal was to maximize the potential success of the application for increased harvest quotas, then both the CCAMLR and Ecopath model would be used as they address different issues and achieve different ends. The CCAMLR model is built on a conservationist ethic derived from Article 2 of the Antarctic convention, is based on the largest krill harvest in the world at this time and has international qualities that will be attractive to DFO policy and decision managers. The Ecopath model is built on a description of food web relationships that may be more readily understood by DFO managers, refers directly to the interaction of herring, salmon and euphausiids, and has a foundation in the U.B.C. (University of British Columbia) Fisheries Centre which has a respected reputation among fishery managers. The benefits are that the two models address different questions which the

fishery managers will ask.

What are the fundamental questions that pertain to the CCAMLR model?

- Given the 10 to 18 fold variation in stock biomass estimates for Jervis Inlet, which estimate should be used; the lowest estimate from any survey, the mean estimate, or some lower confidence interval of the mean which would protect against the risk of high variability in the stock estimate?

- When should the biomass be surveyed; at expected peak abundance, or at the expected period of minimum abundance, or just after the juvenile salmon and herring have had their share of the harvest?

- Should the stock estimate be undertaken before or simultaneously with some conservative harvesting? This will significantly affect how industry proposes to undertake the collection of biomass survey information.

- Assuming a pattern of extending biomass surveys into other coastal areas, should the first extension of surveys be into other parts of the Gulf of Georgia where there is a perceived high risk to salmon and herring stocks, or should it be to central and north coast areas where the perception of risk is likely to be much reduced?

- With reference to the "ERIC" effect (possible longer life span), how does the lifespan of the animal affect the CCAMLR model?

Within the context of biomass surveys:

- To what extent is standardization of (hydroacoustic) gear required for biomass estimates, in that the current proposal is for many fishers' boats to be participating in these surveys?

- What is the appropriate size of the sampling gear, tow speed and search pattern?

- Are sample net results required or can we get by with hydroacoustic estimates only?

- If it is primarily hydroacoustic estimates, how critical is determination of the ratio of signal strength to biomass estimate? How often does this have to be determined?

- If it is primarily hydroacoustic estimates, do we have to standardize that equipment and if so, should it be single, dual or split beam?

- Some confirmatory published information will be required to demonstrate that hydroacoustics can differentiate between krill and other potential targets. If this is not available, then confirmatory net tow sampling will be essential throughout any survey. This is in reference to the two occasions in Jervis Inlet when biomass estimates were derived from hydroacoustic data, but no euphausiids were recovered in the sample nets.

- Do biomass surveys have to be concurrent or within some limited time frame to ensure that they are comparable from one coastal area to another?

- Is it necessary to consider or assess FLUX (immigration and emigration characteristics)?

- How do you logically/rationally define a critical level of biomass for the CCAMLR model?

- With reference to the CCAMLR model, T. Pitcher identified a possible model weakness when the P/B ratio is 4 or greater signifying a high growth rate. Is that in fact a model weakness? If so, what are the growth rate characteristics of our euphausiid species and populations in B.C.? How does this

potential model weakness affect the seasonality of sampling?

With respect to the Ecopath model:

There will be an Ecopath model for the St. of Georgia. It is important that particular attention be paid to the links between euphausiids, herring and salmon, at both juvenile and adult stages. Also, critical attention should be paid to euphausiid prey items. For example, harvest of euphausiids may release other prey items which would serve as alternate food items for herring and salmon.

We will want to refer to the Ecopath model to assess the impacts of the 10% krill biomass harvest that has variously been referred to and proposed for B.C. stocks at this workshop. If the model indicates that the harvest will have no significant effect on herring and salmon, that will be strong supporting evidence for quota increases. That may be because herring and salmon feed on other organisms. Someone will have to review the literature for available information on salmon and herring diets in the Gulf of Georgia.

There was a reference to a phytoplankton - copepod - euphausiid pathway in one of the earlier presentations. If the Ecopath model suggests that euphausiid removal will result in an increase in other salmon and herring prey items such as copepods, that would be strong supporting evidence.

- If industry wants to look outside of the Gulf of Georgia for quota increases, then how transferable is this modelling to other coastal areas?

Other (predator) models:

The existing quota was based on a calculated 1 - 3% of the estimated predator consumption of euphausiids. Presumably, if this type of calculation was accepted to establish quotas in the past for one part of the coast, it could be revisited and applied to other coastal areas.

Other Fundamental Questions:

- How often do biomass surveys have to be revisited?
- Are on-board monitors or observers required for these surveys?
- What is the minimum data requirement to allow for a successful proposal for expansion of the harvest? Can we get by on biomass estimates or do we need to incorporate some measure of productions?

- C. Moreno has referred to the bycatch issue. In B.C. there is a public segment that is opposed to all trawl fisheries. Shrimp trawl fishing in Indian Arm has recently been shut down largely because of that pressure coupled with poor reporting from industry. It is not sufficient to state that bycatch is not an issue without a study to document that that is true.

B. Process

S. Romaine's and D. Mackas' Jervis Inlet work should be submitted through the PSARC (Pacific Stock Assessment Review Committee) process for review. If accepted, the review would substantiate the hydroacoustic method as a scientifically valid means of generating euphausiid stock biomass estimates.

It may also be important to get R. Tanasichuk's work on Barkley Sound euphausiids submitted for PSARC review.

DFO managers may ask that any proposed survey and survey protocol be submitted to PSARC for review and approval. There is good reason to do that. If approved through the PSARC process, it validates the surveys, providing approval in principal for the

generation of biomass estimates for other coastal areas.

In terms of the time frame, the next PSARC meeting is in March 1996. The one following is in late August or early September. From that September meeting, any reviewed survey method or protocol would go to RMEC (Regional Management Executive Committee) for review and approval. That review sets the framework for development of the 1997 management plan.

At the same time the Pacific Region policy on new and developing fisheries is being written. It will provide a reference against which any proposed system of biomass survey can be measured. One goal will be to funnel the CCALMR experience into this policy, notably Article 2.

Finally, there is the possible implication of the federal/provincial memorandum of understanding on underutilized species and developing fisheries that was referred to on Tuesday, that may affect all of this process.

C. Economics

The landed value of the fishery in 1994 was $259,000. The high in 1990 was $415,000. Trying to subsidize the further development of the fishery within the confines of the current landed value will be difficult.

This is a period of federal government downsizing, manpower and budget limitations. Time is a limited resource directly linked to the economics of the proposal. Who will develop the proposed survey methodology for presentation to PSARC or DFO managers for review? Will Dr. Daniel Pauly for example be expected to contribute his time to develop the necessary modelling, or Dave Mackas, or Ron Tanasichuk? The sampling program costs are not limited to the vessel sampling. The costs will include time or contractor costs for data management, analysis, reporting and data quality control functions. Without speaking on behalf of my colleagues in Science who may be able to accommodate some measure of additional participation, it is the fishery managers' view that the onus is on industry to fully underwrite these costs.

So the first question of this session is also the last question. Does industry want to pursue this process?

Summary of workshop discussion (addressing issues raised by Jim Morrison)

Taja Lee, UBC Fisheries Centre, Rapporteur

Glenn Budden (Protein Plus & A.L.H. Enterprises) The answer to the first question is 'yes'. You will always find one interested fisher to do the survey. The problem I have is two-fold. First, this process you describe will take much time in negotiations. The second is the commitment for an increase in quota will come from DFO only after the surveys are done. It will be difficult to invest lots of time, money, and effort to survey unless there is some sort of commitment from DFO beforehand.

David Saxby (Specialty Marine Products) Industry has actually gone through this exercise. The Krill Trawlers Association met 2 years ago and debated over this process. We would get a sliding-scale dedicated quota and we went ahead with the Jervis Inlet survey on that basis. Many of the questions about the model are beyond us, however we have been working with Dave Mathus and Beamish, who has been keen on understanding the interaction between salmon and krill. So, the information gathered from a survey on inside waters goes beyond just trying to identify a quota for trawlers. Recently, we've been discussing with

Beamish on doing a survey based on whatever design that Dave Mathus thinks is appropriate. The input required for the models could be built into the survey/sampling design. We can easily sample 20 times a day. We were willing to do that on the basis of getting the product from two draw down fisheries. We will be presenting this with Beamish to the managers in a short while.

Completely aside from the Krill Trawler Association and the scientific permits that you have suggested, many in the industry feel there must be data collection and monitoring before and after the fishery. We are willing to do this. We understand that there is no commitment, if other people in the industry feel they need a commitment that's fine, but we feel we are on board already. Thus the questions are not new, they have been presented before.

Yvan Simard (DFO, P.Q.) suggested one approach for a cooperative hydroacoustic survey would be through the national acoustic program which has been initiated by DFO.(get more details from James)

fundamental questions pertaining to CCAMLR model

**The issues/questions on which biomass estimates to use, when to survey , and how to cope with large variance in biomass estimates were discussed.*

Denzil Miller (Sea Fisheries Institute, South Africa) Ideally you would survey at every possible opportunity, over the entire range of the species, and do surveys in a stratified manner. In less than ideal conditions you are limited to what you can do. So the question is how many biomass estimates do you want and over what range?

Inigo Everson (British Antarctic Survey, U.K.) Why were the surveys only done for the Jervis Inlet? The krill is much more wide-spread than just the Inlet, and there seems to be strong evidence for flux in and out of the Inlet which is responsible for the extreme variations in biomass.

Dave Mackas (Institute of Ocean Sciences, B.C.) We focussed our efforts to the Jervis Inlet because that is where the commercial fishery is presently operating. At the time of the surveys we knew neither the precision nor the repeatability within time series of succeeding surveys, nor the magnitude of seasonal variance between time periods.

Inigo Everson (British Antarctic Survey, U.K.) The point is are you interested in the long-term in just the Jervis Inlet or are you interested in the expanse of the resource in BC, but selecting areas in which one may develop models for?

Dave Mackas (Institute of Ocean Sciences, B.C.) To determine the reliability of the acoustic surveys we felt we had to focus on one area and hit it hard and hit it often. This meant we had to take a restricted area- that area being where the fishery is operating. The next step is to expand the spatial coverage and to focus our effort during the times of the year where we have the biggest questions, that is, the winter decline and the spring increase. How much (of the variance) is natural change in population change? How much is due to immigration or emmigration (fluxes)? How much is due to fishing? Note that we are also trying to find the relationship between euphausiid aggregations and ocean currents off the west coast of Vancouver Island.

Tony Pitcher (Fisheries Centre, UBC) It seems to me for many areas of the coast there is some biomass information. The question I have is how to combine those figures to get a biomass figure?

Inigo Everson (British Antarctic Survey, U.K.) That is related to the question when to survey: during the peak or during the

minimum or after the salmon have fed? You've got the information I suggest from Ron Tanasichuk's presentation which is telling you information on the growth patterns, and the production patterns going on within the Inlet. From that you can sort out what is going on throughout the year. To a certain extent you're a lot better off in Jervis Inlet than we are in the Antarctic.

David Agnew (CCAMLR,Australia): One of the things we are trying to establish is what the most suitable area for surveys in order to get the whole range of the population and Denzil has already talked about that. In terms of the timing if you are worried about how the model works: it allows you to input when you are surveying (whether in the summer or the winter). As a result from the computer simulations you will get a distribution of biomass that you would expect from a survey. What you assume is that your original, single biomass estimate or multiple biomass estimates in the field are represented by that distribution. You can adjust the model. If you would rather survey in the winter, then do a survey in the winter and adjust the way the model thinks it is surveying the population. There are problems with the model, but I think there are more fundamental questions of where you think the krill are during different parts of the year, and whether in the winter you think it is possible to survey the animals because you are missing the very small krill. These are biological questions; the modelling questions can be dealt with.

Dave Mackas (Institute of Ocean Sciences, B.C.) That is basically the approach we have been taking but basing it on observations rather than model outputs. Over a span of several years, we try to estimate an average seasonal cycle, and then look for deviations from that average seasonal cycle for the time period you happen to make those measurements. Then you can look at the deviation from the winter and summer norms They tend to covary.

David Agnew (CCAMLR, Australia): So, in fact you already do have some feeling for the expected distribution of biomass.

Tony Pitcher (Fisheries Centre, UBC) I get the impression from Jim Morrison's discussion presentation that the decision-makers (the managers) will get more confidence from more direct, concrete, local measurements of biomass rather than the outputs of a model. Yet from the discussions there is a realization that both 'real data' and 'models' have their problems. Regarding the CCAMLR approach do you still have any specific concerns?

Jim Morrison (DFO, Nanaimo) I can see how the CCAMLR model can generate the expected distributions, and the way to get around the issue of summer or winter variation. As for the surveys, I know that we are only going to end up with a single biomass estimate for various coastal areas. What I have concern about is how well the model deals with the possibility that the minimum biomass is much less because of fluxes than the estimate from a survey.

Tony Pitcher (Fisheries Centre, UBC) One way around that problem is to have an annual number for the minimum from a survey during the winter.

David Saxby (Specialty Marine Products) From my own point of view we should use the minimum. If it is 800 tonnes in Jervis Inlet then so be it. Be conservative until we have more confidence on the acceptable level of harvest. Furthermore, do accompanying tows to get more confidence in the acoustic work. In regards to area, we intentionally chose Jervis Inlet because there are no other fisheries there, and it is an area with a lot of data. The error to date is we did not look at

this migrating population (flux) closely enough. We are already having discussions to go back this month and measuring again during that low period. Regarding the information that Michael Macaulay gave about 6 mm animals not being detected: we can sample with double-bongo nets and get an estimate for that number. I think we should be conservative because we are paranoid about models and collapsing fisheries. We have very little confidence in models.

Inigo Everson (British Antarctic Survey, U.K.) About the Jervis Inlet point, how far would you be able to extend your surveys out into the sound?

David Saxby (Specialty Marine Products) Our program right now is to take the next step and do a Jervis Inlet-type survey for the whole of the inside waters.

Dave Mackas (Institute of Ocean Sciences, B.C.) What Dave is proposing is to get the extent of a closed population, not in the genetic sense, but in the sense of 'population dynamics'.

Inigo Everson (British Antarctic Survey, U.K.)If you are heading in that direction then you will probably answer many of the biomass and flux questions.

**discussion of question whether to target the Strait of Georgia, where there is a lot of data to address the problem of herring, salmon and hake consumption of euphausiids, or the north coast, where there is probably less potential for conflicts with other fisheries but for which there is less data to address those concerns.*

David Saxby (Specialty Marine Products) To begin, we think the Strait of Georgia should be surveyed. We don't anticipate a fishery in the Strait of Georgia, but we would like a look at it. Our feeling right now is when we go through the impact of the salmon, herring and euphausiid populations in the Strait of Georgia, we are going to find that the herring and the salmon are not as dependent on the euphausiids as everyone thinks. On the other hand, I think the hake population does depend on euphausids, which returns to Jim Morrison's point about taking down a predator species. I think we are going to see some management opportunities to take a good crack at the hake population. We believe that the inside waters should be surveyed for all of the reasons that Beamish wants and also that the mid-coast is going to be a very good place for an euphausiid harvest. It would be nice to see a simultaneous plan to survey areas of the mid-coast and Jim Morrison has already taken that request to management or is in the process of doing it for the Krill Trawlers Association. I think we should have a plan established so we can fit back into models and in the long-term that can be reinforced as Jim has requested.

Dave Mackas (Institute of Ocean Sciences, B.C.) As opposed to industry involvement, where it is in their best interest to put most of their effort to where they can get the most euphausiids for their costs of operating, for DFO science involvement, and I expect externally-funded university research, the largeness of the other fisheries interactions problem is an attractant not a deterrent. It is far easier for me to get authorization to work in the Strait of Georgia than it will be to work in the Northcoast, and I expect that to be true for getting funding for Daniel Pauly to work on his ECOPATH model and for someone to work on a northwest version of the CCAMLR model.

Jim Morrison (DFO) There is more political and management sensitivity to issues in the Strait of Georgia than for other parts of the coast. As well we have the entire Fraser river salmon run that passes through there twice a year (an out and in-migration).

Salmon of course is one of our 'golden cows'.

Glenn Budden (Protein Plus & A.L.H. Enterprises) Well, if the concerns of salmon and herring feeding on euphausiids is a political problem because there are a lot of people living on the beaches while we are trying to harvest the krill then that is what you should state.

Jim Morrison (DFO)The problem is we had significant declines in salmon stocks leaving from the Strait of Georgia this year. So they are getting extra attention. They always have and now even more than ever.

David Saxby (Specialty Marine Products) Because of that problem industry can get science funding to do surveys because it's a bigger problem than just a krill problem. So it can work together.

** The next issue discussed dealt with how does the life-span of the euphausiid affect the operation of the CCAMLR model (the "ERIC" effect)?*

Stephen Nicol (Biological Science Program, Australia) It's a question of what data you have. See if there are any doubts about the life-span. If there is any doubt be conservative, in which case: the quota will be lower but you will address some of the concerns. So it is a matter of going back to the data and seeing what it shows. If you find two interpretations for the growth and mortality rates, and recruitment data, then take the most conservative interpretation until proven different.

Daniel Pauly (Fisheries Centre, UBC) I'd like to mention that I have offered to look at Ron's length-frequency data using a different approach than he is currently using. In any case even if there are doubts about the exact value of the von Bertalanfy K, one can get an estimate of Z/K. (This means one has later a scaling factor, the P/B ratio, with which one can play with) The value of Z/K does not give one the specific value of K. But given that there is strong seasonality in the system, and given the range of lengths that Ron has covered, I tend to think it should be quite straight-forward to reliably estimate growth and mortality (P/B) parameters. I also think it's quite possible that the bulk of the animals go through a cycle of 1 or 2 years. This should be detectable.

Denzil Miller (Sea Fisheries Institute, South Africa) In terms of the CCAMLR model, length-at-age can be taken into account of, i.e. inputted into the model. The real issue is how will that impact the recruitment function of the model.

David Agnew (CCAMLR, Australia) Daniel Pauly was right about Z/K. I'm not sure if we were successful in building that in because we couldn't clearly determine what an appropriate figure was for superba due to holes in the data. As Denzil Miller said it is just a matter of reformulating the model, as I understand it. You cannot just transfer the model as is to BC. You need to revisit all the assumptions of the model and change it for the context of the fishery you want to apply it to.

Tony Pitcher (Fisheries Centre, UBC) As I understand the CCAMLR model, in the worst case, the uncertainty of the parameters can be built into the simulations.

Carl Walters (Fisheries Centre, UBC) In terms of planning...Fishery after fishery you have biologists agonizing how to apply the fishery response to a system prior to exploitation. Our track record at predicting recruitment responses has been zero. One approach is to propose taking a relatively small area, where its relatively safe to do so, and pound it down and hold it down, and look at the response to the animal after it is

exploited. Do it directly and in a relatively safe fashion. This would solve all the this modelling messing around with the recruitment and provide a direct demonstration of what the stock can take and what happens to the biology when under exploitation.

Tony Pitcher (Fisheries Centre, UBC) How does DFO respond to hammering the population in Jervis Inlet?

Dave Mackas (Institute of Ocean Sciences, B.C.) My concern about that approach is I suspect that in some years the environmental conditions hammer it a lot harder than whatever level DFO will permit the commercial fishery to do. So teasing out of fishery effects from good or bad year environmental effects would be difficult.

Carl Walters (Fisheries Centre, UBC) The way I looked at it was you are going to find out the hard way if the fishery develops anyway. So why not find out in a restricted area even if you have to deal with a lot of variation.

David Agnew (CCAMLR,Australia) Quite apart from the planning/policy aspect of that approach, there is a real question whether the fishery could in fact hammer it hard enough. If you are dependent on fishing swarms and concentrations, you will want to look at the ratio between the concentrations to dispersed krill, and what the economic viability of that is. The message we've had whenever we've raised this sort of issue is: 'it's not just environmental', 'it's not just management', but it's the fishery itself. The message we get is 'You can't expect us to keep on fishing when you are only getting three krill in the trawl.' Even when that in fact is what is expected. That's just a warning from our experience with this.

* *Discussion on the biomass survey questions:*

Do we need to standardize the gear and search patterns for the surveys?

David Saxby (Specialty Marine Products) Yes. I think it the survey should be reviewed. Set a standard, and everyone would conform to that. I'm not sure if we are taking about multiple vessel surveys even. At one point we were discussing that in the Association and having units that Michael Macaulay was referring to where it was not as expensive as master units that you calibrate against and whenever you have a vessel going some place you are going to be gathering information. We are willing to go along with standardization, but who is going to do the standardization? Someone is going to have to say this would be an acceptable standard, then we would be happy to conform to that.

Denzil Miller (Sea Fisheries Institute, South Africa) From our experience setting up the biomass project in the Antarctic, where there was a variety of ships from a variety of nations, two messages came out. The first is pessimistic. Despite the great deal of effort, the standardization did not come up to what was anticipated. Different treatments and nets were used, used in different ways and, the survey designs were changed. The second point that came out of the CCAMLR experience was in fact that, surprisingly, quite a lot could be done with the data afterwards. That's the positive message. Quite a lot can be done. You don't have to make every net comparable, and every single binding on the net comparable.

Michael Macauley (College of Ocean and Fisheries Sciences, U.W.) I agree. Standardization does not necessarily mean you have to have the same make or model. There are standardization techniques, such as calibration to standard spheres, that can be used. If one are using pre-existing sounders there will be a need for standardization.

However, we are not talking about 100's are even dozens of systems, we are talking about two or three systems in BC.

** discussion on types of hydroacoustic equipment that should be used*

Michael Macauley (College of Ocean and Fisheries Sciences, U.W.) Split or dual beams are for direct measures of target strength. The only way one can get direct measures of the size of euphausiids requires equipment that does not exist. You need a 2 MHz frequency range to get a reliable echo off the target.

Inigo Everson (British Antarctic Survey, U.K.) We addressed many of these technical questions which have been published. You will need to calibrate it to your systems in BC. If you follow the guidelines of the ICES Fisheries Acoustics Technical Working Group, which provides a close compliance to calibration methods and ensures the interrelationship between the equipment used on one vessel does relate to others. If this particular methodology is followed then I would be very confident in the acoustic results. In comment to single vs dual vs split beams; the more sophisticated the better. I would advocate using a multifrequency system provided that's available.

Denzil Miller mentioned survey design and problems associated with FIBEX. The bulk of the work done during the FIBEX survey did follow the survey design, and once the raw data was collected it worked quite well. The problem with FIBEX, with the use of nets, came about because of the number of different nations and research institutes involved each with their own particular sampling gear. One cannot tell a research institute to buy a 50K net just because FIBEX decides that's how the survey will be done. But if one recognizes the strengths and weaknesses of each type of gear there are techniques to calibrate them. In BC you are in much better shape because the options for nets in Nanaimo and Victoria are fewer so you should be able to work that out with much less difficulty.

Yvan Simard (DFO, P.Q.) commented on the National Acoustic Programme set up to help deal with the issue in Canada.

David Saxby (Specialty Marine Products) We already have sampling systems in place, working with DFO. To satisfy the management side, we would gladly retain some experts to review the system and report on changes that may be needed. We are trying to build confidence in the data to satisfy the management group.

Dave Mackas (Institute of Ocean Sciences, B.C.) It is quite straight forward to recalculate data compared to collecting the data.

Michael Macauley (College of Ocean and Fisheries Sciences, U.W.) commented on hydroacoustic and survey design standardization techniques.

Stephen Nicol (Biological Science Program, Australia) Details on standardizing survey design are available from a previous workshop for *Euphausia superba*. In terms of standardizing data collected, we've outlined a set of parameters to be recorded from an acoustic survey. The next question is what to do with all the data collected. The more complex and more data you have the more useful in the long run

Denzil Miller (Sea Fisheries Institute, South Africa) It is important to record how you recorded and derived the data, allowing one to breakdown data from different sources to their basic forms

Yoshinari Endo (Lab. for Biol. Ocean., Tohoku Univ., Japan) commented on ongoing survey programs in Japan. A

variety of nets have been used but the data is still in analyses phase. The hydroacoustics being used are the multifrequency type.

Dave Mackas (Institute of Ocean Sciences, B.C.) PSARC is very insistent on proper documentation so that is not a problem. The aspect that will be important is in survey design. Compared to Antarctica, BC has more complex coastline and bathymetry which will impose different rules on how patches behave and the spatial-structure of the population

Inigo Everson (British Antarctic Survey, U.K.) The advice from this group is-Yes, do standardize-and there is information available from a variety of sources

Dave Barrett (Murex Aqua Foods) advocated an adaptive management approach to answer many of the biological questions. Stressed that if industry is expected to pay for this research, DFO must ensure industry can harvest enough to generate money.

**comment on need for confirmatory net tow sampling*

Inigo Everson (British Antarctic Survey, U.K.) David Saxby already answered that with continuous net sampling-do as many net hauls as possible to cross-reference to your acoustic data. Acoustics is not a technique done in isolation.

**discussion of assessment of flux-the movement of krill from one area to another-will we able to get reliable data from an inlet if there is flux-an underlying pattern of movement of the stock?*

Inigo Everson (British Antarctic Survey, U.K.) If considering just the Jervis Inlet, you must monitor and quantify flux. It will depend on the spatial-scale one is dealing with. The Georgia Strait can be considered as a closed system.

**discussion over the trigger level of CAMMLR-the critical level of biomass for the CCAMLR model*

Denzil Miller (Sea Fisheries Institute, South Africa) There are two trigger levels: (1) trigger level set for experimental/exploratory fisheries reaching the scale of commercial fishery; (2) trigger level for spatial disaggregation of catch-to avoid concentration of fishery in one area once some level is reached for protection of land-based predators with limited foraging range. This trigger level has been based on historical catch level. I suspect the same for BC. This is a negotiated level unless there is some level of certainty on the biological limits

Tony Pitcher (Fisheries Centre, UBC) suggested for BC such a trigger level may be based on the impact level on herring, salmon, hake and other predators

Inigo Everson (British Antarctic Survey, U.K.) commented the various trigger levels will again depends on the scale of the fishery-coastwide vs a limited area

**ECOPATH Questions*
-what are the kinds of links between krill and salmon, hake and other predators?
-what supports the euphausiids and how does that influence the dynamics of the model?
-implications of harvest on the model?

Daniel Pauly (Fisheries Centre, UBC)-The Georgia Strait model was an exercise done mainly by students. If a model is to be applied properly we will need to hire a Masters student for a year to interact with experts and assimilate the available knowledge. The present model can then be used as a base starting point. Many of the questions asked can be answered. I suggest establishing a partnership with DFO/Nanaimo scientists interested in using

this approach.

Dave Mackas (Institute of Ocean Sciences, B.C.) commented on separation of numerical abundance and biomass in the model

David Saxby (Specialty Marine Products) suggested if interest is present then funding can be found

Other fundamental questions
** discussion over the need for observers question*

Inigo Everson (British Antarctic Survey, U.K.) For a survey it is not a question of observers but need for experts in field of acoustics and other scientists to monitor and review

David Saxby (Specialty Marine Products) A precedent has already been established with a DFO nomination of a person on vessel to accumulate data

Dave Mackas (Institute of Ocean Sciences, B.C.) With acoustic data, it is more a question of ensuring availability of data not misreporting since bad acoustic data is very easy to pick out

**discussion over the need production-based or biomass-based models*?

Dave Mackas (Institute of Ocean Sciences, B.C.) suggested a need for biomass-based models for the management screening process

**discussion over the by-catch issue*

Jeff Marliave (Vancouver Aquarium, BC) commented on frozen products with some myctophids

Dave Mackas (Institute of Ocean Sciences, B.C.) commented on some recent data now showing some by-catch of fish larvae from April-May catches.

Denzil Miller (Sea Fisheries Institute, South Africa) By-catch is an important issue and you need to establish a screening process. The philosophical basis in CAMMLR is by-catch is money out of fishers' pockets. Fishers need to show bycatch is not happening or minimized and scientists need to show how much (numerate) bycatch is happening

Inigo Everson (British Antarctic Survey, U.K.) If one knows the time of the season that larval fish is at a minimum in the plankton then one can minimize the amount of bycatch

David Saxby (Specialty Marine Products) A statutory closure of the fishery has been setup from June 1st to August 15th.

Carlos Moreno (Universidad Austral de Chile) The most important thing is to monitor levels of bycatch and take decisions, an adaptive management approach, as you go along. Information is the most important issue at this stage.

LIST OF PARTICIPANTS

David Agnew
Commission for the Conservation of
Antarctic Marine Living Resources
Hobart 7000
AUSTRALIA
Tel. (61-02) 310-556
Fax. (61-02) 232-714
e-mail: david_agn@antdiv.gov.au

Dave Barrett
Murex Aqua Foods
#207 - 20701 Highway 10
Langley, B.C. V3A 5E8
CANADA
Tel. (604) 530-7217
Fax. (604) 533-4053

Glenn Budden
Protein Plus & A.L.H. Enterprises
7820 156A St.
Surrey, B.C. V3S 8H6
CANADA
Tel. (604) 543-6373
Fax. (604) 543-6373

Yoshinari Endo
Laboratory of Biological Oceanography
Faculty of Agriculture,
Tohoku University, Sendai
JAPAN
Tel.
Fax. (81-22) 272-1870
e-mail: e21506@cctu.cc.tohoku.ac.jp

Inigo Everson
British Antarctic Survey
Madingley Road, Cambridge CB3 0ET
U. K.
Tel. (44-1223) 251-563
Fax. (44-1223) 362-616
e-mail: iev@pcmail.nerc-bas.ac.uk

Christian Gendron
PREVAL INC.
4300, boul. Bourque,
bureau 101, Rock Forest
Québec, J1N 2A6
Tel. (819) 564-4008
Fax. (819) 564-7638

Astrid Jarre-Teichmann
Institute for Marine Science
Dept. of Fisheries Biology
Düesternbrooker Weg 20,
24105 Kiel
GERMANY
Tel. (49-431) 597-3921
Fax. (49-431) 565- 876
e-mail: ajarre@ifm.uni-kiel.d400.de

Michael Macaulay
Applied Physics Laboratory
College of Ocean and Fisheries Sciences
University of Washington
Seattle, WA 98195
USA
Tel. (206) 543-7105
Fax. (206) 543-6785
e-mail: macaulay@anchor.apl.washington.edu

Dave Mackas
Institute of Ocean Sciences
PO Box 6000
Sidney, B.C V8L 4B2
CANADA
Tel. (604) 363-6442
Fax. (604) 363-6479
e-mail: MACKAS@ios.bc.ca

Jeff Marliave
Vancouver Aquarium
PO Box 3232
Vancouver, B.C. V6B 3X8
CANADA
Tel. (604) 631-2526
Fax. (604) 631-2529
e-mail: jmarliave@mindlink.bc.ca

Denzil Miller
Sea Fisheries Institute

Private Bag X2, Rogge Bay 8012
Cape Town
SOUTH AFRICA
Tel.
Fax. (27-021) 252-920
e-mail: DMILLER@sfri.sfir.ac.za

Carlos Moreno
Universidad Austral de Chile
Instituto de Ecologia y Evolucion
Casilla 567 - Valdivia
CHILE
Tel. (63) 221486 - 221344
Fax. (63) 221344 - 212953
e-mail: cmoreno@valdivia.uca.uach.cl

Jim Morrison
Department of Fisheries and Oceans
3225 Stephenson Pt. Rd.
Nanaimo, B.C. V9T 1K3
CANADA
Tel. (604) 756-7233
Fax. (604) 756-7162
e-mail: MORRISONJ%AM%SCDNAN
@MR.PBS.DFO.CA

Stephen Nicol
Biological Science Program
Australian Antarctic Division
Channel Highway, Kingston
Tasmania, 7050
AUSTRALIA
Tel. (61-02) 323-324
Fax. (61-02) 323-351
e-mail: stephe_nic@antdiv.gov.au

Daniel Pauly
Fisheries Centre
2204 Main Mall
Vancouver, B.C. V6T 1Z4
CANADA
Tel. (604) 822-1201
Fax. (604) 822-8934
e-mail: pauly@bcu.ubc.ca

Tony Pitcher
Fisheries Centre
2204 Main Mall
Vancouver, B.C. V6T 1Z4
CANADA
Tel. (604) 822-2731
Fax. (604) 822-8934
e-mail: tpitcher@fisheries.com

Luc Rainville
PREVAL INC.
4300, boul. Bourque,
bureau 101, Rock Forest
Québec, J1N 2A6
CANADA
Tel. (819) 564-4008
Fax. (819) 564-7638

Stephen Romaine
School of Earth and Ocean Sciences
University of Victoria
Victoria, B.C.
CANADA
Tel. (604) 363-6321
Fax.
e-mail: romaine@ios.bc.ca

David Saxby
Specialty Marine Products,
4727 South Piccadilly,
West Vancouver, B.C. V7W 1J8
CANADA
Tel. (604) 685-4977
Fax. (604) 926-2626, (604) 222-5572

Greg Saxby
Specialty Marine Products,
4727 South Piccadilly,
West Vancouver, B.C. V7W 1J8
CANADA
Tel. (604) 685-4977
Fax. (604) 926-2626, (604) 222-5572

Yvan Simard
Canadian Dept. Fisheries and Oceans
Maurice Lamontagne Institute
850 route de la Mer,
PO Box 1000, Mont-Joli
P.Q. G5H 3Z4

CANADA
Tel. (418) 775-0527
Fax. (418) 775-0542
e-mail: Y_SIMARD2QC.DFO.CA

John Spence
Science Council of British Columbia
Suite 800, 4710 Kingsway
Burnaby, B.C. V5H 4M2
CANADA
Tel. (604) 438-2752
Fax.(604) 438-6564
e-mail: jspence@scbc.org

Ron W. Tanasichuk
Department of Fisheries and Oceans
Pacific Biological Station
Nanaimo, B.C.V9R 5K6
CANADA
Tel. (604) 756-7197
Fax. (604) 756-7053
e-mail: tanasichukr@pbs.dfo.ca

Carl Walters
Fisheries Centre
2204 Main Mall
Vancouver, B.C. V6T 1Z4
CANADA
Tel. (604) 822-6320
Fax. (604) 822-8934
e-mail: walters@bcu.ubc.ca

Workshop Organizer: Ying Chuenpagdee
2204 Main Mall
Vancouver, B.C. V6T 1Z4
CANADA
Tel. (604) 822-0618
Fax. (604) 822-8934
e-mail: ying@fisheries.com

Rapporteurs: Sean Gadway, Spark Oceans.
Taja Lee, Fisheries Centre, UBC.

Harvesting Krill: Ecological impact, assessment, products and markets

Workshop Programme
November 14-16, 1995

Tuesday November 14, 1995

0845 - 0915	Continental breakfast
0915 - 0930	Opening remarks -- About the workshop (focus, scope and outputs from the workshop).....*Prof. Tony Pitcher*

Session 1: Krill sustainable harvest (Moderator: Inigo Everson)

1000	Exploitation and management of Antarctic krill.....*Denzil Miller (Sea Fisheries Institute, South Africa) and David Agnew (CCAMLR, Australia)*
1000 - 1030	Fishery biology of *Euphausia pacifica* in the Japanese waters .....*Yoshinari Endo (Tohoku University, Japan)*
1030 - 1100	Coffee break
1100 - 1130	The importance of euphusiids to a British Columbia coastal marine ecosystem.....*Ron Tanasichuk (Fisheries and Oceans, Nanaimo)*
1200	Development of krill fishing industry.....*Stephen Nicol (Australia Antarctic Division, Australia)*
1330	Sandwich lunch in Ralf Yorque Room

Session 2: Ecological implications of krill harvesting (Moderator: David Agnew)

1330 - 1400	Putting Antarctic krill into ecosystem models.....*Astrid Jarre-Teichmann (Institute of Marine Science, Germany)*
1400 - 1430	Juvenile fishes in the krill swarms and the bycatch problem.....*Carlos Moreno (Universidad Austral de Chile, Chile)*
1430 - 1500	The CCAMLR experience.....*Inigo Everson (British Arctic Survey, U.K.)*
1500 - 1530	Coffee break
1530 - 1600	The influence of inter-annual variations in sea temperature on the population of biology and productivity of euphausiids in Barkley Sound, Canada.....*Ron Tanasichuk (Pacific Biological Station, Canada)*
1630	Overview of the krill of the Gulf of St.Lawrence....*Yvan Simard, (Dept. of Fisheries and Oceans)*
1700	Using the Ecopath II approach to assess krill biomass and dynamics.....*Daniel Pauly (Fisheries Centre, UBC)*
1600 - 1730	**Discussion:** *(Moderator: John Spence)* ***Krill harvest in British Columbia: issues and potential*** (Identify issues to be discuss on Wed. pm)

Wednesday November 15, 1995

0830 - 0900	Continental breakfast

Session 3: Krill resource assessment methods (Moderator: Denzil Miller)

0900 - 0930	Biological parameters necessary for the management of the krill fishery.....*Stephen Nicol (Australia Antarctic Division, Australia)*
0930 - 1000	Acoustic methodology.....*Inigo Everson (British Arctic Survey, U.K.)*
1000 - 1030	Acoustic estimation of krill abundance utilizing volume scattering measurements.....*Michael Macaulay (University of Washington, USA)*
1030 - 1100	Coffee break
1130 - 1200	Comparisons of repeat acoustic surveys in Jervis Inlet.....*Steve Romaine (Institute of Ocean Sciences)*
1200 - 1230	Modelling and data requirements for the management of the Antarctic krill-based ecosystem.....*David Agnew (CCAMLR, Australia)*
1230 - 1330	Sandwich lunch in Ralf Yorque Room

Afternoon session:

1400 - 1500	**Discussion:** *(Moderator: Stephen Nicol)* ***Resource utilization: products and markets for krill*** (Identify more issues to be discussed)
1500 - 1730	Divide into working groups to discuss selected issues

Thursday November 16, 1995

0830 - 0900	Continental breakfast
0900 - 1030	Reports from working groups
1030 - 1100	Coffee break
1100 - 1230	Planning of book output
1230 - 1400	Sandwich lunch in Ralf Yorque Room
1400	Adjourn