LA PEROUSE PROJECT

EIGHTH ANNUAL

PROGRESS REPORT

1992

LA PEROUSE/MASS PROJECT

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DECEMBER 1993

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1. INTRODUCTION

The La Perouse/MASS Project is a multi-disciplinary, multi-species investigation conducted by the Pacific Biological Station and the Institute of Ocean Sciences in support of long-term management of the major fish stocks off the west coast of Vancouver Island. Inititated in 1985 following the large 1982/83 El Niño event in the Pacific Ocean, the primary focus of the La Perouse/MASS program has been directed toward describing and understanding the causes of annual and interannual variability of the fish and zooplankton stocks over La Perouse Bank on the southwest portion of the shelf. Located within the coastal upwelling production zone that extends from northern Vancouver Island to Baja California, La Perouse Bank is an extremely productive fishing area (Fig. 1). In the last decade, the catch of commercial fish from this area has averaged 5-6 tonnes/km^2/yr. The La Perouse region is one of the most productive fishing zones in the northern hemisphere and produces about 5 times the average yield per unit area as the eastern boundary of the Gulf of Alaska (Fig. 2). The La Perouse region fisheries generate a landed value to the British Columbia economy in excess of $40 million annually.

In summer the west coast of Vancouver Island is a migration corridor for large numbers of returning salmon, and is an important feeding ground for abundant trans-boundary migratory fish stocks from California such as Pacific hake. La Perouse Bank also supported large numbers of Pacific sardine prior to the collapse of the fishery in the mid 1940s. Salmon, hake, sablefish, herring and crab currently support important fisheries in the region.

A fairly strong El Niño event struck the North Pacific in 1992. The resulting anomalously high spring and summer temperatures saw the appearence of large numbers of migratory Pacific hake, Pacific mackerel, and Jack mackerel in BC coastal waters. These predators, particularly Pacific mackerel, had a significant impact on juvenile salmon and herring survival in Barkley Sound, and at other locations along the west coast of Vancouver Island. An "historic" event also occurred in the summer of 1992, as four DFO fisheries surveys reported catching Pacific sardine. These are the first confirmed sardine catches in BC since the 1950's.

This report integrates results for La Perouse Project and the MASS (Marine Survival of Salmon) Project into a single document.

Program Objectives

One of the most important goals of the La Perouse/MASS program is to improve the ability of the Department of Fisheries and Oceans to make accurate forecasts of multispecies fish production and potential yields a few years in advance. This would provide considerable benefits to the commercial fishing industry by minimizing potential fishery conflicts, and by optimizing the catch quotas to the general level of productivity in the system. The program will also enable us to anticipate the probable impacts of ocean climate change on the general productivity, and on the recruitment and distribution of the major species.

The principal objectives of the La Perouse/MASS Project are:

To determine the key physical and biological factors that affect commercial fish population distributions, abundances and natural mortality rates;

To determine the dominant predator-prey relationships in this productive upwelling system and to use measurements of spatial and temporal distributions of predator and prey stocks to model the principal interactions in the system;

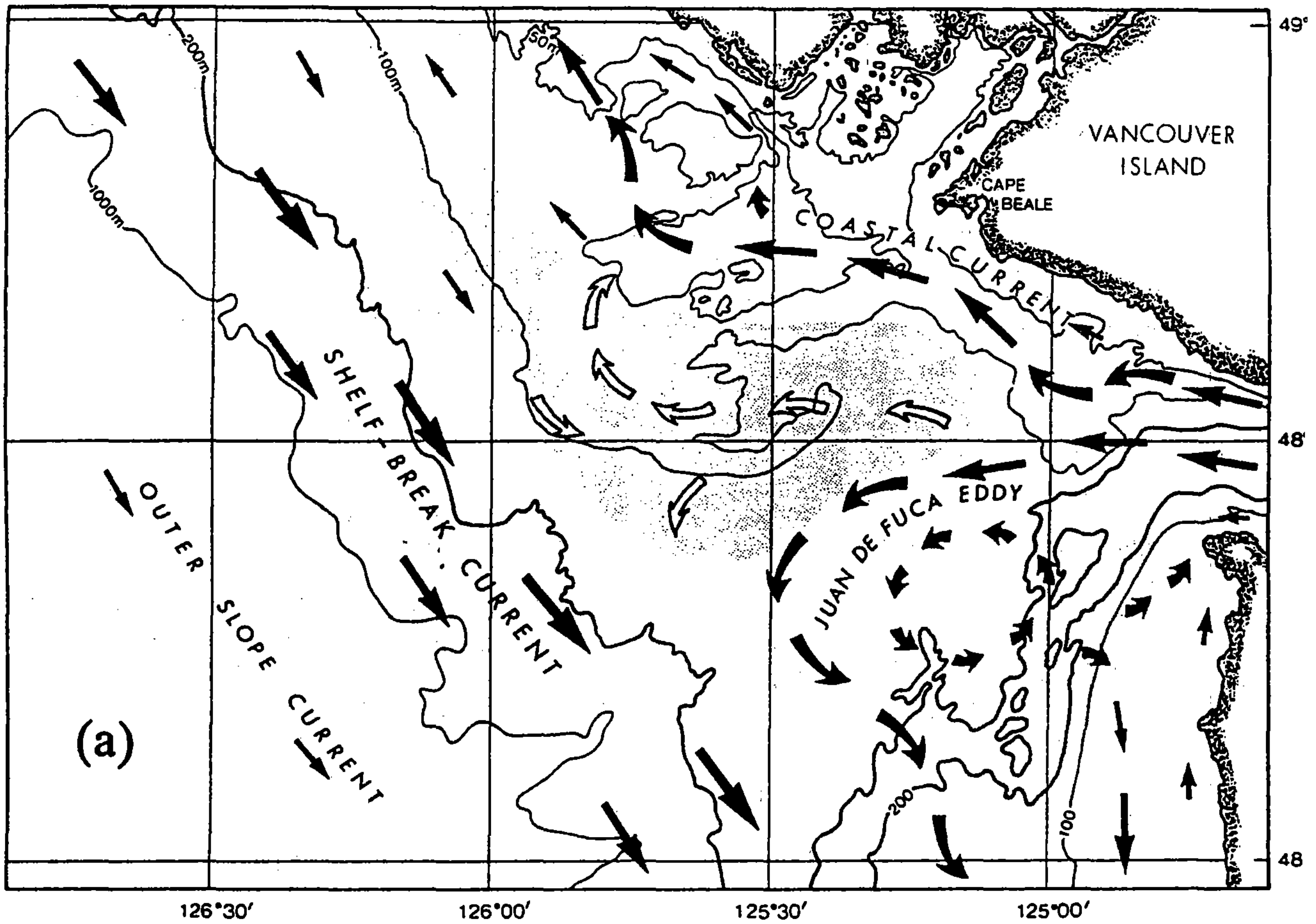

Figure 1a. General summer circulation pattern on La Perouse Bank and surrounding waters. Shaded region denotes an area of confused flow.

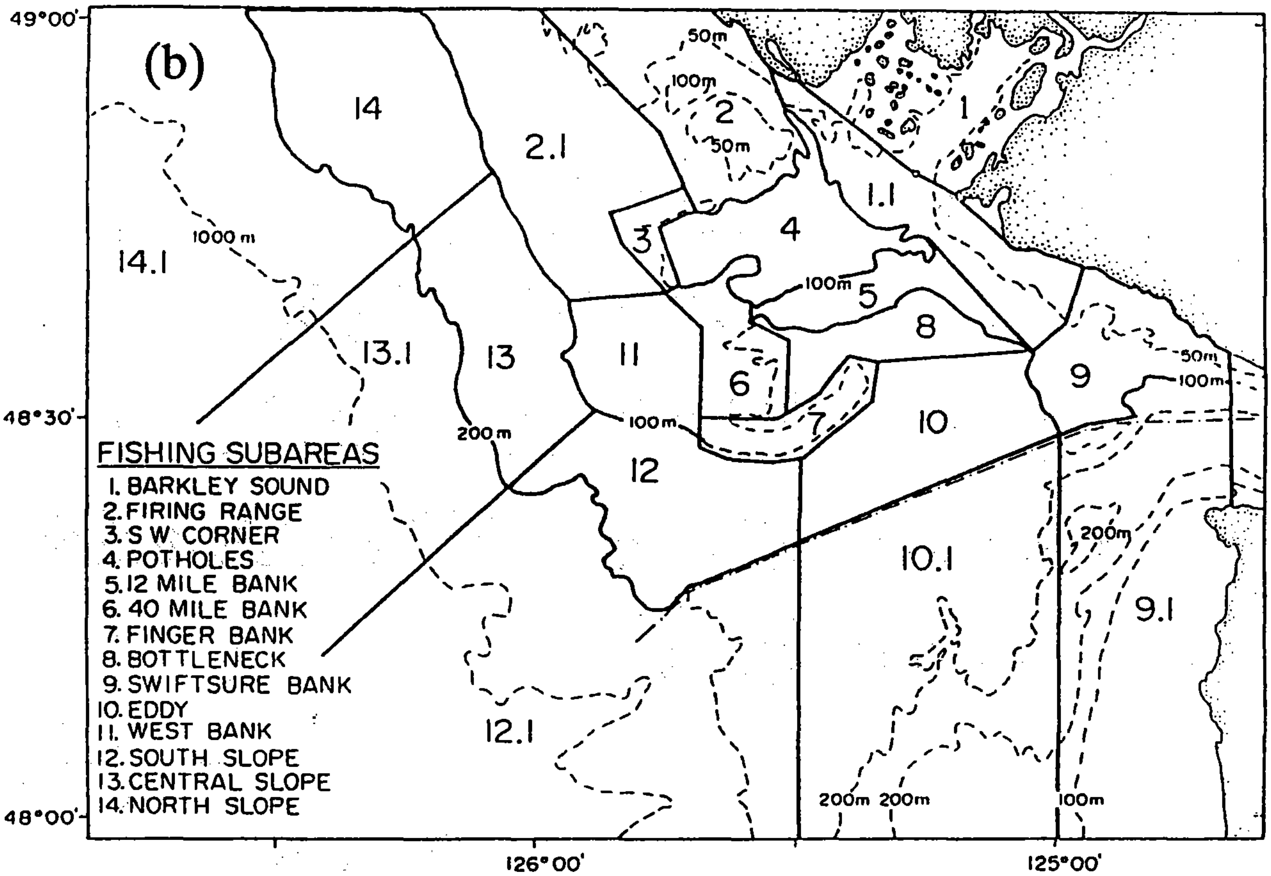

Figure 1b. La Perouse Bank fishing subareas. The map shows the locations of some important places mentioned in this report.

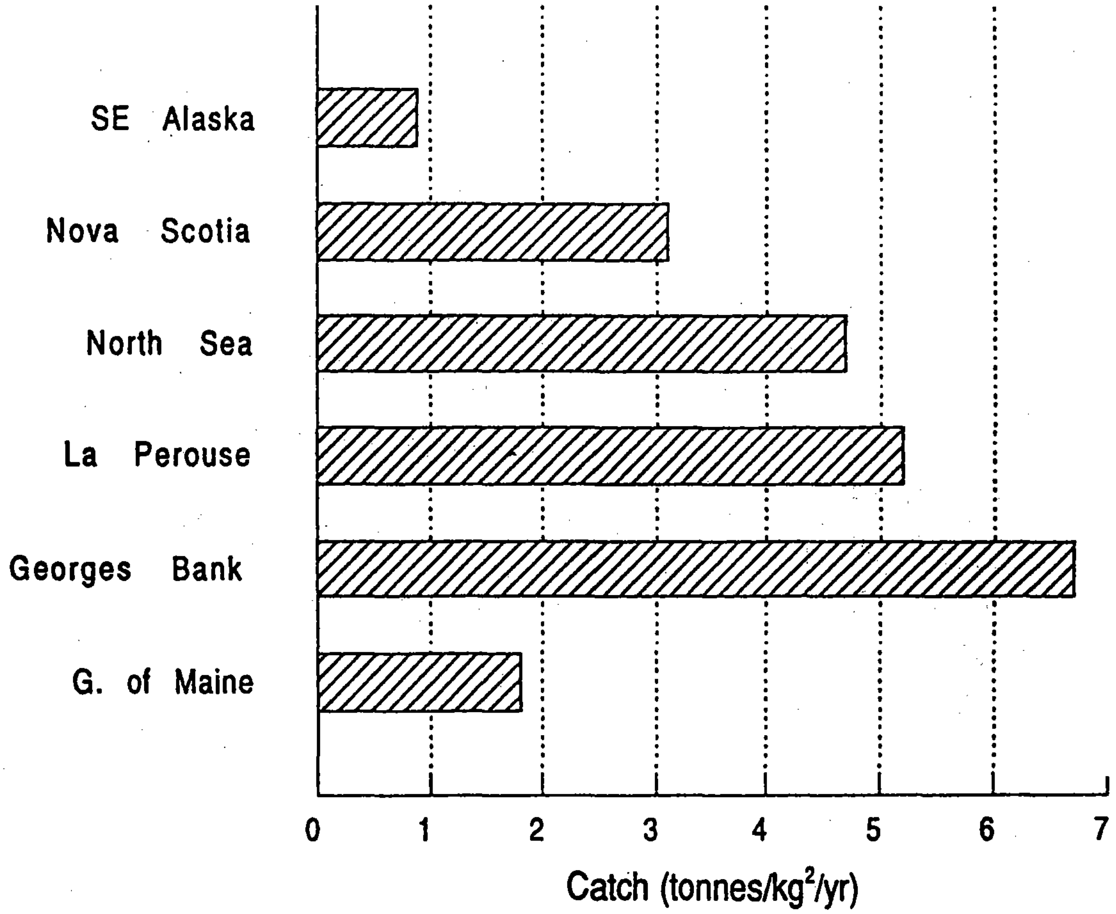

Figure 2. Average fisheries yields from major fishing zones in the northern hemisphere.

To use the emerging scientific results from the program to develop and verify sophisticated bio-physical models that can be used as operational tools in the long-term planning and management of the multispecies fisheries off the west coast of Vancouver Island.

Application of Results

The La Perouse/MASS Project has proven to be a highly successful fisheries-oceanographic investigation with immediate, practical implications. We can count a number of successes that have a direct impact on British Columbia's commercial fisheries, and on international negotiations on the harvesting of transboundary stocks. Specifically,

1. The La Perouse/MASS project has given us fundamental information on the seasonal patterns in the physical environment and the resulting primary and secondary productivity along the west coast of Vancouver Island. We have also developed new theories on how changes in ocean climate affect the general productivity of the system, especially the success of herring, salmon and sablefish year-classes. These results have been published and have been made available to the fishing industry and the public.

2. The LaPerouse/MASS project has increased our understanding of the seasonal distribution and biological response of fish stocks, like Pacific hake, to local oceanic and feeding conditions. This vital new information has been used to secure a fair share of the North American west coast hake quota for Canadian fishermen. The arguments made to support Canada's position were based on scientific evidence collected by the La Perouse/MASS project. The annual landed value of the Canadian hake fishery is currently about $15 million.

3. The salmon component of the La Perouse/MASS project is using biological and physical oceanographic data to forecast the strength of the returning sockeye run, and the resulting fisheries potential for local fisheries managers. Recent work predicted recovery of the Barkley Sound sockeye fishery after 3 years of closure, and helped assure the orderly harvest of commercial and sport caught sockeye worth $15 million in 1991.

4. The La Perouse/MASS project has shown that one of the principal reasons why the Barkley Sound herring stock has been so unproductive for the last 6 years is due to the increased abundance of hake in the region, in association with abnormally warm oceanic conditions (warm water results in poor herring survival). Hake are the principal predator of herring. New information collected by the program is used at annual DFO-Industry meetings to explain why the herring stock is declining. Our scientific evidence and interpretations have been accepted generally by industry as a believable explanation of what is happening, and has made it easier for them to accept DFO's attempts to rebuild the stock. The average landed value of the Barkley Sound herring fishery over the last 5 yrs is about $10-11 million.

5. Our knowledge of fish distributions in the La Perouse region enabled us to anticipate, and forewarn DFO managers about, the serious potential consequences to salmon and herring of a summer trawl fishery for hake in, and near the mouth of, Barkley Sound, which was scheduled to begin in 1992. The La Perouse/MASS working group advised that Barkley Sound be closed to hake trawling in the summer to minimize the by-catch of salmon and herring.

The Operational Coupling of Fishery Science and Management

The La Perouse/MASS program is in the process of developing increasingly sophisticated numerical models of the oceanic circulation and fisheries oceanography off the west coast of Vancouver Island. The evolution of these models over the next few years will lead to operational tools for fisheries managers. These models won't be the only tool, but they could be important for developing multispecies fishing plans, and for fish recruitment, stock abundance and productivity forecasting.

For example, a first generation model of the environmentally-forced, south-west Vancouver island upwelling ecosystem has been developed and accepted for publication. The model has been adequately tested and validated to warrent using it to generate quarterly and annual proxy indicies of primary and secondary production. The resulting production indicies can be used: 1) to describe the effect of current oceanic conditions on the productivity of this ecosystem (this is the most cost-effective way to estimate trends in primary production), and 2) determine if the model production time series (which starts in 1972) can "explain" observed variations in the growth and survival of important regional invertebrate, fish and marine bird stocks. The model production indicies have great potential and could prove to be a better indicator of regional production trends than the widely used Bakun upwelling index.

Our modelling research will lead to the development of the new operational tools required for the integrated management of the productive multispecies fisheries off the west coast of Vancouver Island.

This manuscript contains the 1992 progress reports for the individual investigators in the La Perouse Project, as well as the MASS project. Annual meetings are held to review the design, recent progress and future plans of the three main components of the program:

1. The Physical Oceanography Program (headed by Rick Thomson);
2. The Biological Oceanography Program (headed by Dave Mackas);
3. The Fisheries Oceanography Program (headed by Dan Ware and Sandy McFarlane).

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2. STANDARD SAMPLING GRIDS

The standard sampling grids for CTD/hydro profile stations and plankton tow stations are presented in Figs. 3a and 3b, respectively. Figure 3a also shows the locations of the standard current meter moorings A1, B1, and C1. Mooring site B1 was not occupied during 1991. Generally, the area of interest is defined from north to south, between 48°00.0' and 49°00.0' N latitude, and from east to west, between 124°40.0' and 126°50.0'W longitude. Furthermore, the sampling grid transect lines run perpendicular to the coast of Vancouver Island and pass through the above defined area at an approximate bearing of 235° true N.

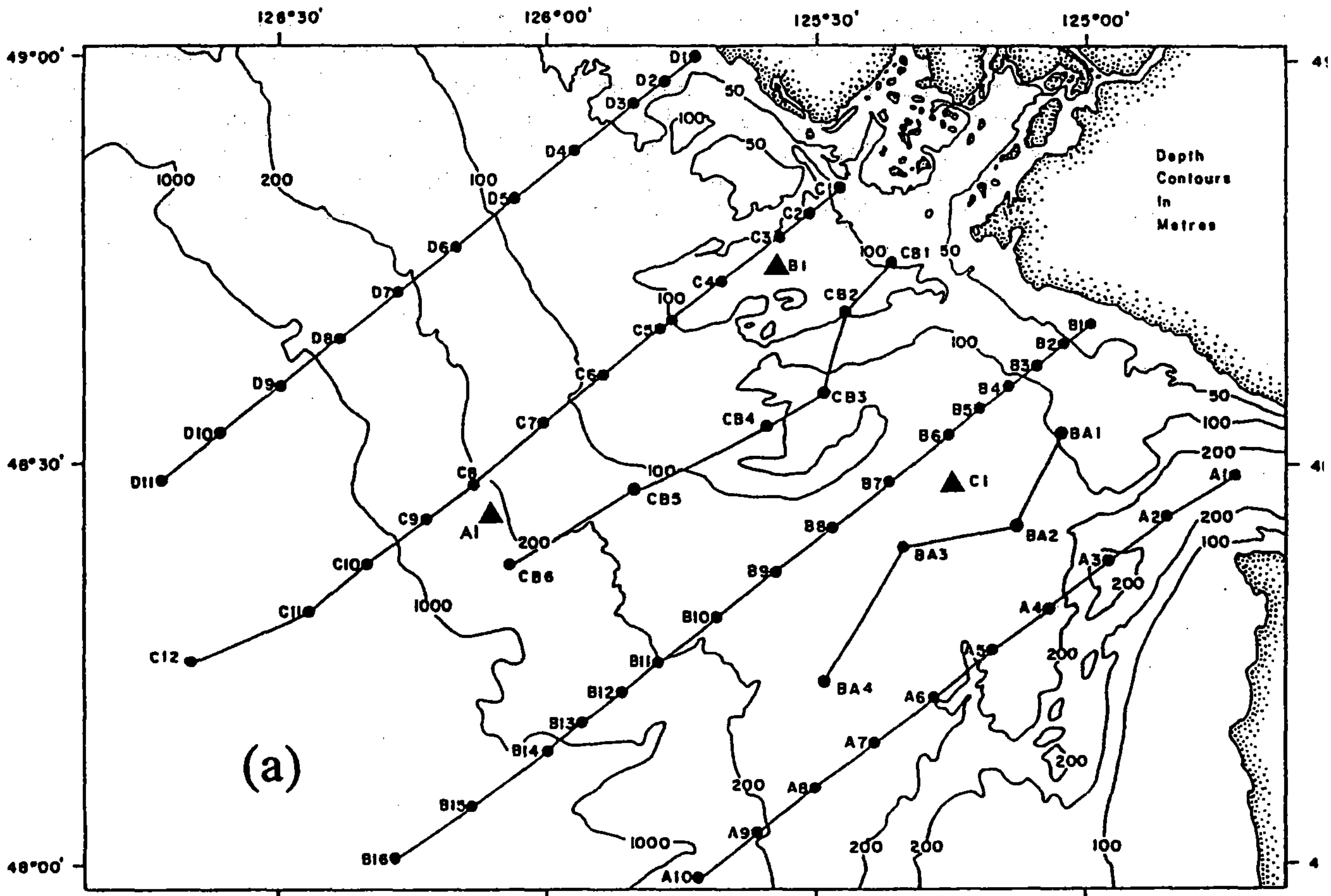

Figure 3a. La Perouse Bank CTD survey lines and current meter moorings (triangles A1, B1, C1).

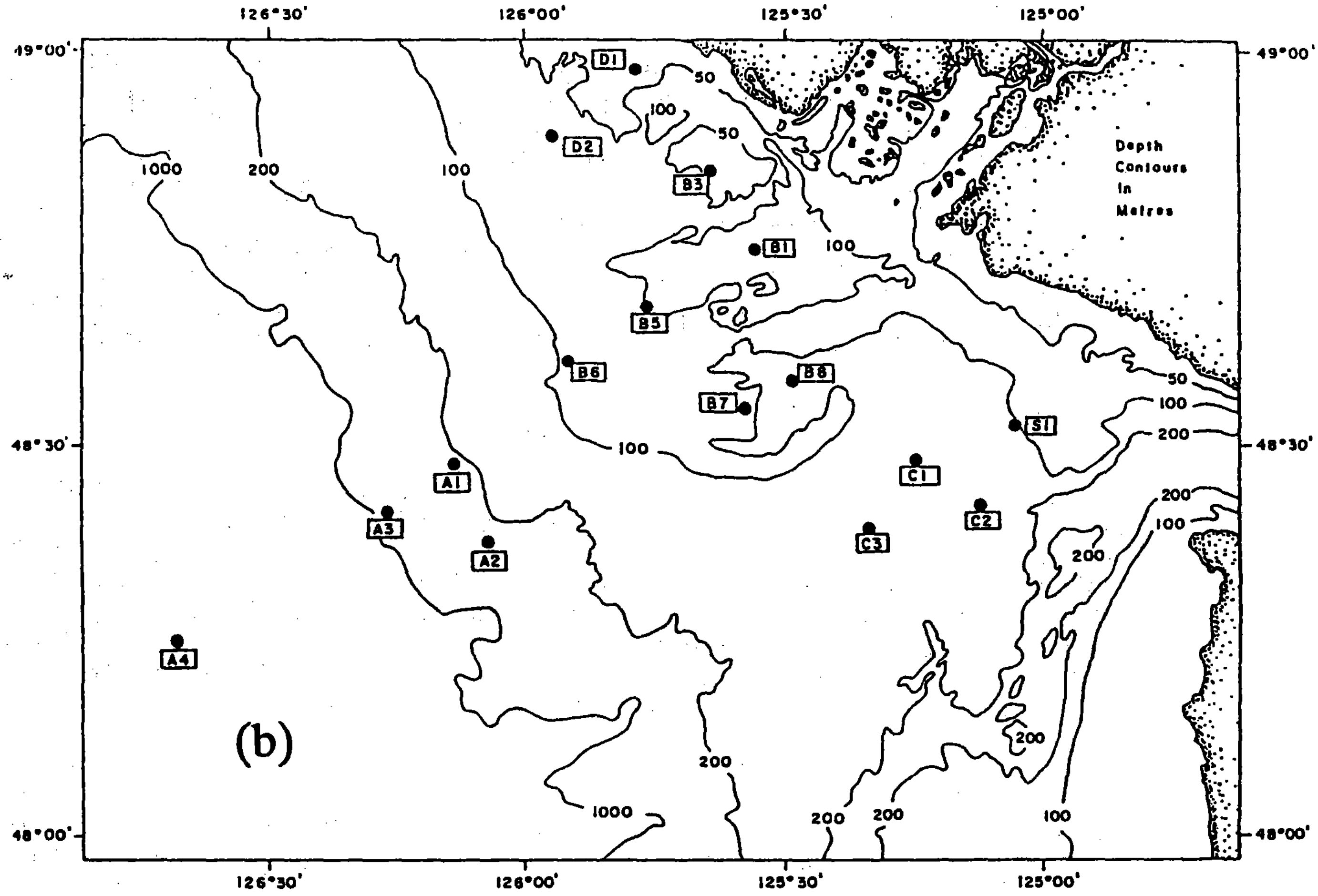

Figure 3b. La Perouse Bank plankton sampling stations.

3. INVESTIGATORS SUMMARIES

3.1 PHYSICAL OCEANOGRAPHIC PROGRAM

The physical oceanographic component of the La Perouse Project provides current and water property data along the west coast of Vancouver Island and in the western portion of Juan de Fuca Strait in support of fisheries and interannual climate investigations. The physical data also contribute to our understanding of the circulation dynamics over the shelf and provide a data base for El-Niño type oceanic variability in the northeast Pacific Ocean. Additional applications include the study of shelf/slope exchange processes, determination of the interannual variation in the timing and intensity of the Spring and Fall transitions, provision of input and calibration data for numerical circulation models, and calibration of remote sensing measurements. Observations collected during the program are used in the development of oil-spill trajectory models, in the interpretation of sea-bird distribution and in studies of sediment distribution and transport.

3.1.1 Current and Water Property Observations in 1992

Oceanographic data in the survey region (Figs. 3a,b) were collected during 6 dedicated La Perouse/MASS cruises between January 1 and December 31 (see section 4. Survey summaries). This compares with 6 dedicted cruises in 1991, 9 dedicated cruises in 1990, 10 in 1989 and 17 in 1988. Several near-shore survey lines from three WOCE (Line P) cruises in 1992 have also been added to the data set. The decline from 1988 to 1989 was due to structural problems on the *W.E. Ricker* which forced cancellation of scientific cruises during the main portion of the field season. The decline in 1991 is related to the transfer of the principal IOS research vessel *CSS Parizeau* from the west coast to the east coast fleet.

Archived water property files include plots and listings of individual vertical CTD profiles of temperature, salinity and light attenuation together with horizontal maps and cross-sectional maps of temperature, salinity, density, dissolved oxygen, light attenuation coefficient, dynamic height and geostrophic currents. Transect records from the shipboard SAIL system also are available but considerable processing is needed to render the data useful. Unlike previous years, all stages of editing and processing of the CTD data are conducted under contract. Calibration and editing of the current meter and thermistor chain data are conducted in-house by Andrew Lee. Post processing of all data is done through external contract. Joseph Linguanti of IOS continues to oversee the editing and archiving stages of the data processing while Richard Thomson is directly responsible for data quality control during the editing stage. Profile data from the shipboard 150 kHz acoustic Doppler current profiler (ADCP) are processed under contract and kept in a separate archive. Copies of all data collected by the various contributing groups are available from Richard Thomson of the Institute of Ocean Sciences. Because of the government cutbacks on spending throughout 1992 and 1993, a large segment of the data set has yet to be edited and processed. The lack of funding also has caused many highly trained contractors to find other sources of funding, limiting our ability to anlayze and interpret the data sets.

Current Meter Moorings in 1992

The standard deployment positions for all La Perouse/ MASS current meter moorings are shown in Fig. 4. [Owing to heavy fishing activity and associated data losses in recent years, the deployment of mooring, B1, off Barkley Sound was suspended following the recovery cruise of April 1990.] Mooring C1 measures the variability in the flow over the central portion of the fishing bank while A1 records the variability in the wind-induced flow along the outer edge of the broad continental shelf to the west of the main fishing sites. Mooring E01 off Estevan Point monitors the poleward flow associated with the buoyancy-driven, near-shore Vancouver Island

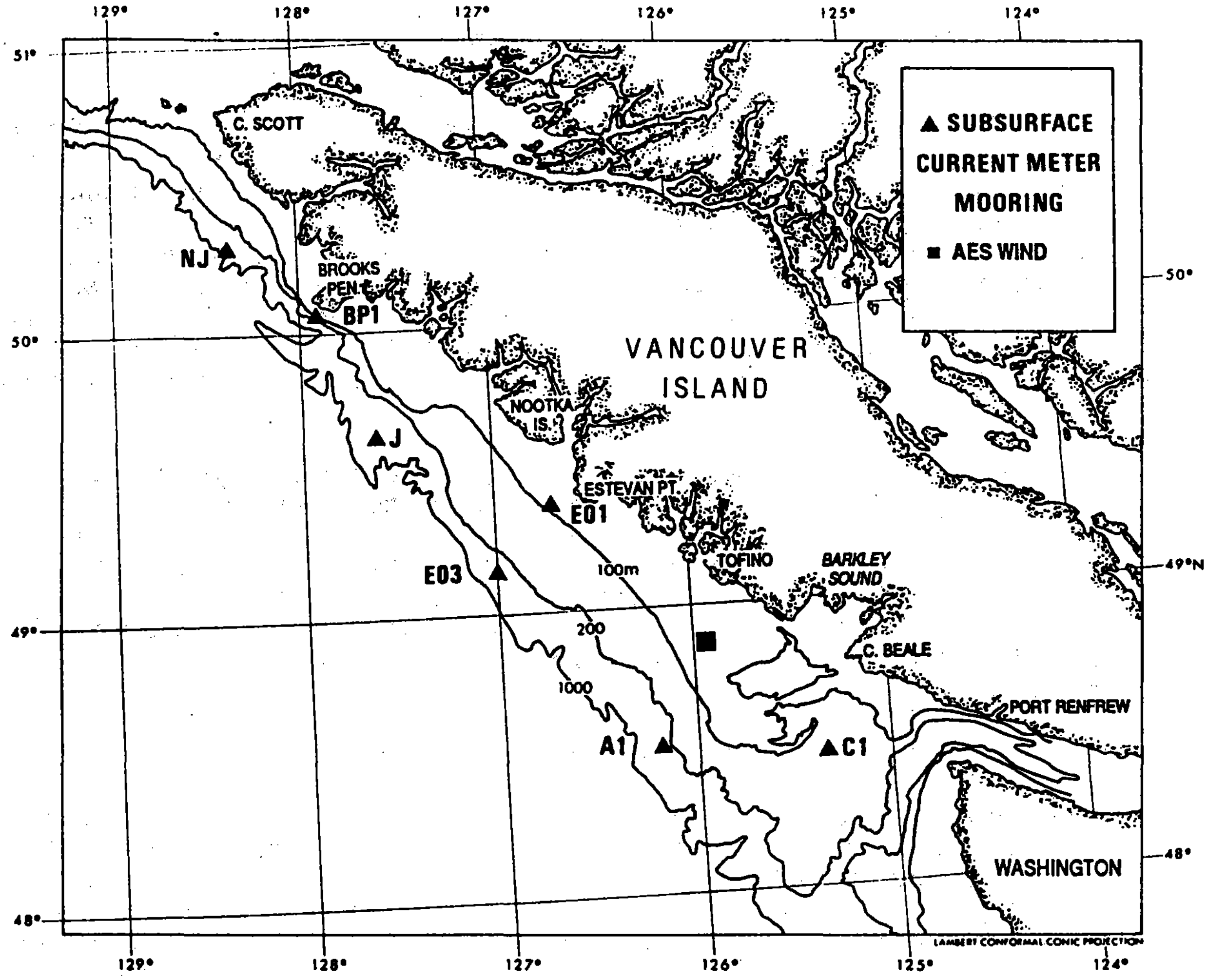

Figure 4. Location of current meter moorings on the west coast of Vancouver Island during 1992 and location of AES Weather Buoy (■) and moorings Jet (J) and NoJet (NJ).

Coastal Current. At this relatively "safe" quasi-permanent mooring site, the Coastal Current is known to be stable and well defined (Thomson et al. 1989).

Moorings E03 and A1 record the temporal scales and longshore coherence of the Shelf-Break "jet". With its core centered near the surface over the 200 m depth contour, the Shelf-Break Current is a direct measure of summer upwelling intensity along the Vancouver Island continental shelf. Thermistor chains between 100 and 150 m depth on moorings A1 and E03 provide detailed information on high frequency temperature variability during the upwelling period. Moorings A1 and E03 also help to establish the long-term timing and intensity of the spring and fall transitions off the west coast of the island. Mooring BP1, consisting of current meters at 35 and 75 m depth at the edge of the steeply sloping shelf, provides data on the intense and highly-sheared flow past Brooks Peninsula and is maintained as an integral part of our long-term fisheries-climate program.

In addition to the La Perouse/MASS moorings, we deployed a single subsurface mooring (CRD1) near the Macaulay Point outfall in support of effluent dispersal research by the Capital Regional District (CRD). As part of this program, four CTD stations are occupied in the vicinity of the mooring. The purpose of this sub-program was to provide direct flow information for the outfall site as well as provide long-term verification and calibration data for numerical models being developed for the region by Seaconsult Marine Research and the Institute of Ocean Sciences. This work is partially funded through the Engineering Department of the CRD.

Recovery and Servicing Operations

Servicing of all moorings took place in June and October 1992 (Table 1). Moorings deployed in October 1991 were returned with some data loss but no instrument losses. Mooring C1(-N) was "hit" during the spring of 1992 and returned in part by a fisherman. The remaining portion was recovered from the CSS *Tully* during the June 1992 servicing period. Because of the increasing data losses sustained at this site, current meter station C1 was not redeployed until October 1992. No losses were incurred between June and October, 1992. As in previous years, there was a survival problem with slope mooring E03, which was first deployed on October 10, 1990 in 500 m of water to the southwest of Estevan Point. This mooring was "hit" sometime in October 1992 (as indicated by a witness buoy "alert") and the top three instruments recovered by the *FPV Tanu*on November 8 as the array drifted off the west coast of Vancouver Island. The bottom portion of the mooring, consisting of an acoustic release, current meter vane and three glass balls, was recovered on March 8, 1993. Losses from this mooring (the total losses for the year) were a single RCM4 current meter and a SS28 float. Redeployment of the La Perouse array took place in early June 1992. Standard recovery and servicing of all moorings was undertaken during the period 25-30 October 1992.

The CRD mooring (CRD-B) deployed on October 5, 1991 failed to surface during the recovery cruise of June 1992. It was not until November 2, 1992 that we were able to recover the top instrument of the mooring through a dragging operation by the *CSS Tully*. The bottom instrument and acoustic release were recovered on May 9, 1993 with no loss of instrumentation. To ensure data continuity, a new CRD mooring was deployed in June 1992 near the site of the original mooring.

Safeguarding Moorings

Several steps are taken each year to safeguard the moorings. In March 1991, over 5000 full page flyers (some in Japanese, Russian and Polish) were sent for distribution to the fishermen licensing agencies through the Commercial Licensing Division-Pacific Region of DFO. Distribution to the trawlers was kindly handled by Mr. Athol Lang of the Hake Consortium.

The flyers detail instrument configurations and locations for each mooring and supply telephone numbers of Institute staff. Exact positions are also supplied to Tofino Coast Guard Radio for direct transmission to marine traffic in the area of moorings (Notice to Mariners).

In addition to the dissemination of mooring information and labelling of all equipment placed in the ocean, other steps taken to reduce data and equipment loss are: (1) in-house maintenance and pre-deployment testing of all mooring components; (2) proper design and selection of mooring components; (3) controlled deployment and recovery techniques combined with accurate (GPS, Loran-C, Radar) positioning techniques; and (4) provision for alternate recovery methods in conjunction with use of relocating aids such as VHF transmitters, Xenon flashing lights and Argos satellite beacons or "witness Buoys". Witness buoys have proven very successful in our ability to recover hit moorings. A summary of all losses during the La Perouse/West Coast project prepared by Tom Juhász for the period November 1984 to October 1991 is presented in last year's report. For the 60 deployments in 9 years involving 274 individual instrument deployments to October 1992, the potential loss (equipment hit, cut adrift or suffering component failure) was roughly 36%; real losses (instruments not recovered or highly damaged) was about 6%.

Table 1. Mooring Status as of October/November 1992. RCM is an Aanderaa current meter and TR is an Aanderaa thermister chain.

Station ID	Latitude °N	Longitude °W	Deployment DD-MM-YY	Depth (m)
CRD-1C	48 24.16	123 24.55	02-11-92	RCM 25
				RCM 50
				Water depth 56
A1-16(P)	48 31.86	126 12.17	28-10-92	RCM 35
				RCM 100
				TR 101
				RCM 175
				RCM 400
				Water depth 500
C1-15(P)	48 29.28	125 15.26	30-10-92	RCM 35
				RCM 100
				Water depth 152
E01-16(P)	49 17.91	126 36.46	27-10-92	RCM 25
				RCM 35
				RCM 75
				Water depth 100
E03-16(P)	49 04.93	127 57.06	27-10-92	RCM 35
				RCM 100
				TR 101
				RCM 175
				RCM 400
				Water depth 495
BP01-16(P)	50 03.71	127 53.84	25-10-92	RCM 35
				RCM 75
				Water depth 100

Oceanic Winds

The Atmospheric Environment Service has maintained a 3-m discus wind buoy at 48°50.05' N, 125°59.74' W on La Perouse Bank (Fig. 4) since November 1, 1988. Data are transmitted to shore via the GOES satellite and are archived by the Marine Environmental Data Service in Ottawa. All wind data are now archived at AES in Vancouver and arrangements have been made to have these data transmitted to Ocean Physics, IOS (contact Robin Brown).

Standard Oceanographic Products

The edited oceanographic data are processed using a set of standard techniques that have been customized for the La Perouse region. Standard products derived from these data are listed below. (Further details can be found in the Annual La Perouse Report for 1988 (see section 5). Archived data products are:

1. Files and plots of 1-m averaged temperature, salinity and light attenuation as a function of depth for all oceanic surveys from June 1984 to January 1993. Dissolved oxygen profiles from water bottle casts at standard depths are available for many of the La Perouse grid stations.

2. Files at standard hydrographic depths (e.g. 0, 10, 20, 30, 50m, ...) of temperature, salinity, density (sigma-t), light attenuation coefficient, dissolved oxygen, sound speed, and dynamic height.

3. Objectively mapped water properties on horizontal surfaces at standard oceanic depths for each oceanic survey including temperature, salinity, density (sigma-t), dissolved oxygen, light attenuation coefficient, depth of sigma-t surfaces and geostrophic velocity (Fig. **5a,b**).

4. Objectively mapped cross-sections of the above oceanic properties (including geostrophic velocity relative to several reference depths) along all cross-shore survey lines (**Fig. 6a,b**).

The program to calculate cross-sections of geostrophic velocity normal to the CTD survey line has been recently generated under contract. Velocities are determined relative to user-defined depths of 50, 100, and 300 m and smoothed with the standard objective cross-sectional mapping program.

5. Three-dimensional maps of water properties for the La Perouse region including bottom topography. [Not available for 1992 data sets due to a lack of funds and contractor support.]

6. Edited current meter records for all sites plus hourly and low pass filtered records. [The 1992 data are not yet available due to a lack of funds and computing support.]

7. Satellite thermal imagery (NOAA AVHRR data) for specific cruises. There is no mechanism to process the acquired data other than through contractors that specialize in these products (e.g. Borstad Associates and Arctic Sciences Ltd.)

8. Shipboard acoustic Doppler current profiler (ADCP) data consisting of horizontal currents and acoustic backscatter anomalies. Problems remain with the analysis and dissemination of the shipboard ADCP data. The data files are large and there are many erroneous values that require labour-intensive editing. Observations mix time and space scales so that interpretation of the data is difficult. Considerable development work is needed. The contractor who normally does the analysis and who has written all the software (Luc Cuypers) is not always available. All data from Ocean Physics cruises have been archived and cruise tracks plotted (see Rick Thomson and Robin Brown).

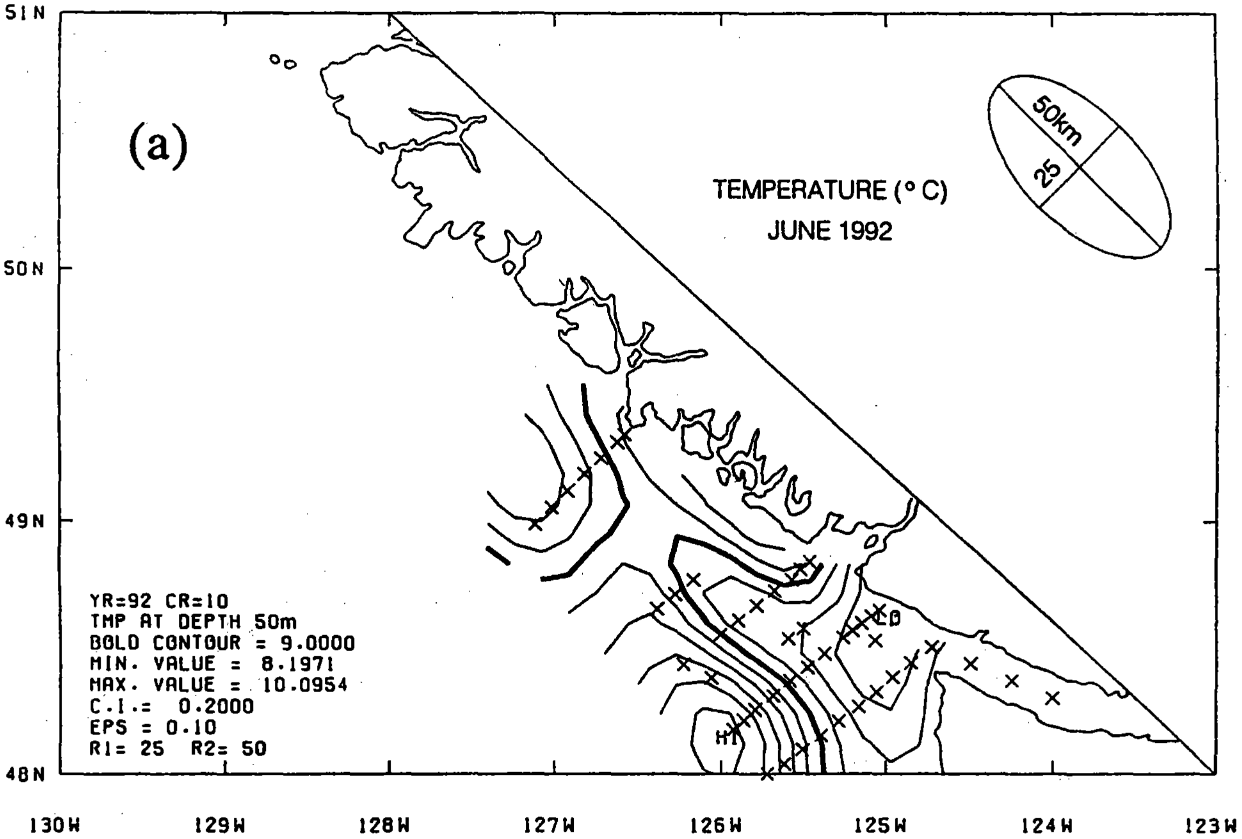

Figure 5a. Objectively mapped temperature at 50m depth for the southwest coast of Vancouver Island for June 1992. Ellipse shows the assumed correlation mapping scales of 50km longshore and 25km cross-shore used to smooth the observations (from IOS survey 92-10).

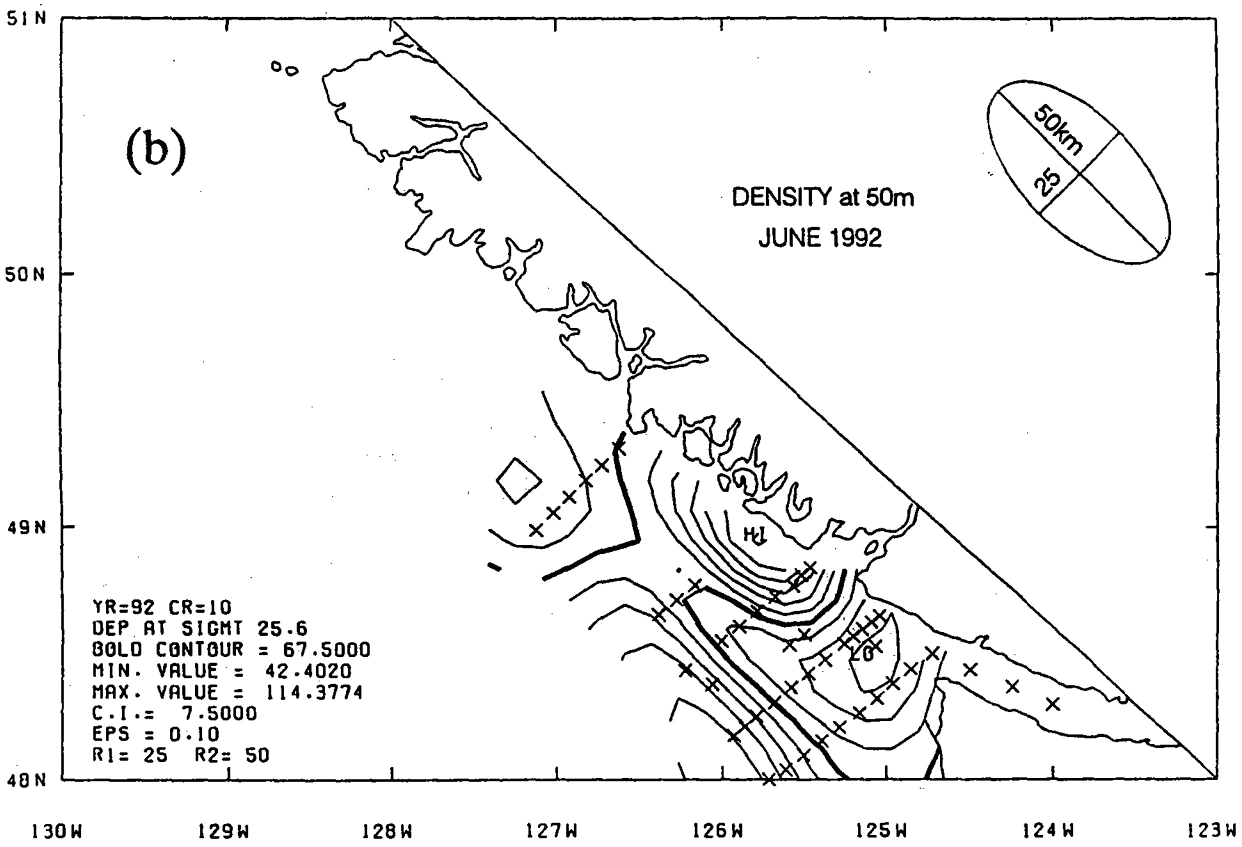

Figure 5b. Objectively mapped density (sigma-t) at 50m depth for the southwest coast of Vancouver Island for June 1992. Ellipse shows the assumed correlation mapping scales of 50km longshore and 25km cross-shore used to smooth the observations (from IOS survey 92-10).

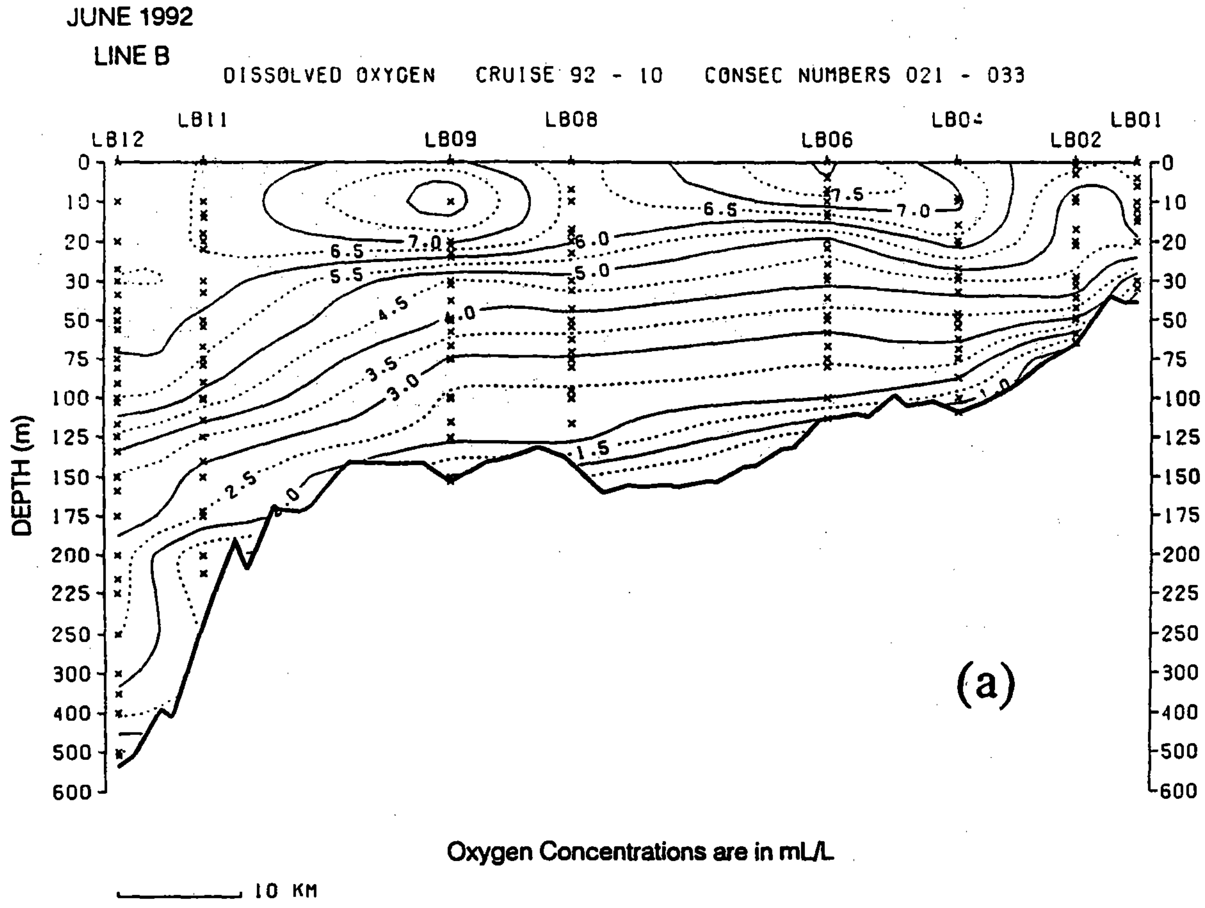

Figure 6a. Objectively mapped dissolved oxygen. Cross-section is for Line B (see Figure 2a) for June 1992 (from IOS survey 92-10).

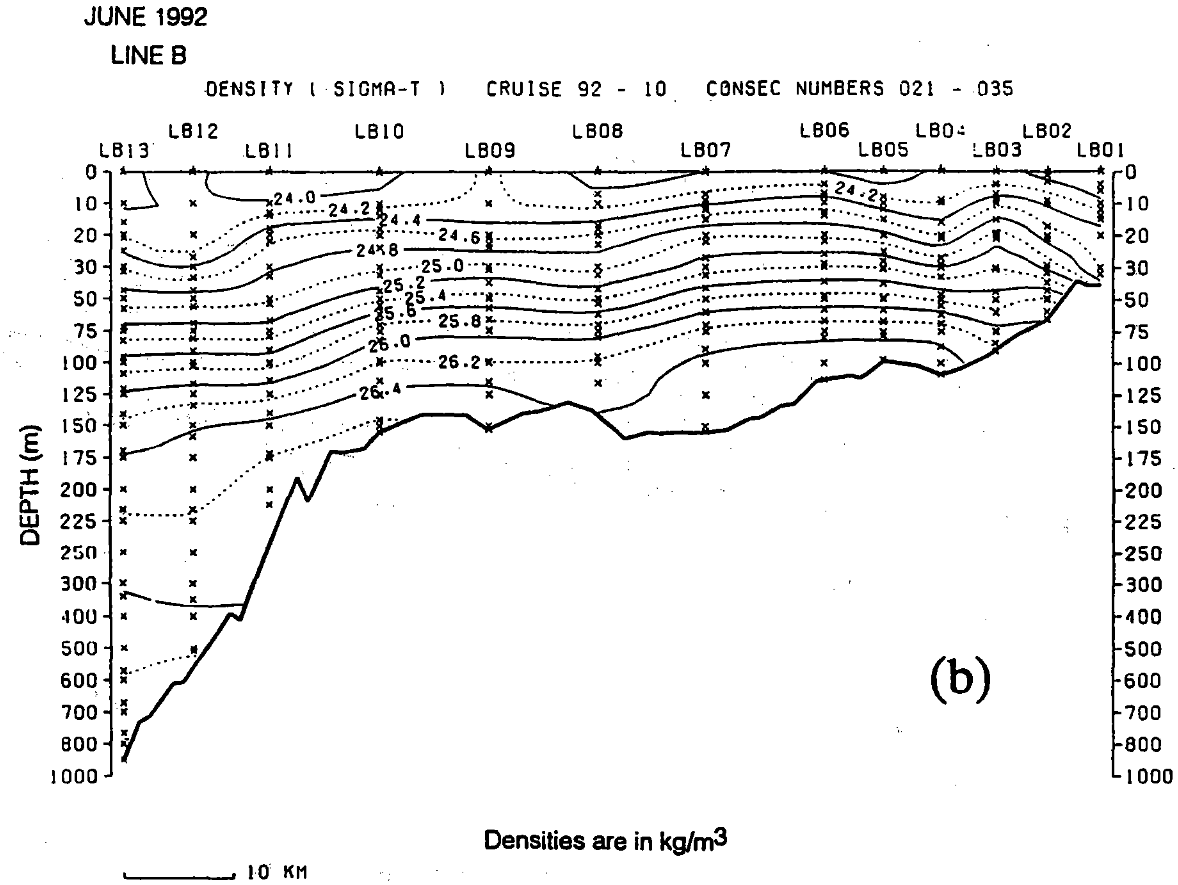

Figure 6b. Objectively mapped density (sigma-t). Cross-section is for Line B (see Figure 2a) for June 1992 (from IOS survey 92-10).

Research Projects

Because of the major funding cuts in 1993 and reallocation of support staff within the Institute, collection and post-editing of the La Perouse data sets was reduced. Data from all major cruises have been put into the data base by Robin Brown. Much of our effort went into support of editing, software development and data dissemination for colleagues within the project. Project-related research conducted in FY1992/93 is listed as follows:

Joint CTD Field Program

As part of a joint fisheries-oceanography program between B. Hargreaves and R. Thomson, Guildline Digital CTD data were collected along the west coast of Vancouver Island in July, 1992 during cruises on the *W.E. Ricker* and *CSS Tully*. This allowed us to merge the two CTD surveys into one detailed data file covering the entire length of Vancouver Island. These data are, in turn, being used to interpret the salmon distribution data collected by the Ocean Salmon Group at PBS.

Synthetic Aperture Radar (SAR) Study

The June 1990 La Perouse survey was combined with a high resolution airborne radar imaging survey of the west coast of Vancouver Island by the Canadian Centre for Remote Sensing (CCRS, Ottawa) and G.A. Borstad Associates (Sidney). The primary purpose of this study was to test SAR's ability to map oceanic features such as internal gravity waves, oil slicks, currents and fronts under different atmospheric and oceanic conditions. Processing of the SAR/oceanic data was completed in 1991 (see La Perouse/MASS Annual Report for 1991). Two papers on the results were published in 1992 (Thomson et al. 1992; Vachon et al. 1992 - see section 5.).

The Vancouver Island Coastal Current

The poleward flowing, buoyancy-driven Vancouver Island Coastal Current (VICC) is a permanent feature of the circulation off the west coast of Vancouver Island (Fig. 1a). Evidence from the La Perouse project indicates that in summer the current originates with outflow from Juan de Fuca Strait but is not organized into a well-defined boundary current until north of Barkley Sound. In a sense, the Coastal Current "emerges" from the region of low density water and confused circulation that forms over La Perouse Bank and only rarely is the consequence of direct outflow from the strait (see Seventh Annual La Perouse Report for 1991).

We continued to monitor the variability of the Coastal Current in 1992 using moorings E01 and E03. Moorings deployed off Estevan Point at mooring site E01 provide the most complete long-term record of the Coastal Current. Based on four years of complete data in 1991, the monthly averaged longshore flow (positive toward 315^{o}T) is maximal (~25 cm/s) in late fall and winter during the time of strongest southeast winds and maximum coastal runoff. The Coastal Current is weakest (10 cm/s) in late spring and early summer during times of minimal coastal runoff and variable longshore prevailing winds. Standard deviations are similar for all months with possible maximum variability in May at the time of the spring transition.

Shelf-Break Current

The study of upwelling and stability of the Vancouver Island Shelf-Break Current is continuing. In conjunction with Andrew Willmott of Exeter University, we developed a theory for the formation of eddy-like subinertial flow variability in Queen Charlotte Sound and along the west coast of Vancouver Island. The theory suggests that the generation of mesoscale eddy-like features on the west coast may be related to groups of propagating subinertial shelf waves generated by the longshore wind, diurnal tidal currents or by propagating offshore circulation cells. The patterns associated with the wave groups propagate poleward along the shelf and closely resemble the eddy-like features seen in satellite imagery. Results are being published (Willmott and Thomson 1994).

Seasonal Cycles in Coastal Upwelling

The alongshore wind stress computed from monthly mean air pressure has been used to compute an index of wind-induced coastal upwelling/downwelling for eight stations along the west coast of North America for the period 1899 to 1988 (Hseih et al. 1994). For winters since around 1940, wind-induced upwelling has intensified along Alaska and northern British Columbia, while downwelling has increased along Baja California. El Niño events were found to induce greater winter coastal downwelling poleward of 40° North. During summer months, upwelling has increased since about 1940 along southern British Columbia to Baja California. Off southern British Columbia, the alongshore winds from this analysis agreed very well with the Bakun Upwelling Index available from 1946 onward. Correlation of winds and salinity was weak except in spring and summer. In contrast, correlation between winds and coastal temperature was strong in summer but weak in winter.

R.E. Thomson

3.1.2 Numerical Model Studies off the Entrance to Juan de Fuca Strait

In 1992/93, work continued with the numerical model that calculates three-dimensional velocities from CTD data. Given the importance of upwelling as the major source of nutrients in the La Perouse region, the specific objective was to validate previously calculated vertical velocities such as those suggesting greater upwelling along the shelf break at Clayquot, Barkley, and Nitnat Canyons. (See La Perouse Annual Report for 1991) Although vertical velocities calculated with a similar model have been qualitatively compared to analytic solutions (Lynch et al., 1991), comparisons have yet to be made against observations.

To achieve this end we focussed on CTD measurements taken by three cruises between March and June 1985. This time period was chosen because it corresponded to the operation of seven current meter moorings that Freeland and McIntosh (1989) (henceforth FM) deployed to study the Tully Eddy and its associated upwelling, and an eighth mooring that Thomson deployed (as part of the La Perouse Project) along the shelf break northwest of Barkley Canyon. All the FM moorings had meters at the depths of 40m and 100m, three had meters at additional depths, and the Thomson mooring had instruments at 51 and 201m. Six of the FM moorings were placed in a pentagonal array (one in the centre) over the Tully Canyon with an approximate separation of 9-11 km. With a simple conservation of volume argument, the observed horizontal velocities from these instruments can be used to estimate vertical velocities that can then be compared to the model values. In order to reduce the potentially large uncertainties that FM suggested might arise with such an approach, the horizontal velocities were low-pass filtered to remove the tides, and averaged over the period of each CTD cruise. Although the computations are not yet complete, the hope is to provide more precise vertical velocities than the 0.005 cm/s typical values estimated by FM.

To illustrate the progress of the study, Fig. 7 shows the model currents at 40m depth as calculated from the CTD data collected between May 12 and 15. A counterclockwise eddy is clearly evident off Cape Flattery but unfortunately its center (where the maximum upwelling should occur) is not where the current meters were moored. The filtered and averaged observations at 40m and 51m depth are shown as vectors emanating from the centers of circles, and although they are not in perfect agreement, the model values compare very well. The similar figure for 100m depth does not show as good an agreement. This is largely due to problems in specifying conditions along the Juan de Fuca boundary so that the correct estuarine pattern of eastward flow at depth and westward flow at the surface is produced. Although Figure 7 shows surface westward flows, the model flows at 100m depth are not eastward. Present efforts are attempting to correct this problem.

Figure 8 shows the associated model vertical velocities at 100m depth. Upwelling regions are contoured with solid lines while downwelling regions have dotted contours and the bathymetric contours are dashed. Notice the upwelling on the southeast sides of Barkley, Nitnat, and Juan de Fuca Canyons; on the southeast flank of La Perouse Bank; and around the southern flank of Swiftsure Bank. Unfortunately neither the model nor observations suggest much upwelling (or downwelling) in the Tully Canyon, so this case probably does not provide a sufficiently strong signal for validating the model vertical velocities.

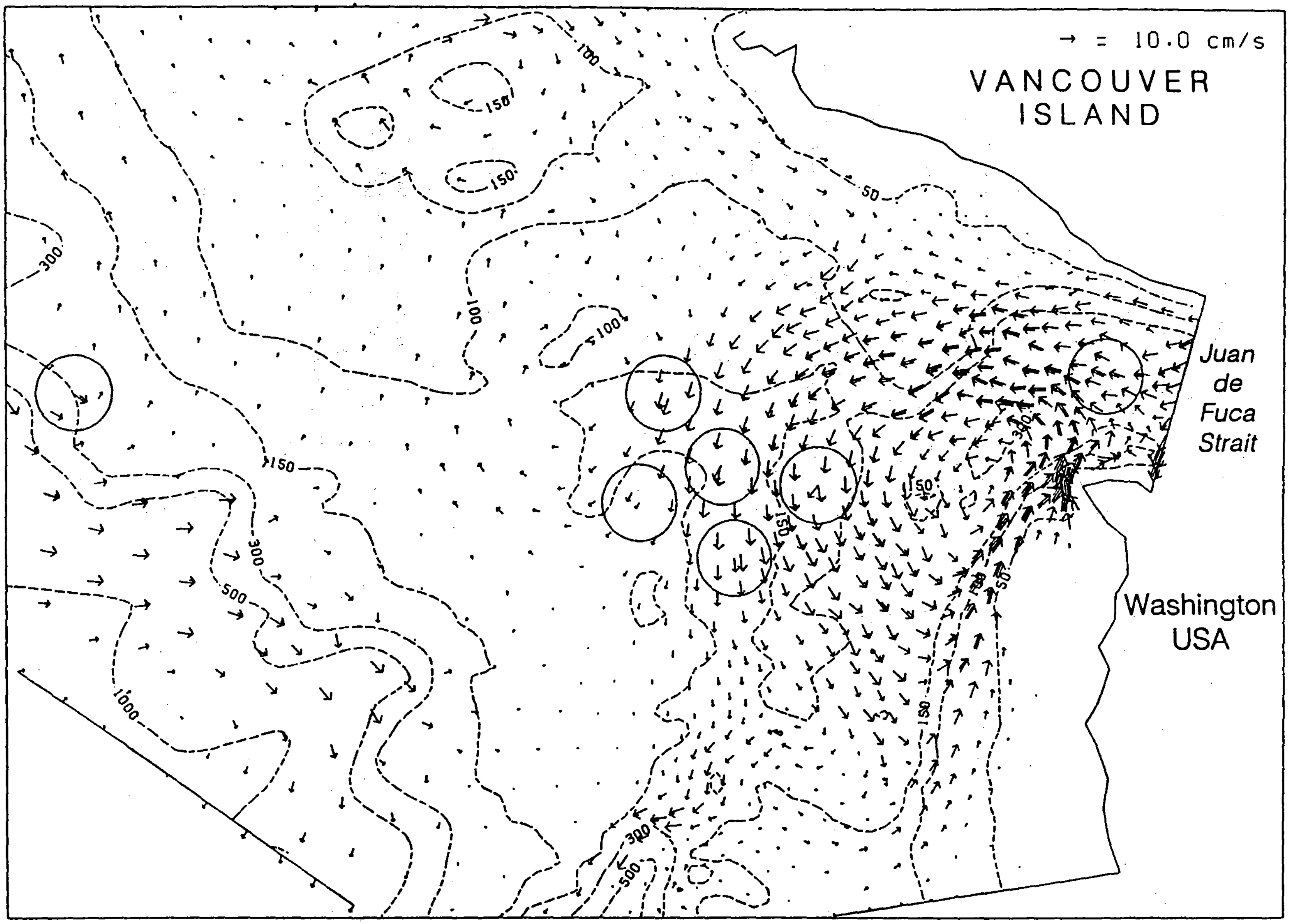

Figure 7. Horizontal currents at 40m depth as calculated from CTD observations collected between May 12 and 15, 1985. Circled vectors are low-pass filtered observed velocities that have been averaged over the same four days. Each full shaft in multi-shafted vectors represents a current of 10 cm/s. Bathymetric contours are in metres.

Model currents have yet to be computed from the other two CTD surveys, but the sigma-t surfaces from the June cruise suggest a well-formed eddy over the Tully Canyon. It is expected that the vertical velocities estimated from the current meter observations over the duration of this cruise will be sufficiently strong to provide a viable comparison for their model counterparts. A full presentation of this comparison is planned for a future journal publication.

M.G.G. Foreman, J.C. Muccino

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Lynch, D.R., Werner., F.E., Greenberg, D.A., and Loder, J.W. 1992. Diagnostic model for baroclinic, wind-driven and tidal circulation in shallow seas. *Continental Shelf Research* **12:** 37-64.

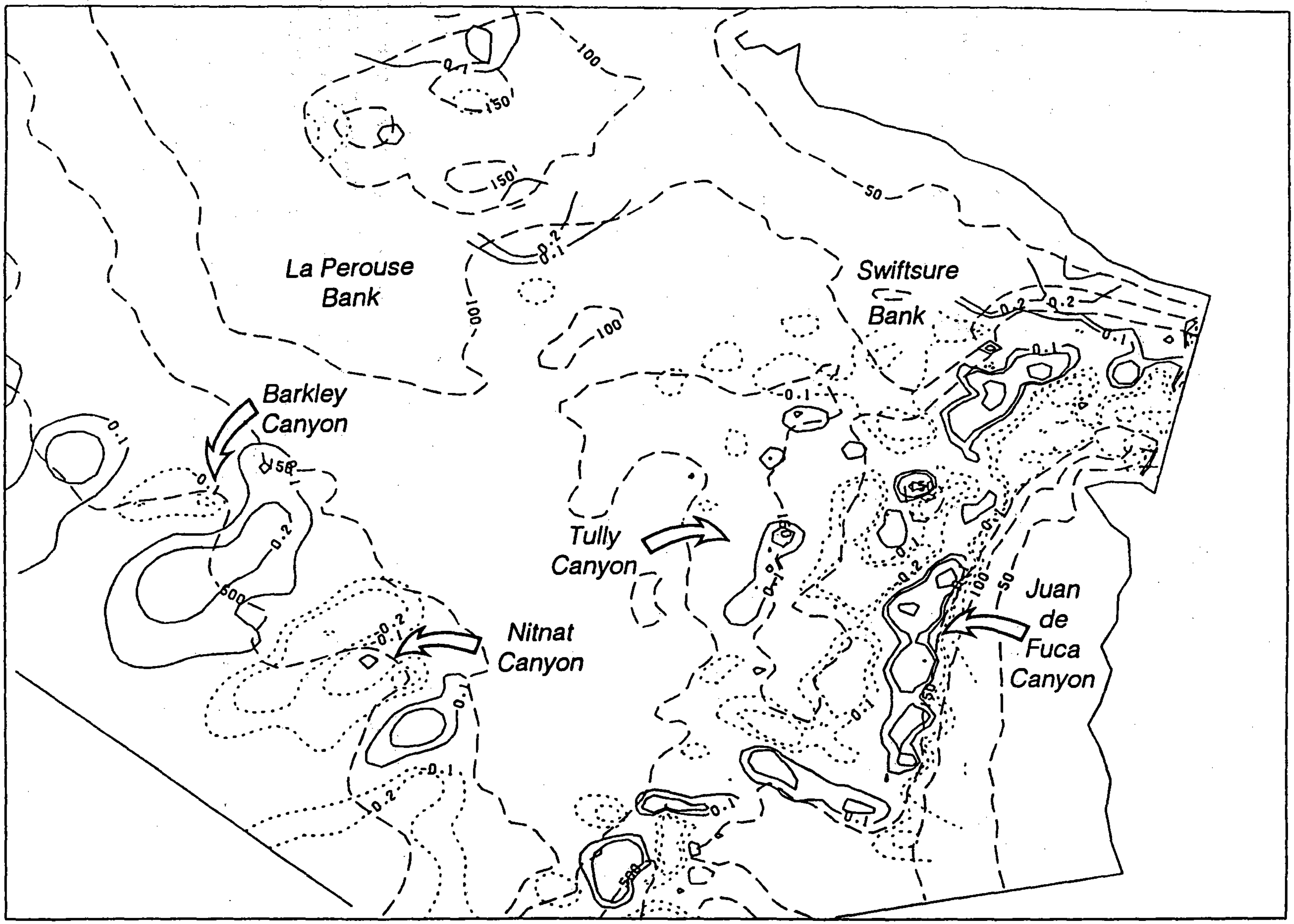

Figure 8. Vertical velocities (mm/s) (positive upward) at 100m depth for the same model calculation as in Figure 1.

3.2.1. Seasonal cycle of plankton biomass and species composition in the La Perouse study area.

A detailed description of the "normal" seasonal cycle of water properties and plankton concentration using spatial and bimonthly time-period averages of samples collected from 1979-89 has been published (Mackas 1992), and subsequently updated to include 1990 and 1991 data (Mackas, in press; Fig. 9b shows an area-weighted spatial average over all statistical regions). Knowledge of the average seasonal cycle is an essential first step toward examination of year-to-year anomalies in plankton productivity. All regions have a spring-summer maximum in zooplankton biomass but there are between-region differences in timing and in the relative ranking of zooplankton species. In general, peak biomass is lowest and earliest on the inner shelf banks, higher and more persistent in offshore and deep water shelf locations. Zooplankton biomass tends to decline in mid to late summer. In contrast to the zooplankton, nutrient and phytoplankton levels remain high or increase throughout the summer. This suggests sustained high input rates of nutrient-rich (upwelled) water and substantial advective export of phytoplankton and zooplankton biomass.

Interannual Variability

We can also now make meaningful comparisons of the zooplankton seasonal cycle observed in a single year against the multi-year average. Fig. 9a compares the averages from 1992 sampling (February, April, June, August, October, and December) vs. the multi-year average shown in Fig. 9b. 1992 was a moderate El Niño year. The most notable feature is the low total biomass in June at the time of the normal annual peak. The relatively high euphausiid biomass in February and August 1992 may reflect upward bias due to reduced spatial coverage during these cruises. However, even with these two high values, both cruise and annual averages of euphausiid biomass are slightly lower than they had been during the previous 2-3 years.

Annual anomaly time series (within-year averages of deviations from the multi-year average seasonal cycle) have been calculated for all three statistical areas and for the time span 1985-1992 (Mackas, in press). Statistically significant deviations from the long-term average occur in all of the major taxa and in all three statistical regions. Fig. 10 shows as an example the anomaly time series for four of the important crustacean zooplankton groups in the outer shelf region. Average persistence of the anomalies ranges from less than a year for gelatinous zooplankton, to 1 to 2 yr for the common copepods, to 3 yr or more for chaetognaths and euphausiids. Significant zooplankton anomalies occur throughout the time-series; they are not confined to transient episodes such as the 1987 and 1992 El Niño events. However, coincidence of timing and duration suggests an association of local zooplankton and environmental anomalies with the 1988 change in winter-season atmospheric pressure patterns in the North Pacific Ocean.

D.L. Mackas

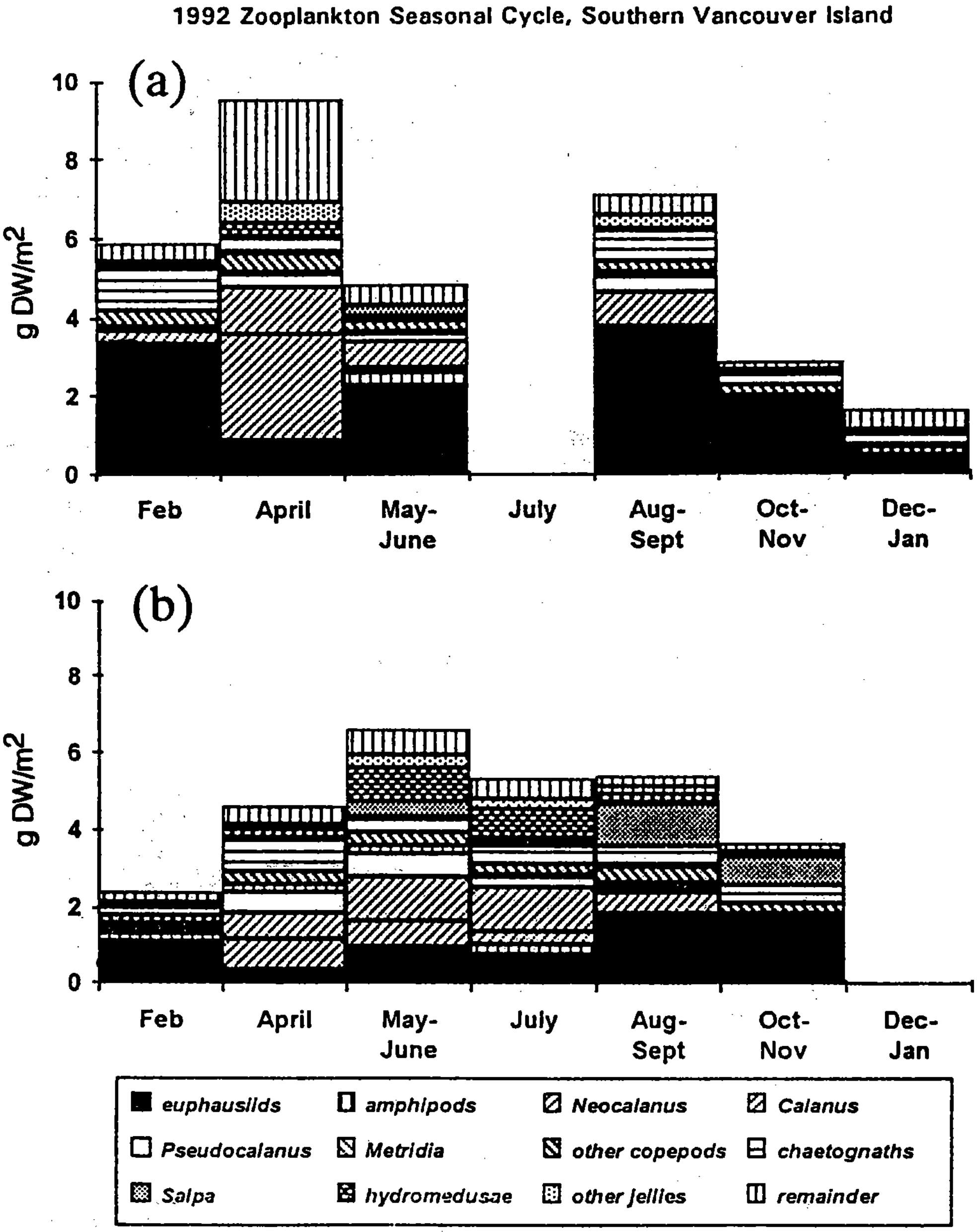

Figure 9. Comparison of area-weighted zooplankton seasonal cycles between 1992 (a) and the 1979-91 multi-year average (b).

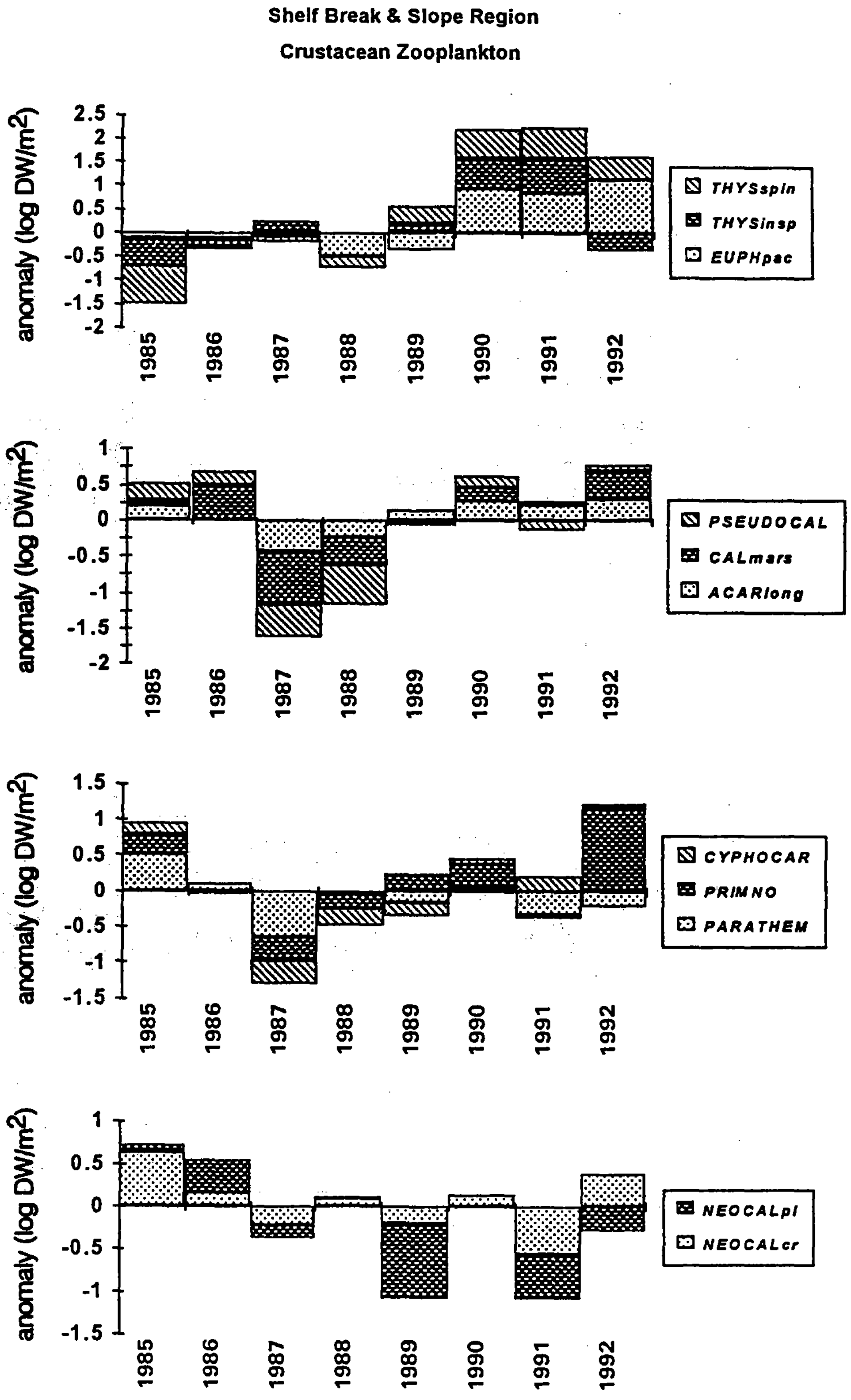

Figure 10. Time series of annual anomalies (averages of all sampling periods within a given year) for major crustacean zooplankton in the "offshore" sub region of the La Perouse study area. To save space and show shared patterns, each graph groups individual time series of 2-3 taxonomically and/or ecologically similar taxa. A log-scale anomaly of +0.5 indicates that the species is about three times more abundant than average; an anomaly of 0.5 indicates about one-third the average biomass. Units are DW/m^2.

3.2.2 Modelling plankton and fish trophodynamics in the Juan de Fuca Eddy

A trophodynamics model (Robinson and Ware, in press - see section 5.) is used to estimate the average annual plankton and fish production in the Eddy region on the southern British Columbia continental shelf during 1985-89. The model describes the feeding interactions among diatoms, copepods, euphausiids, Pacific herring, Pacific hake, Spiny dogfish, and Chinook salmon. The trophodynamics model is forced by observed seasonal patterns in Ekman transport (upwelling), sea surface temperature, and solar radiation. The model is relatively complex and requires data for about 50 parameters to simulate the feeding, growth and mortality processes of the seven state variables (Fig 11). It uses a numerical integration routine with a 1 day time step.

The first-order simulated average (and standard error) estimate of annual production for diatoms in the late 1980s is 330 (10.6) gC/m^2/y, for copepods: 24.3 (2.8) gC/m^2/y, for euphausiids: 11.9 (0.6) gC/m^2/y, for adult herring: 1.4 (0.04) g C/m^2/y, and for Pacific hake: 0.24 (0.015) gC/m^2/y. Production estimates for Chinook salmon and Spiny dogfish are not determined at present.

Production dynamics of herring and hake were found to be tightly coupled to the euphausiids. Furthermore, the model indicates that late spring (April/May) had the greatest influence on euphausiid production. During this period, euphausiid production was influenced by perturbations in parameters affecting the increase in euphausiid biomass (e.g., gross growth efficiency), and by the arrival time and biomass of migratory Pacific hake.

A relatively rapid increase in spring euphausiid biomass was required to track the observed early summer euphausiid biomass pattern, the empirical hake ingestion rate pattern, and the fraction of euphausiids in the hake diet. The large increase in euphausiid spring biomass occurs in the model because euphausiids have high growth efficiencies, and a significant biomass of euphausiids is believed to be imported into the Eddy region from surrounding oceanic regions by upwelling currents. The model results clearly identify the importance of understanding the growth dynamics of the most dominant euphausiid (*T. spinifera*) in the system, and the hypothesized euphausiid biomass import mechanism.

Variable hake biomass and arrival time are also important processes affecting simulated euphausiid production. For example, the model predicts that if Pacific hake arrive in early May, euphausiid biomass will only increase after hake emigrate to the outer shelf in July/August. Alternatively, a late arrival of hake (late June) allows a 'build-up' of euphausiid biomass during May/June. The simulated effects of variable hake biomass and arrival time combined indicates that euphausiid annual production should be greatest when few hake arrive late (in June). In contrast, copepod production should increase when many hake arrive early (in May), while adult herring annual production should be greatest when few hake arrive early (in May). Interestingly, there was little effect of variability in migratory properties of the hake stock on diatom production.

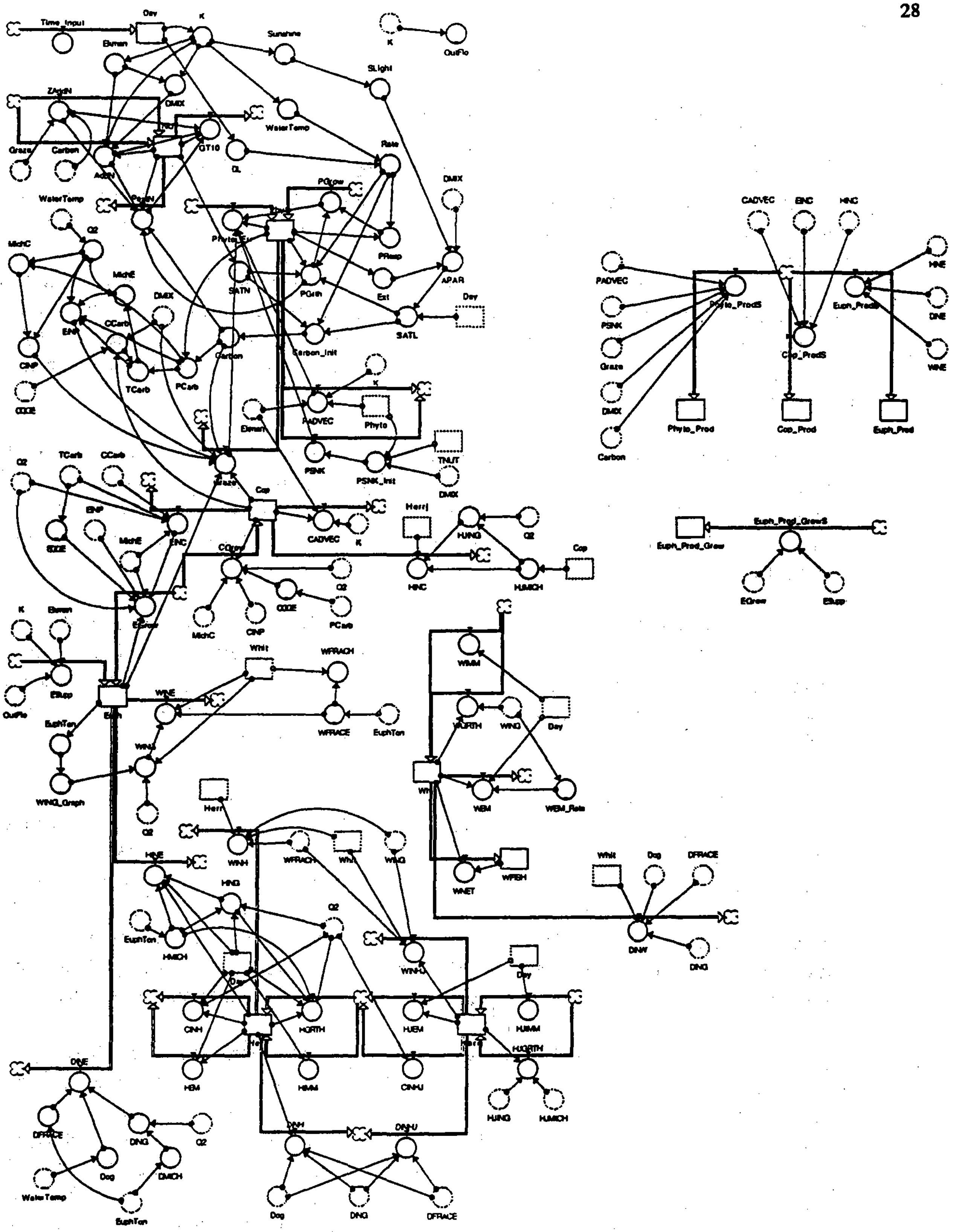

Figure 11. Illustration of the relative complexity of the Juan de Fuca Eddy trophodyanmics model.

Dynamics of the coastal upwelling system have also been identified from model simulations. For example, the system's efficiency in transferring diatom production to zooplankton was highest in months of intermediate Ekman transport. On average, about 11% of annual diatom production is transferred to zooplankton, 14% of euphausiid production to herring and hake, and 0.7% of diatom production to fish.

The trophodynamics model has been used to develop an index of diatom and zooplankton production for the Juan de Fuca Eddy region for the period 1972 to 1990. The production estimates were hindcasted from measured seasonal patterns in Ekman transport, water temperature, and solar radiation, and from observed biomasses of hake and herring. We now have the capability of using oceanic data to produce seasonal and annual production indices for the southwest coast of Vancouver Island. This production index provides a new indicator of environmental conditions that can be compared to survival and growth indices of important commercial fishes found on the southern BC continental shelf (see Fig. 12).

C. Robinson.

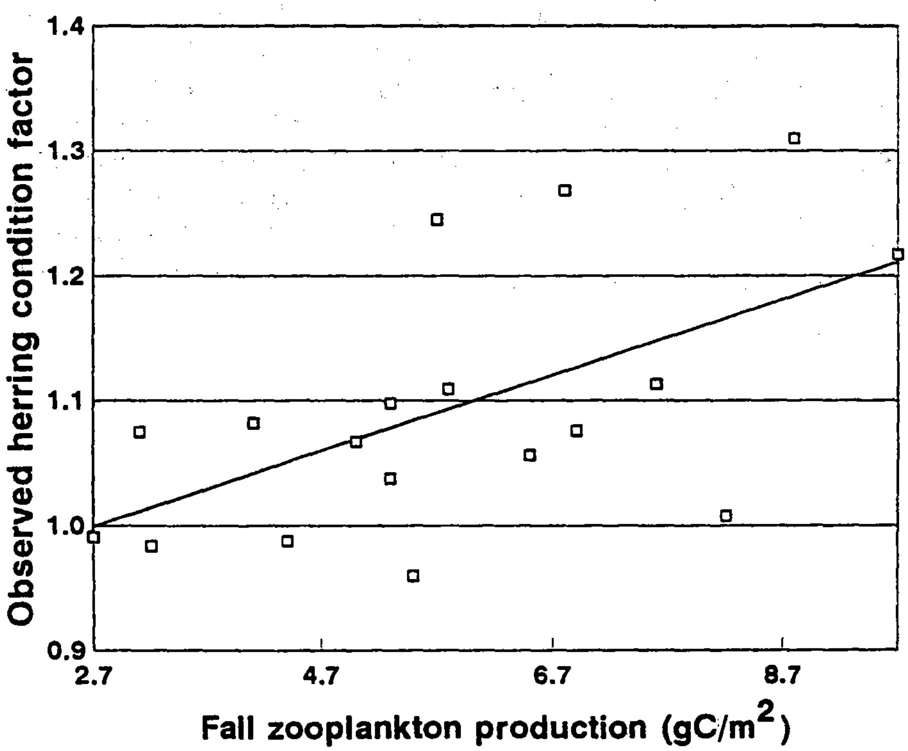

Figure 12. Relationship between the condition of age 5 herring and simulated fall zooplankton production, during 1972 to 1990 ($r = 0.58$; $p < 0.05$).

3.2.3 Euphausiid population biology studies

I present preliminary results on abundance, growth and mortality based on preserved samples of *Thyssanoesa spinifera* and *Euphausia pacifica*. These data are from samples collected between March 1991 and October 1992. All abundance data are expressed as the mean number/m^3, weighted by the volume filtered at each sampling site. The study was initially designed to concentrate on *T. spinifera* but *E. pacifica* occurred frequently in samples. I decided to take advantage of the opportunity to compare the responses of both species to variation in ocean climate.

Length frequency histograms for both species are presented in Figs. 13 and 14. For *T. spinifera,* there is a large influx of individuals shorter that 18 mm in August 1991. Abundance declines progressively as the animals grow. The most striking difference between the normal (1991) and warm (1992) years is that the abundance of smaller euphausiids is much lower in August 1992. The temporal variation in length frequency is similar for *E. pacifica.* However, there is an exceptionally large influx of smaller animals in October 1992.

Inferences on mortality from length frequency histograms can be misleading because more than one cohort can exist in a given year and these may show different growth characteristics. I began investigating this by examining the modality of length frequencies of samples. I found 8 cohorts for *T. spinifera* and 7 for *E. pacifica.* Cohorts were separated by identifying modes and then segregating distributions. These were assigned to cohorts using published seasonal growth trajectories for other sub-arctic latitude euphausiids. These curves suggested that growth begins in March-April and stops in October, which is coincidental with the upwelling season.

For *T. spinifera,* I suggest that cohorts 0, 1 and 2, 3 through 5, and 6 and 7 are from the 1989, 1990, 1991 and 1992 year-classes respectively (Fig. 15). For *E. pacifica,* cohorts 0, 1 and 2, 3 and 4, and 5 and 6 likely represent the 1989, 1990, 1991 and 1992 year-classes respectively (Fig. 16). I found for both species that the timing of spawning can have a great effect on growth. For example, *T. spinifera* cohorts 3 and 5 are from the same year-class. Cohort 3 animals were about 18 mm long at the beginning of the 1992 growth season (day 452=late March 1992) while cohort 5 animals were only about 11 mm long. I think that this is because the cohort 5 animals were produced so late in the 1991 growth season.

I found dramatic inter-annual variations in size-specific mortality. Catch curves for both species are presented in Figs. 17 and 18. For both species, mean length of cohort 1 individuals in 1991 was similar to that for cohort 3 in 1992. Lengths of cohort 2 animals in 1991 were similar to those of cohort 4 euphausiids in 1992. However, instantaneous daily natural mortality rates over summer (M), which are estimated as the slopes of the catch curves, were vastly different. M for *T. spinifera* cohort 3 (-0.016) was 8 times that for cohort 1 in 1991 (-0.002). Cohort 2 actually increased in abundance (M=+0.001) while cohort 4 didn't (M=-0.006). Results were similar for *E. pacifica.* While the abundances of cohorts 3 (M=-0.004) and 4 (M=-0.011) declined over summer, the similar-sized animals the year before became more abundant (M=0.005 and 0.027 for cohorts 1 and 3 respectively). This dramatic

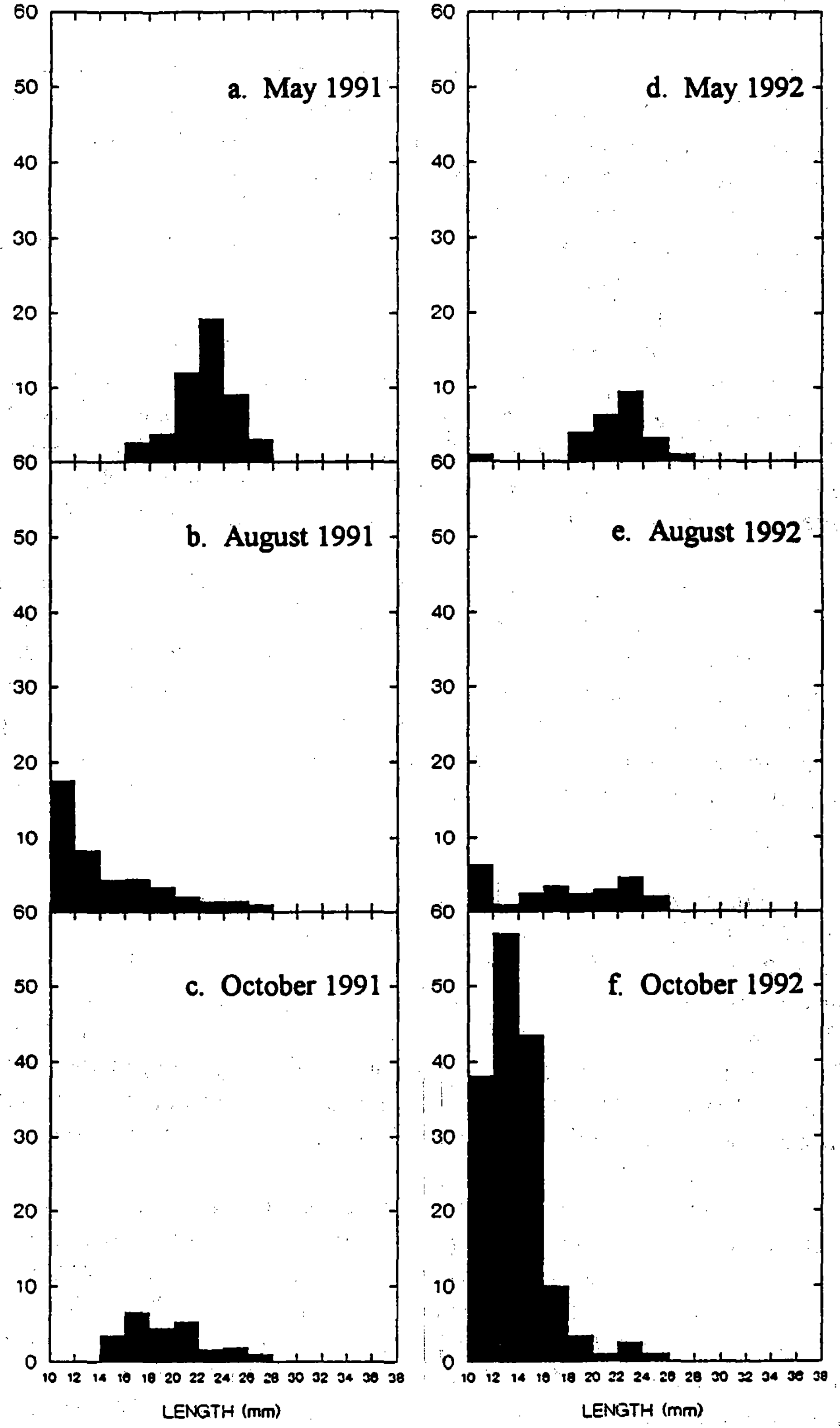

Figure 13. Length frequency histograms for E. pacifica. Values are numbers/m^3.

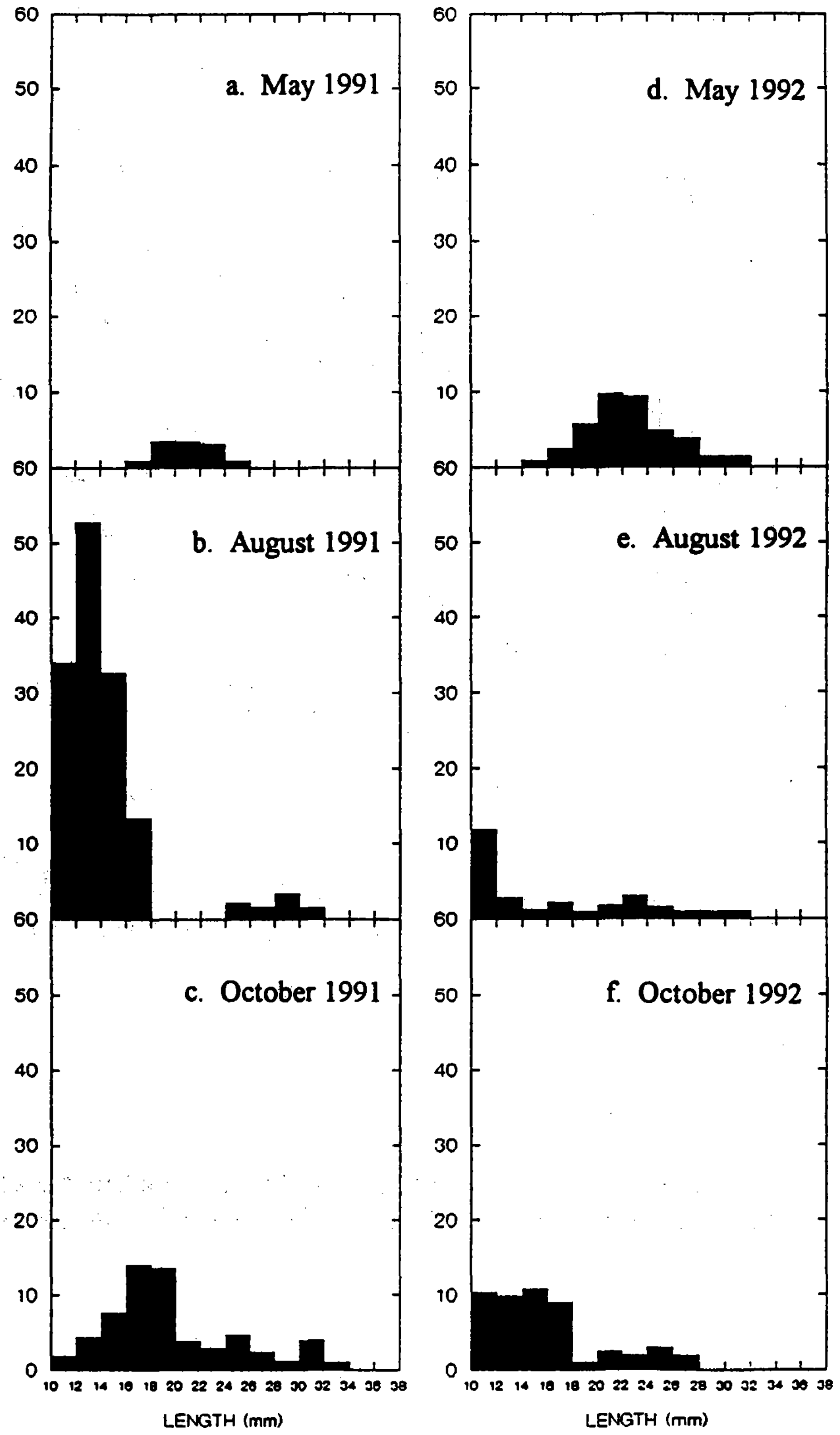

Figure 14. Length frequency histograms for T. spinifera. Values are numbers/m^3.

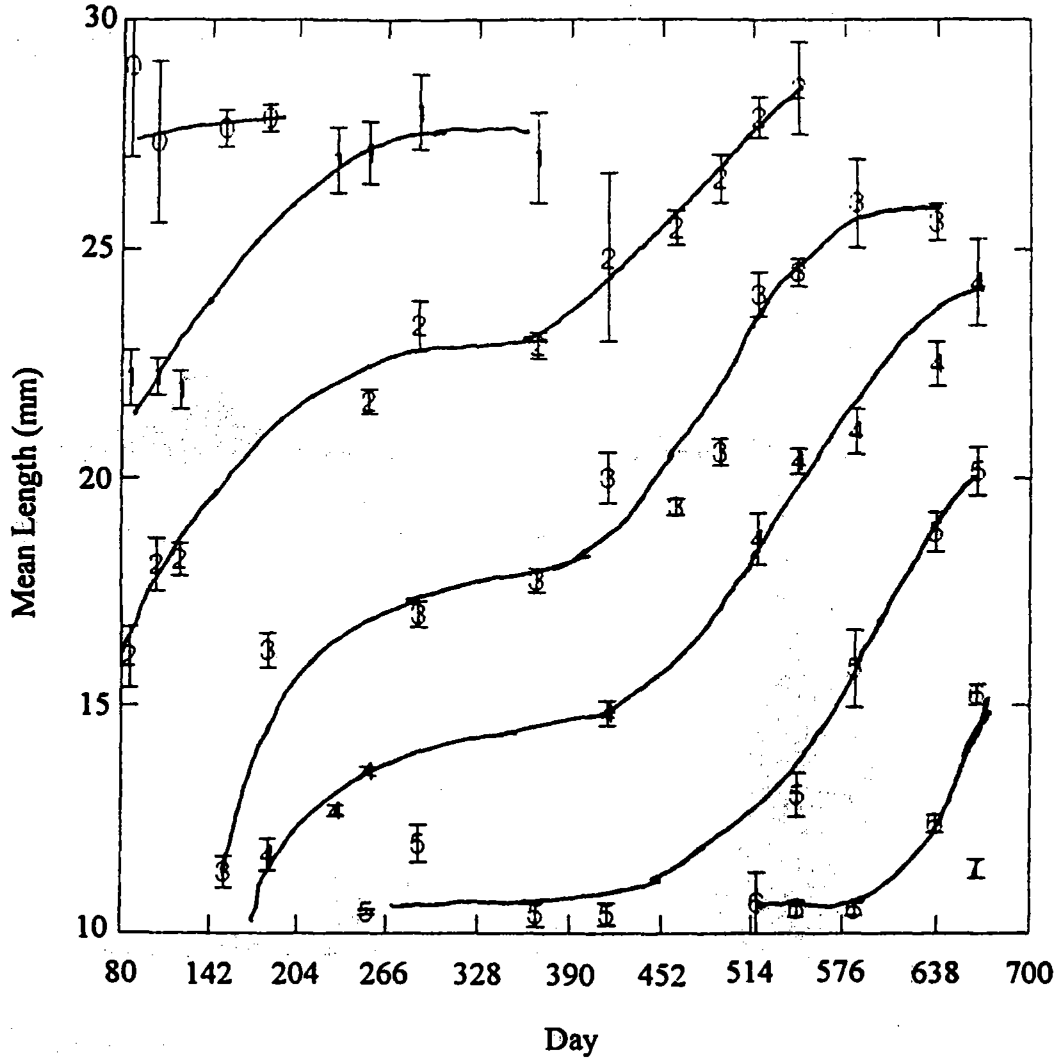

Figure 15. Mean length by cohort for T. spinifera. Error bars are 2 S.E. Day 1 = January 1, 1991. Plotting numbers = cohort. Growth trajectories fitted by eye.

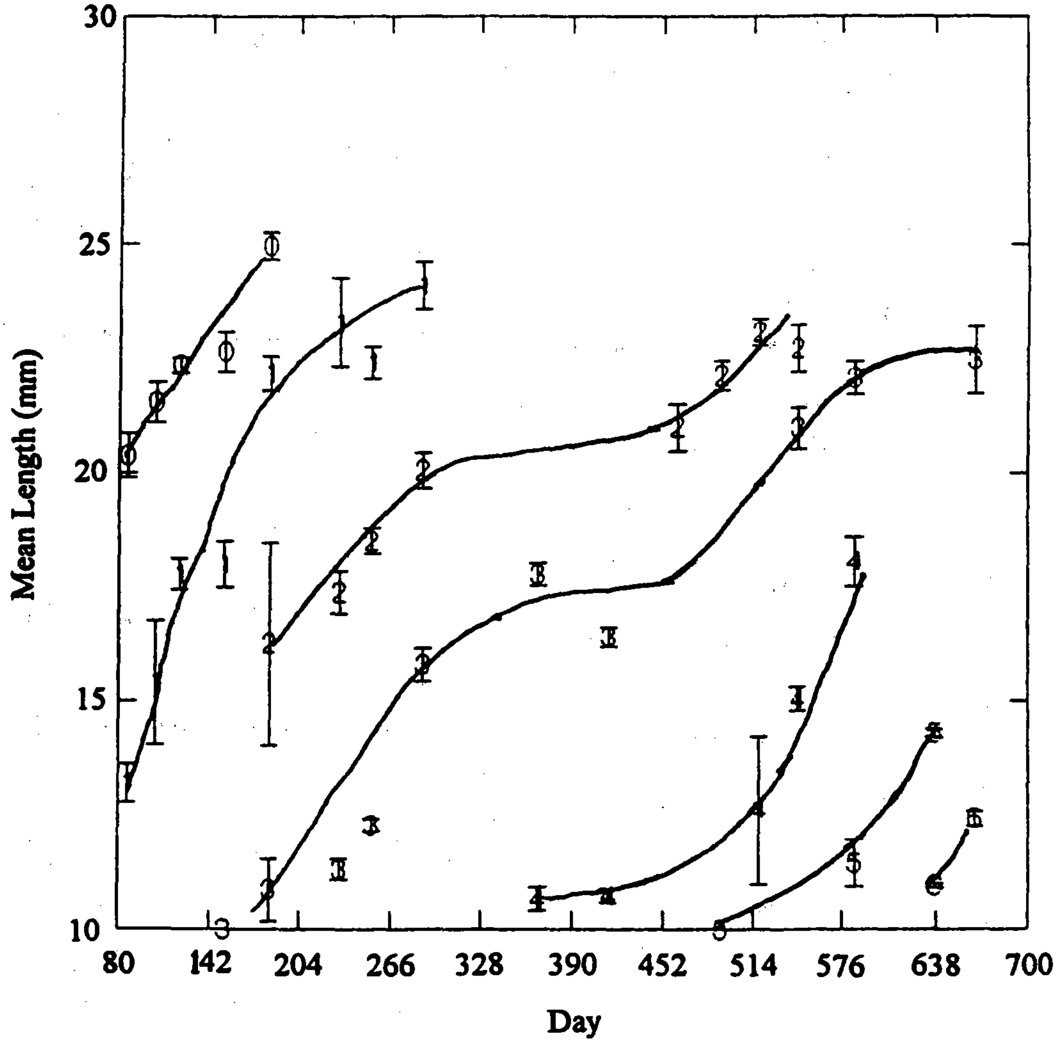

Figure 16. Mean length by cohort for E. pacifica. Error bars are 2 S.E. Day 1 = January 1, 1991. Plotting numbers = cohort. Growth trajectories fitted by eye.

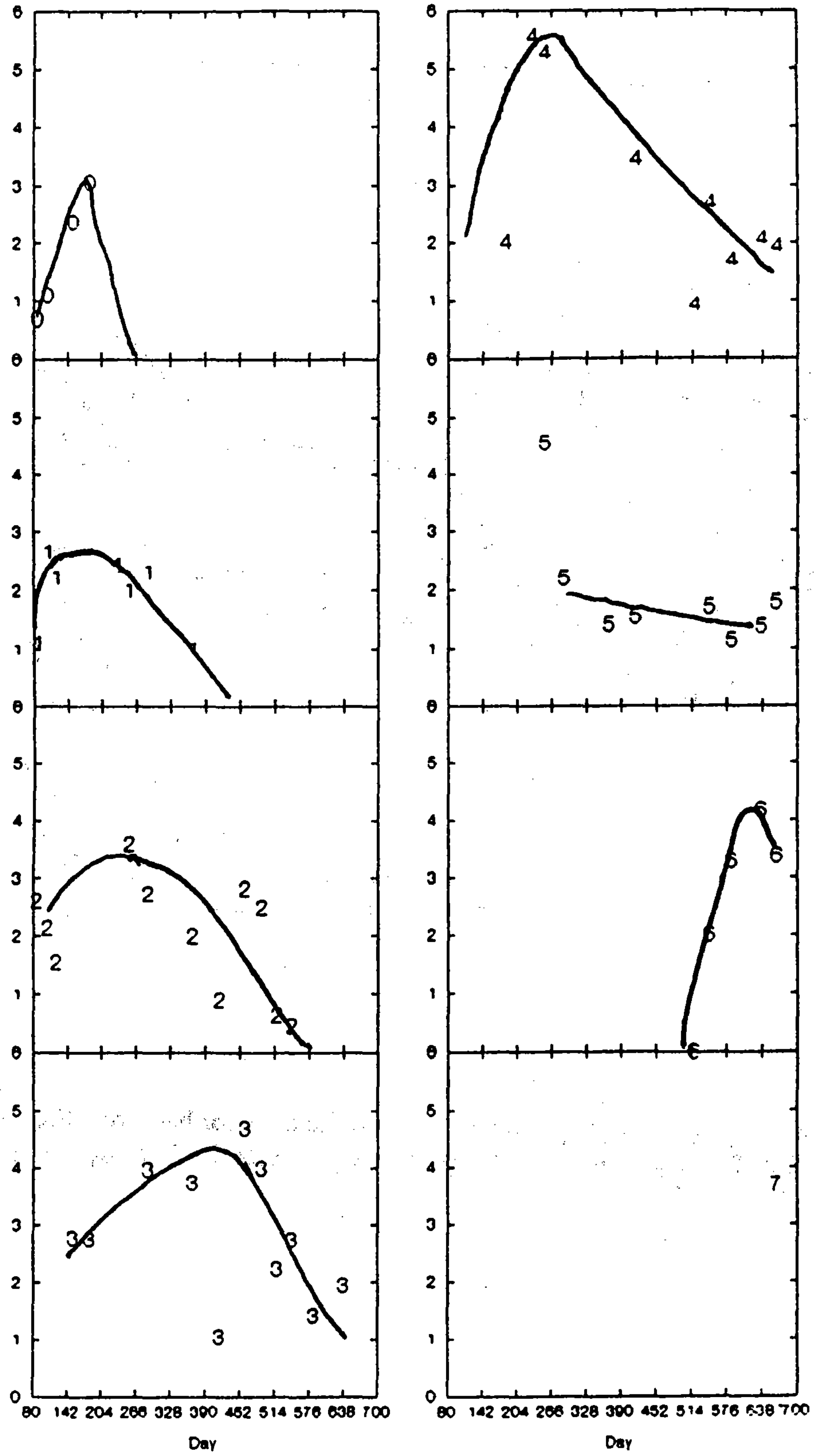

Figure 17. Catch curves for T. spinifera. Curves fitted by eye. Day 1 = January 1, 1991. Day 640 = October 1, 1992. Values are log numbers/m^3. Plotting symbols = cohort.

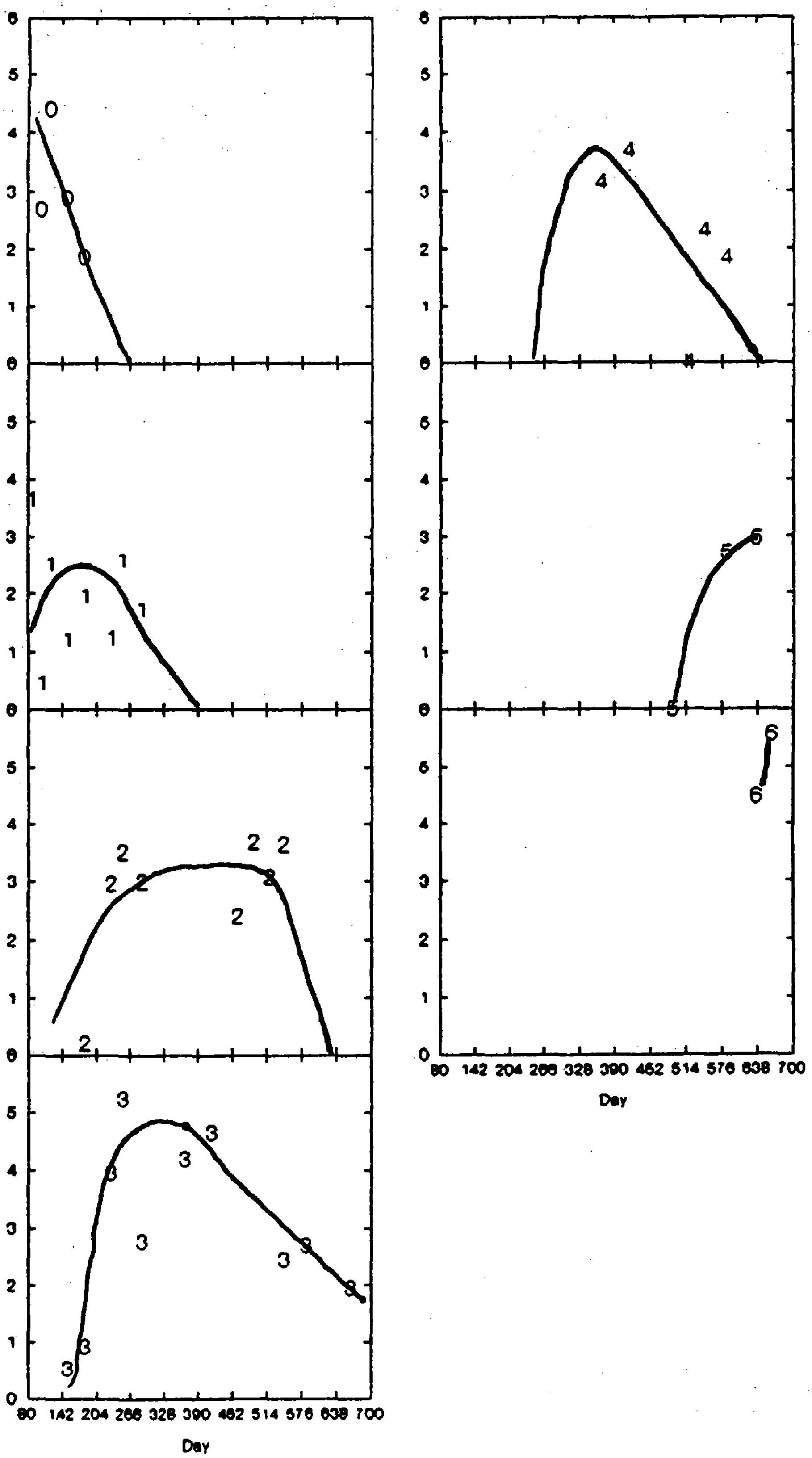

Figure 18. Catch curves for E. pacifica. Curves fitted by eye. Day 1 = January 1, 1991. Day 640 = October 1, 1992. Values are log numbers/m^3. Plotting symbols = cohort.

change in mortality coincided with the appearance of mackerel in Barkley Sound. In addition, the smoothness of the catch curves suggest no immigration or emigration of animals.

The results I presented show that there can be a severe impact of fish predation on euphausiid stocks. Detection of effects on other aspects of euphausiid population biology awaits sample and data analyses.

R. Tanasichuk

3.2.4 Processes controlling vertical exchanges of carbon along the Pacific continental margin

Further progress was made in analyzing the samples from the 1990 pilot moorings off Brooks Peninsula. To summarize results reported last year, sediment trap mooring yielded roughly the same total sinking flux over 6 months at two sites off the west coast of Vancouver Island, one under a recurring upwelling jet ('jet' site - Fig 4) and one in a control area north of the upwelling jet ('no-jet' site - Fig. 4). A one-week long spring bloom was observed at the 'jet' site, but results from the 'no-jet' site were inconclusive because of a malfunction in the sequencing motor. The sinking fluxes of total material in one-week samples over the 6-month study were highly correlated with the silica amount in each sample, indicative of dominance by diatoms with significant skeletal structures. Amounts of organic C and N in the samples were inversely correlated with the sinking fluxes. Our interpretation of this result is that during high flux periods, much of the sample consists of the remains of diatom shells after grazing, which are slow to dissolve and be oxidized relative to the organic C and N in the sinking debris.

The isotope analyses of the trap samples have now been completed and show the following features. The $\delta^{13}C$ isotope analyses of the trap contents yield values between -17 and -25 ppt. They span the range of values typical for coastal diatoms to values found in the trap samples at Ocean Station Papa. The time series of $\delta^{13}C$ and $\delta^{15}N$ isotopes for the southerly ('jet') site are shown in Fig. 19, both plotted together with the sinking flux of carbon. Before and especially during the spring bloom peak (just before Julian Day 150 = 30 May), $\delta^{15}N$ was low and increased abruptly after the flux maximum (bloom). The low values during the bloom may reflect preferential uptake of the lighter isotope during periods of lower growth rates when nutrients were probably limiting. The $\delta^{13}C$ trends are more complex: heavier values are found during the bloom, after which they decrease, but there are two other periods of heavier values during the low flux period following the bloom. The heavier values (more ^{13}C) during the bloom may reflect less fractionation of the isotopes during rapid phytoplankton growth, whereas the heavy values centred at day 220 and day 270 may be related to dissolved CO_2 limitation during periods of nutrient depletion.

Two questions have been raised: (1)regarding the possible input of terrigenous materials and the contribution of this fraction to the overall flux, and (2) regarding the fate of sinking biogenic materials.

First, Scanning Electron Microscope photographs of the samples show abundant diatoms, with some background unidentifiable debris. However, there is no indication, either from the SEM photographs or the isotope data, that the trap samples contain significant amounts of terrigenous materials. Furthermore, Macdonald and Pedersen (1991) pointed out that the residence time for the Fraser River runoff before it reaches the Vancouver Island shelf is about 0.8 years, ensuring that most of the terrigenous materials would already have been removed. Also, even runoff from local streams probably delivers little terrigenous material onto the shelf, rather it sinks out in the fjords. They cite as evidence C:N weight ratios of around 6 off Alberni Inlet, characteristic of marine detritus rather than of terrigenous materials which have C:N ratios normally above 16, ranging as high as 30. The organic C:N weight

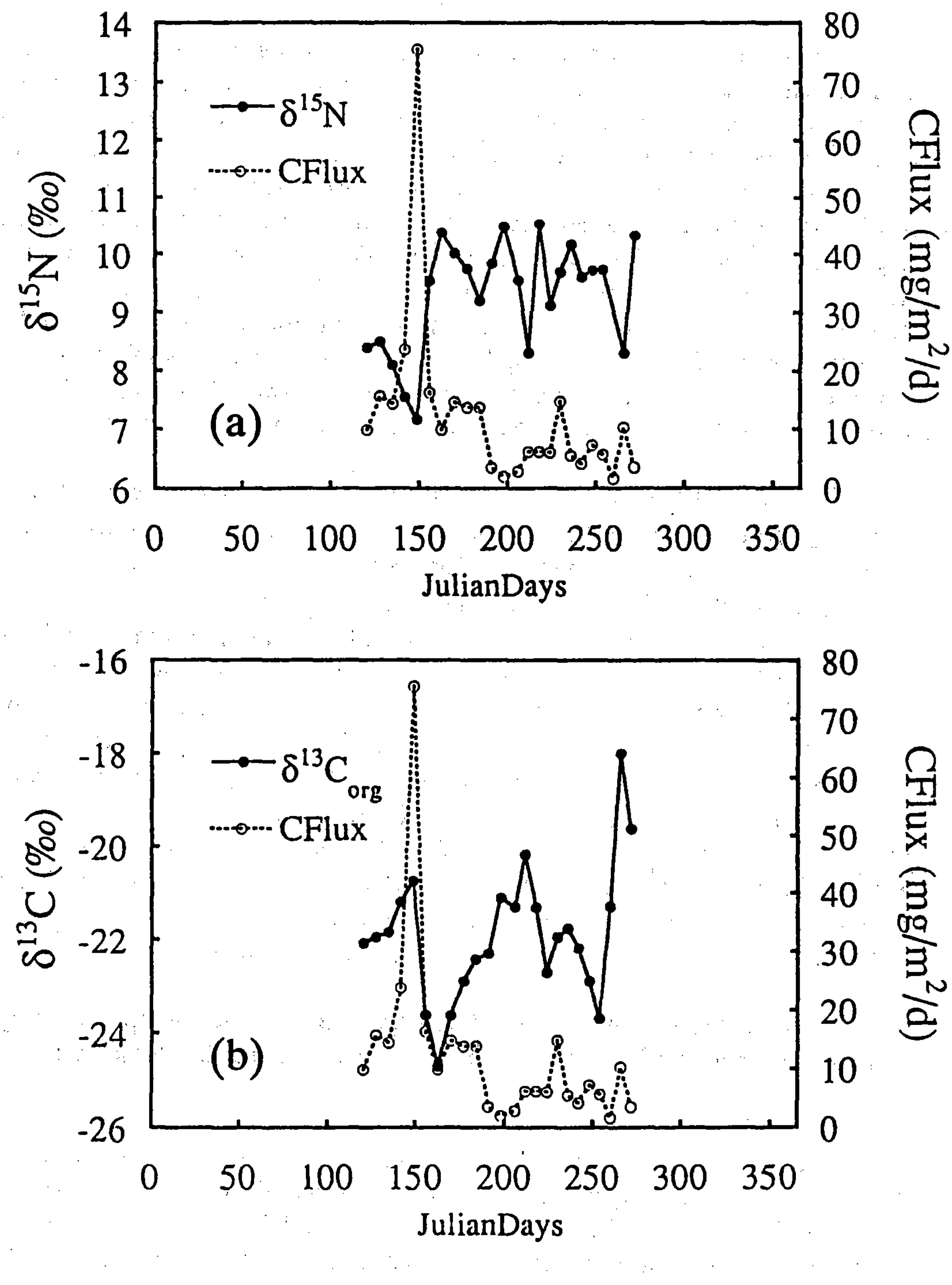

Figure 19. Time series of isotope ratios (a) $\delta^{15}N$ and (b) $\delta^{13}C$, and carbon sinking flux for the 1990 "Jet" sediment trap mooring south of Brooks Peninsula on Vancouver Island, 49°38.9'N; 127°37.8'W. Heavier isotope ratios are upwards on the graphs. Courtesy of Dr. Steve Calvert, University of British Columbia.

ratios from our trap samples range from 6 to 9, comparable with those from Ocean Station Papa (6 to 8) and again indicative of materials of marine rather than terrigenous origin. Unfortunately, geochemical studies of the benthic environment off Vancouver Island have been few, and much information has been inferred from studies off Washington and Oregon.

Second, we searched the Pacific Geoscience Centre's core and grab collections for bottom samples in the vicinity of our traps. There were no cores and only two grabs off the continental shelf, which were reported as containing mixed sand and gravel. The shelf of Vancouver Island in known to be covered with relict and reworked, coarse-grained sediments, with very little modern, equilibrium sedimentary material (Bornhold and Barrie, 1991). To address our lack of knowledge of the geochemistry of the shelf and slope regions off Vancouver Island, R. W. Macdonald of IOS, and Steve Calvert and Tom Pedersen of University of British Columbia are planning a study of the sediments in these areas. Initially they plan to obtain several large box cores in the area, possibly in 1994 depending on shiptime availability, and perform an extensive set of geochemical analyses on these core samples.

Research Plans:

In October 1993, the sediment traps will be deployed at the five sites given below, with site 'F' as the lowest priority if bad weather results in too much lost time. It is hoped that the sediment traps will be serviced in April 1993 and redeployed for the 1994 spring bloom. Because the Tully is supposed to carry out a North-South WOCE line roughly the last 4 months of 1994, it may be necessary to recover the traps in August 1994. Depending on DFO Green Plan funding, ship availability, and equipment losses, we would like to deploy some of the traps for a second year, i.e. 1994-95. Subsequent to that, we would like to deploy one mooring with several sediment traps at different depths to determine the vertical gradient of the remineralization rate, whereby organic particles are oxidized back to inorganic nutrients and carbon by the action of bacteria.

J	50 02.5' N	128 51.8' W	1950 m
G	49 39.0' N	127 38.0' W	550 m
O	49 09.0' N	127 45.9' W	2475 m
F	49 00.7' N	127 15.3' W	2000 m
S	48 47.0' N	128 00.0' W	2500 m

References:

Bornhold, B.D., and J.V. Barrie, 1991. Surficial sediments on the western Canadian continental shelf, Continental Shelf Research, 11, 685-699.

Macdonald, R.W., and T.F. Pedersen, 1991. Geochemistry of sediments of the western Canadian continental shelf, Continental Shelf Research, 11, 717-735.

K. Denman (Project Leader), R. Forbes, R. Thomson, S.E. Calvert

3.3 FISHERIES OCEANOGRAPHY PROGRAM

3.3.1 Summer Pelagic Fish Distributions and Trophic Interactions

An exploratory analysis of the existing oceanographic and fisheries data for the 1960-81 period (Ware and McFarlane 1986 - see section 5.) at the onset of the project indicated that year-class strength of the lower west coast of Vancouver Island (LWCVI) herring stock was negatively correlated with: 1) the summer biomass of hake in the Canadian zone, and 2) the annual surface water temperature. These findings were corroborated by a more extensive analysis of herring recruitment and growth using the complete historical data base which extends back to the 1930s (Ware 1991). More recent work has also uncovered a negative correlation between winter wind stress and year-class strength: very windy winters produce poor year-classes (Ware and Tanasichuk 1993. PSARC Working Paper)

Guided by these relationships, a program was designed to determine if mortality of pre-recruit and adult herring was related to: 1) the spatial and temporal overlap in the herring, and offshore predator distributions on the continental shelf, and 2) the abundance of alternative prey during the upwelling season (May to October). Since the inception of the program in 1985, the LWCVI herring stock has averaged 32 thousand tonnes in mid-summer, which is below the long-term average. There are eight key predator species in the La Perouse Bank area. In order of importance according to the size of stock and amount of herring they consume, they are: Pacific hake, chinook salmon, coho salmon, lingcod, Pacific cod, dogfish, sablefish and halibut. Pacific hake account for 1/3 of all predator-related herring deaths, which makes them the single most important predator species. This independent diet analysis corroborates the statistical evidence above, and provides a causal predator-prey interaction to account for the significant negative correlation between herring recruitment and hake biomass.

The two most abundant prey items of commercial-sized fish at La Perouse Bank are euphausiids and herring. Euphausiids are the dominant prey accounting for 21-63% of the mid-summer diet of offshore predators; herring make up 12-71% of the diet, depending upon the predator species (Ware and McFarlane 1994). Preliminary estimates suggest that virtually all estimated natural mortality of the LWCVI herring stock can be accounted for by predation.

The results of the program to date indicate that interannual variability in summer oceanic conditions has an impact on predator-prey interactions, and herring mortality. Two important changes occur in warm summers like 1992. First, a retrospective analysis of 13 years of midwater trawl survey data in the La Perouse Bank area (8 years of our own surveys and 5 others dating back to 1968) convincingly demonstrates that significantly more hake migrate northward into the La Perouse survey area in warm summers (Fig. 20; Ware and McFarlane 1994). For a 1^{o} C rise in summer temperature, 174,000 more tonnes of hake enter the area ($p<0.001$). Second, modelling studies suggest that this increased abundance of hake quickly grazes down the euphausiid stocks on the continental shelf and in the Juan de Fuca Eddy. In response to this depletion of the local food supply, hake begin moving, earlier than usual, to comparatively better feeding grounds along the shelf-break (Ware and McFarlane 1994).

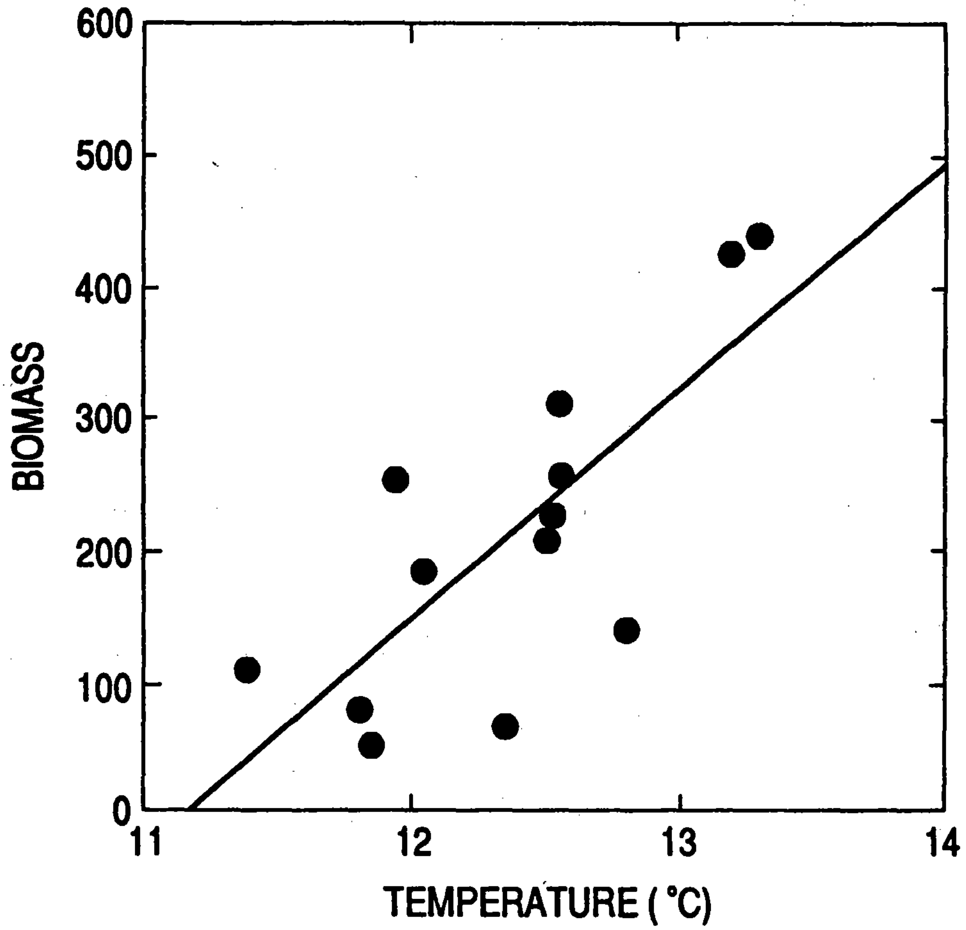

Figure 20. Relationship between the average June & July sea surface temperature and the summer biomass of hake in the survey area for 13 summer surveys conducted between 1968 and 1991.

1992 Multispecies Survey

The 1992 mid-water trawl survey of the herring, hake and dogfish stocks off the lower west coast of Vancouver Island was conducted by the R/V *W.E. Ricker* between July 29-August 7. The survey covered 6000 km^2 of the continental shelf from the U.S.-Canada border, to 49^o N, and seaward to the 200 m isobath. Thirty-two mid-water tows were made to determine species composition, diet, and length and age composition of the dominant pelagic fish species in the area (Fig. 21). This multispecies trawl survey has been conducted annually for the last 8 years, as part of the La Perouse Bank Project. A principal objective of this project is to quantify how interannual changes in oceanic conditions, and in the distribution and abundance of offshore predators, affect herring recruitment and mortality.

Hake Distribution

The hake stock was most highly concentrated off the mouth of Barkley Sound in subareas 4 and 8, and along the shelf-break (near the 200 m isobath) in subarea 13 (Fig. 22). The concentrations in subareas 4 and 8 are fairly typical for this time of year. However, the concentrations along the shelf-break so early in the summer are indicative of ENSO conditions.

Pacific Sardine Distribution

Sixty-four Pacific sardine were captured in five tows made in subarea 4 (close to the 100 m isobath) between August 4 and 5. The first sardine was discovered in a tow dominated by herring. The largest catch of sardine (42 fish) was obtained from a tow targeted on mackerel (concentrated at depths between 40-70 m) , which were distributed on top of a layer of hake, found at 70-90 m depth. In order of abundance this set caught a mixture of dogfish, hake, Jack mackerel, herring, sardine, and Pacific mackerel. The presence of Pacific sardine in the La Perouse Bank area in the 1992 survey, and two others in the area, represent the first confirmed catches of Pacific sardine in B.C. waters since the 1950s (Hargreaves, Ware & McFarlane, 1994. in press). It is also of interest that Ron Tanasichuk found sardines overwintering with herring in the Strait of Georgia in March 1993. He found two sardines during a routine herring maturity sampling program.

Mackerel Distribution

More Pacific and Jack mackerel were caught during the 1992 survey than at any time since 1985 (both species were abundant in the area during the last strong ENSO event in 1983 and 1984). Jack mackerel were the most abundant and widely distributed of the two species in the survey area (they were found in subareas 1,2,6,7,8,9,10; Fig. 22) and were caught in 16 of 32 tows in 1992 . Pacific mackerel were caught in 9 tows, primarily in subareas 1, 7, 9 and 10. The unusally high abundance of both species was related to the 1992 ENSO warm event.

Herring Distribution

The spatial distribution of different ages of herring varied markedly between subareas

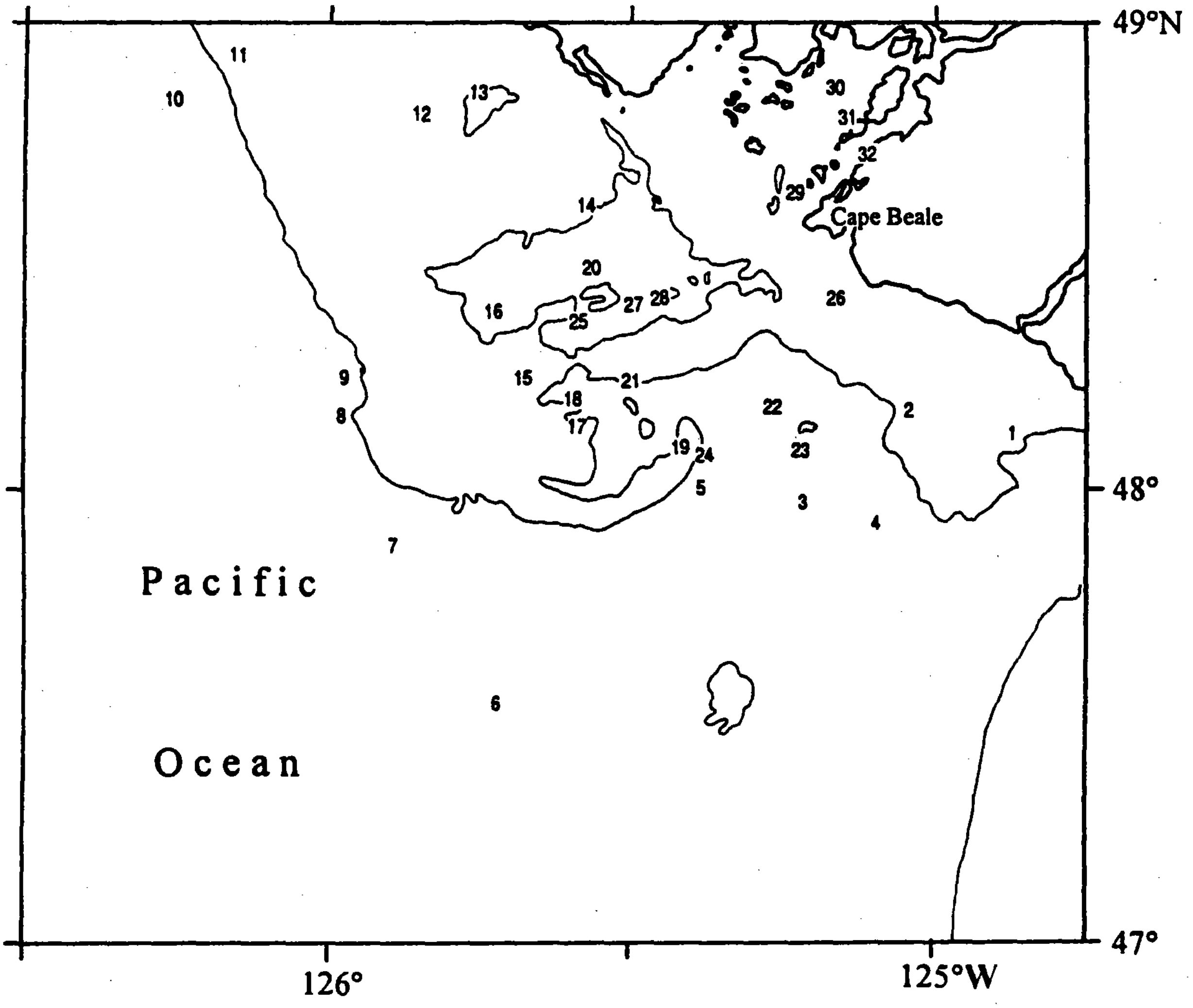

Figure 21. Postions of mid-water tows made during the 1992 August survey over La Perouse Bank.

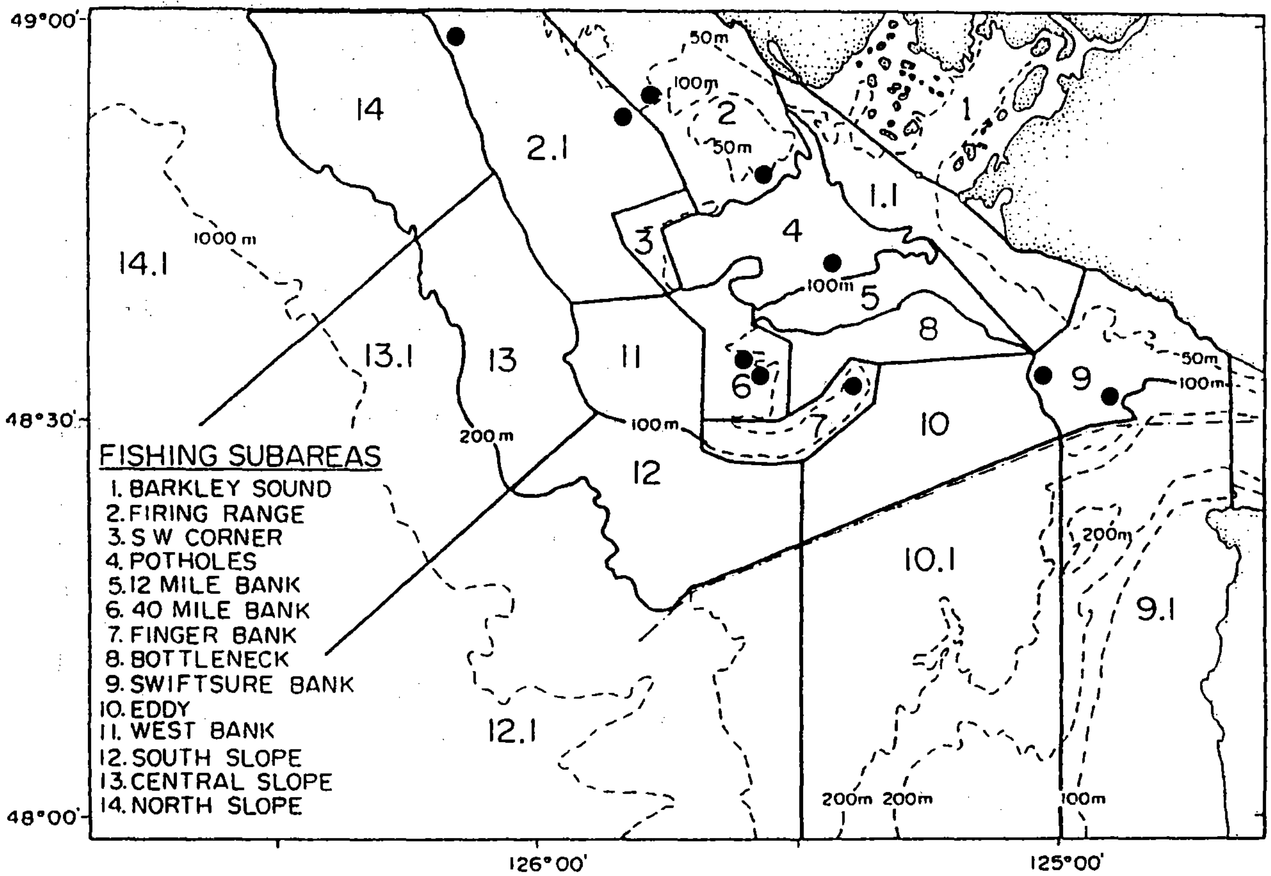

Figure 22. La Perouse Bank fishing subareas. Dots (●) denote position of the herring mid-water tows.

during the 1992 survey. This is typical in this region in the summer. Young-of-the year herring (age 0+, the 1992 yr-class) were not plentiful offshore during the survey. The small numbers we ecountered were in the northern part of the survey area and in Barkley Sound. Age 1+ juvenile herring were most abundant in the northern part of the shelf (subareas 14, 2.1, and 2) and Swiftsure Bank (Fig. 22). Age 2+ (prerecruits) and older, adult herring were most abundant on 40-mile (subarea 6) and Swiftsure Banks (subarea 9). Last year we found large concentrations of adult herring (age 3+ and older) near the outer edge of the continental shelf (subarea 12). This year we didn't find enough in subareas 12 and 13 to justify making a tow.

Predator Diets

The diets of 1663 hake, 511 dogfish, 122 Pacific mackerel, 111 Jack mackerel, and 155 chinook salmon were examined at sea. Euphausiids made up 57%, and herring 36% of the diet (by weight) of hake. The corresponding 8-yr average values for hake in August are 60% and 32%, respectively. Euphausiids made up 32%, and herring 37% of the diet (by weight) of dogfish. The 8-yr average values for dogfish are 58% and 12%, respectively. Thus both hake and dogfish had slightly lower proportions of euphausiids in their diets, and higher proportions of herring in their diets in 1992.

1993 Herring Recruitment Forecast

The relative abundance of maturing age 2+ fish encountered during the August trawl survey is being used to forecast the proportion of the same age group (which will appear as recruit spawners) six months later in early March 1993 in the Barkley and Clayoquot Sounds spawning stock. This forecast is used in association with the age-structured herring stock assessment model to determine the projected biomass of new recruits, and hence the fishing quota recommended by the Pacific Region Herring Stock Assessment Committee.

Based on the relative abundance of age 2+ herring encountered during the survey we forecast in September 1992 that 24% of the Barkley and Clayoquot Sounds spawning stock will consist of age 2+ recruits in the spring of 1993. Fig. 23, summarizes the 'track-record' of the forecast since its inception ($n=7$, $p=0.018$). To date, our sampling procedure has produced a fairly reliable projection. The August 1992 forecast was quite accurate since the anticipated recruitment frequency of 24% was remarkably close to what was measured (26%) by the pre-fishery charters in Barkley and Clayoquot Sounds prior to the 1993 roe herring fishery.

Future Activities

The 1992 diet information corroborates the mechanism that we hypothesized was behind the negative correlations between herring year-class strength, hake biomass, and water temperature. These results are being incorporated into a multispecies predator-prey model that will be used to estimate interannual variability in herring natural mortality rates (in collaboration with Cliff Robinson).

D. M. Ware
R.W. Tanasichuk

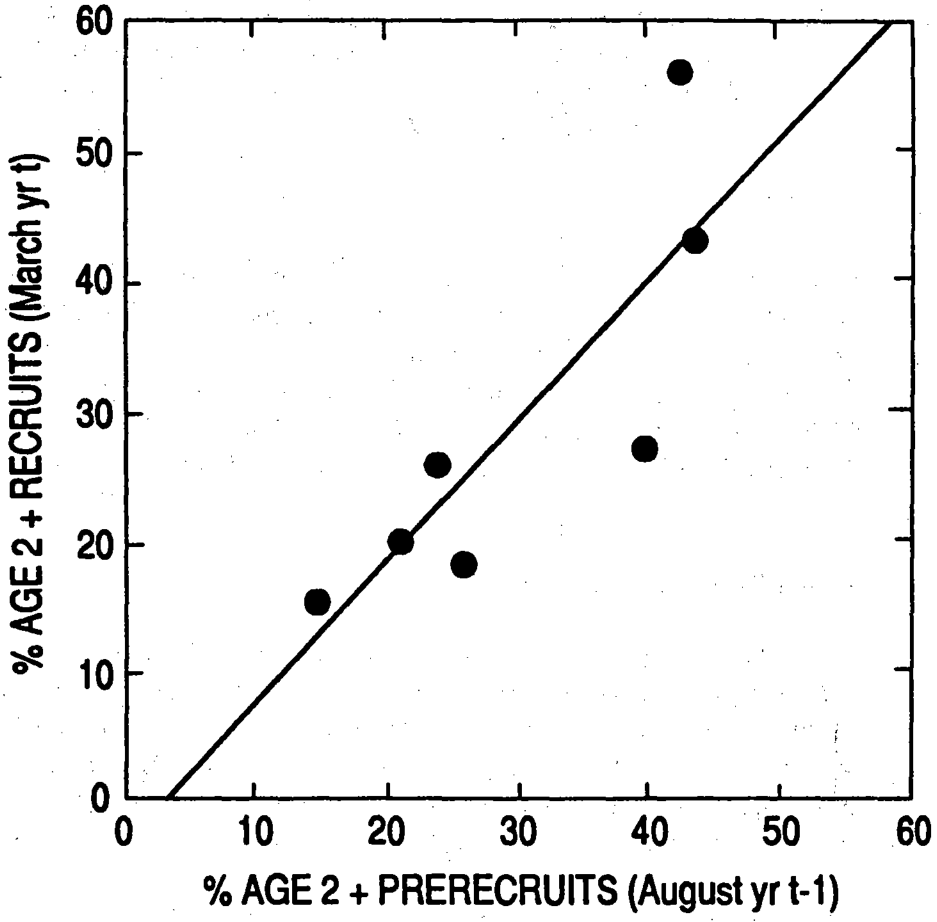

Figure 23. Relationship between the % age 2 + (prerecruit) herring measured in August (yr t-1) in the La Perouse survey area, and the % of the same yr-class measured six months later in the spawning stock in March (yr t).

3.3.2 Pacific Hake Distribution and Recruitment

Pacific hake (*Merluccius productus*) is the most abundant species in waters off the west coast of Canada and is a major component of the groundfish fishery. The offshore stock is migratory and, after spawning off California and Mexico during the winter, moves northward to feed during the summer from northern California to Queen Charlotte Sound. Schools of adult hake first appear off Vancouver Island in late May and remain until late November. The southward migration may be triggered by the onset of the fall transition.

Total reported catches in the Canadian zone averaged 90.5 Kt over the five year period 1988-1992. The catch in 1992 decreased to 86,370 t from 104,522 t in 1991. Participating countries in 1992 were Poland, China and Japan. In 1992, most hake was landed through a joint venture with Canadian fishermen. Interest in domestic processing of hake, in particular in the Ucluelet area, continues to grow.

The proportion of the stock supporting the Canadian fishery is in good condition as the Canadian fishery continues to be supported by a series of strong year-classes, in particular, 1980, 1984 and 1987/88. Over the last several decades Pacific hake have generated strong-year classes approximately every 3-4 years. The stock overall is beginning to decline in abundance as the strong 1984 and 1980 year-classes are declining. There is no indication yet that either the 1990 or 1991 year-classes are strong. It is anticipated that quotas will decline over the next several years unless recruitment increases.

The objectives of this study are: (1) to determine the distribution and relative abundance of Pacific hake in Canadian waters on an annual basis; (2) to examine distribution in relation to oceanographic and biological features; (3) to determine biotic and abiotic factors controlling year-class success; and (4) to determine the impact of Pacific hake and other predators on the abundance of Pacific herring (with D. Ware and R. Tanasichuk).

Research on the distribution, abundance and biology of this stock has been conducted annually since 1977. Qualitative surveys examining the distribution of hake were conducted annually from 1985 to 1989 and found hake from the Canada-U.S. border to Queen Charlotte Sound. In 1990, 1991 and 1992 hydroacoustic surveys were conducted over this range. In general, large concentrations were found in the basins adjacent to La Perouse Bank and adjacent to Brooks Peninsula. Smaller, dense schools were found along the 150-200 m isobath (Fig. 24).

In 1992 a coastwide hydroacoustic survey was conducted by the U.S. using the NOAA ship *Miller Freeman*. A side by side comparison of the Canadian and U.S. acoustic systems indicated that over the range of hake densities observed, the two systems recorded similar biomasses. Overall results of the independent surveys of the Canadian zone were comparable with the U.S. finding of 932 Kt and the DFO survey finding of 1,101 Kt. This was a substantial increase from the 1990 and 1991 estimates of 316 Kt and 568 Kt, respectively. The high level of abundance in the Canadian zone was expected due to the warm ocean conditions and the positive correlation between high temperatures and the proportion of

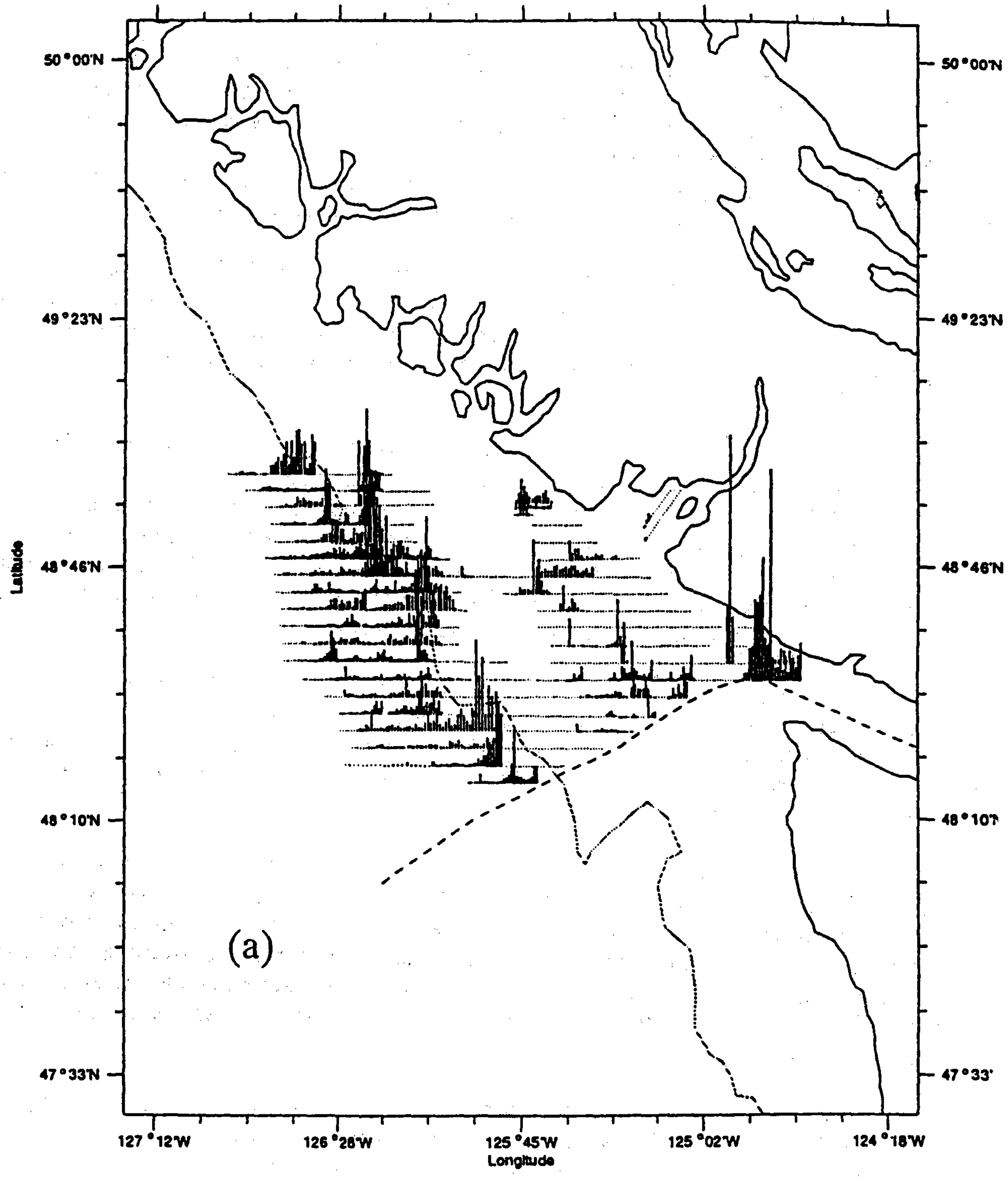

Figure 24a. Southern portion. Distribution of hake biomass during August 1992 based on the DFO hydroacoustic survey. A bar height of 1 degree of latitude corresponds to a surface density of 5 kg m^{-2}. Target strength = -35 dB/kg.

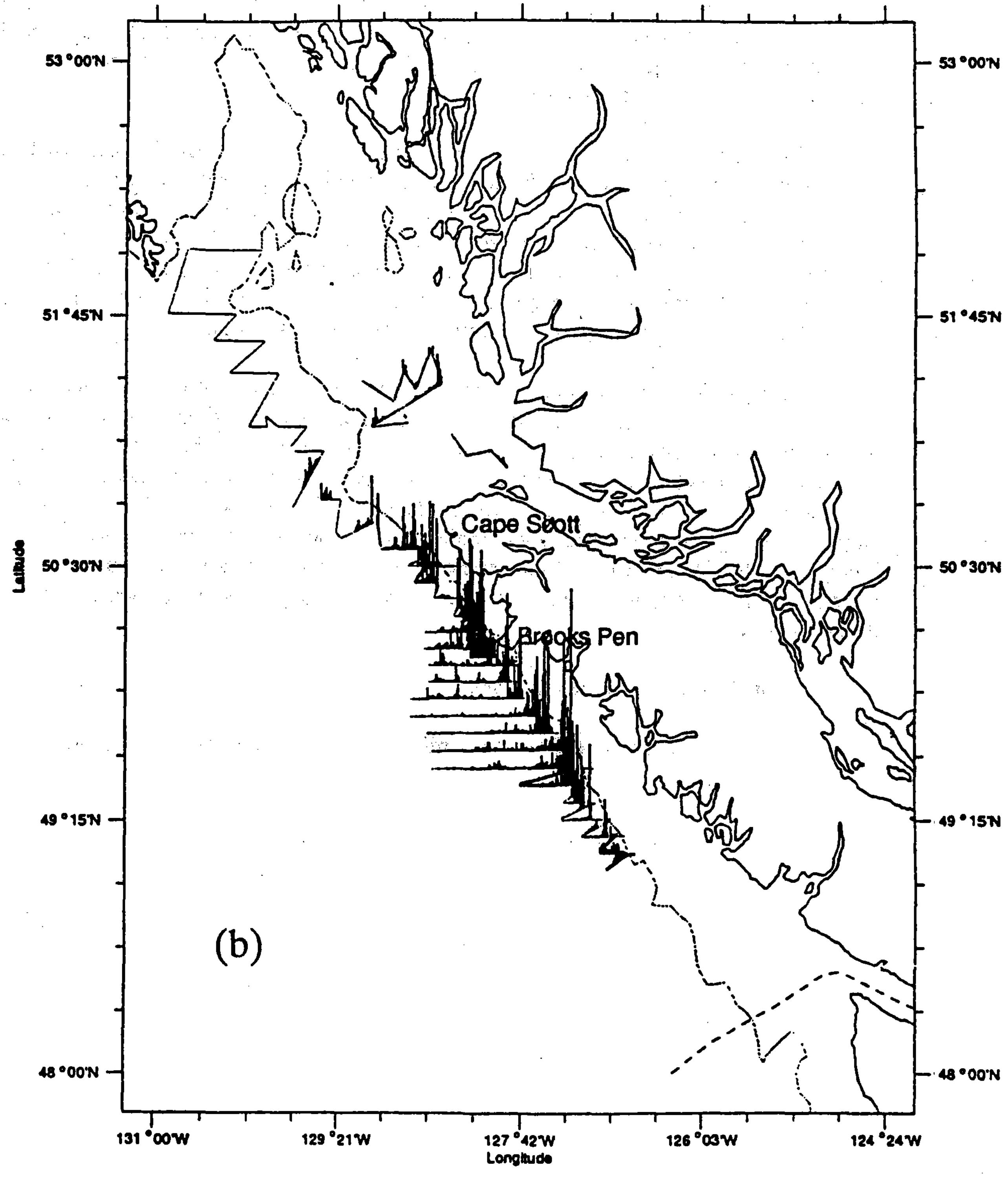

Figure 24b. Northern portion. Distribution of hake biomass during August 1992 based on the DFO hydroacoustic survey. A bar height of 1 degree of latitude corresponds to a surface density of 5 kg m^{-2}. Target strength = -35 dB/kg.

hake in the Canadian zone. Tracklines were extended further offshore in 1992 than in previous surveys due to a light scatter of hake that persisted seaward of the shelf/break. This offshore extension was also noted during the concurrent U.S. survey and may reflect anomalous oceanographic conditions coastwide.

The 1990-92 survey data were used extensively in analysis related to Canada/U.S. negotiations regarding allocation of yield. Briefly, negotiators agreed to use coastwide surveys conducted by the U.S. to determine the proportion of total coastwide biomass found in the Canadian zone. This same proportion would be used to split available yield. The U.S. surveys however, did not go beyond 50 degrees with one going only to 49 degrees. The Canadian surveys provided evidence of substantial quantities of fish north of the U.S. survey limits and formed the basis for increasing the proportion accredited to Canada.

During 1992 work continued on the factors affecting the distribution of hake we have examined the effect of physical and biological environmental conditions on hake distribution. The distribution of hake matched very closely the distribution of euphausiids reported by Simard and Mackas (1989 - see section 5.). Given the importance of euphausiids in the diet of hake it appears that the distribution of hake is linked to the distribution of their primary prey. A cooperative program with industry was initiated to examine the interannual variation in the timing of entry of hake into the Canadian zone. Preliminary analysis indicated that commercial quantities were present in the Canadian zone as early as May throughout the summer range of hake (Fig. 25).

Future research will include the following:

1. Continue to examine the factors influencing the summer and winter hake distribution.

2. Examine factors controlling hake year-class success.

M.W. Saunders
G.A. McFarlane

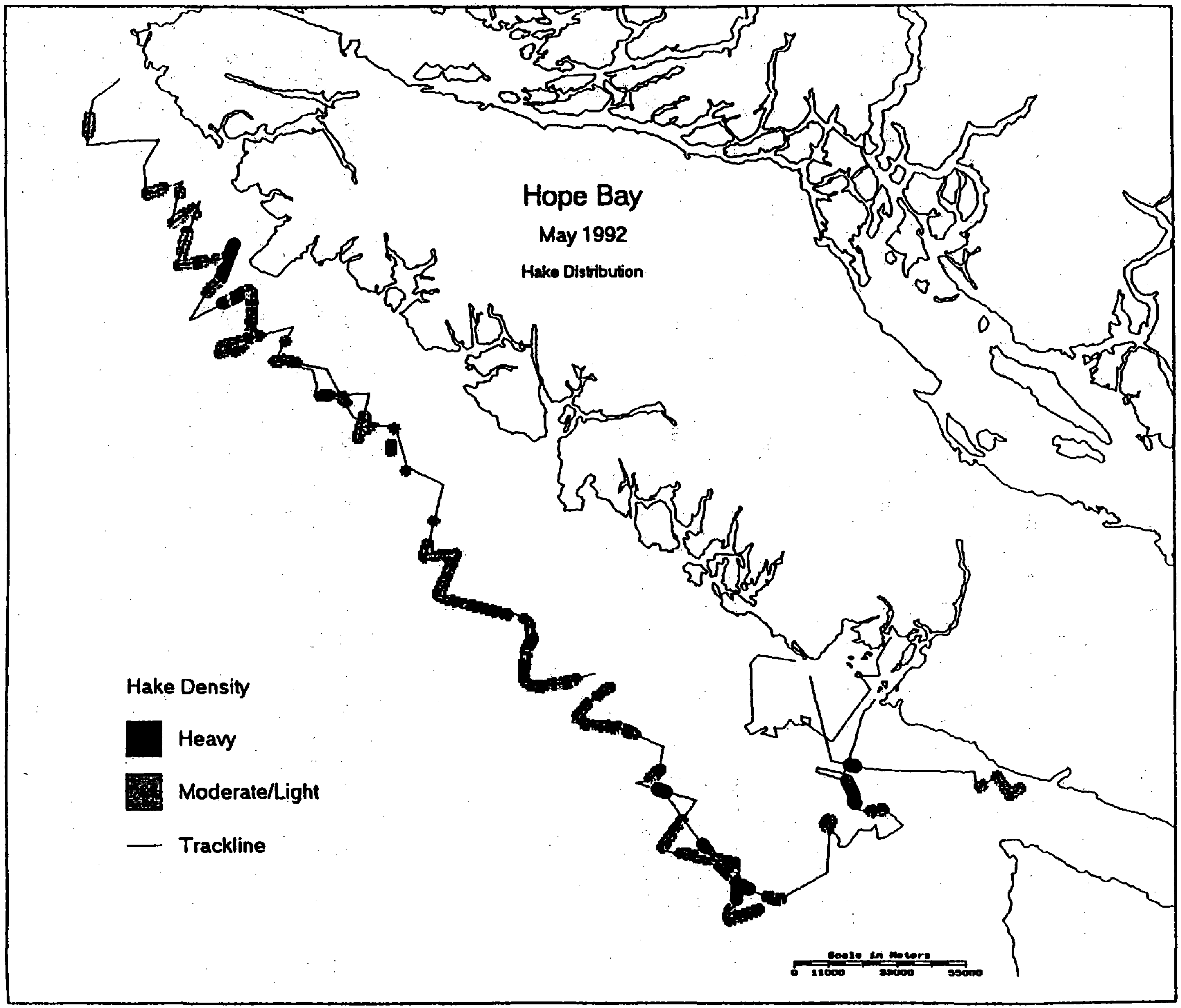

Figure 25. Subjective estimates of hake density during May 1992.

3.3.3 Larval/juvenile fish and plankton interactions

General Overview

This project concerns the cross-shelf exchanges and interactions of plankton off the west coast of Vancouver Island, and the impact of these exchanges for larval and juvenile fish production and growth. Mackas (1992 - see section 5.) identified a general seasonal flux of zooplankton from the continental shelf to the shelf break and open ocean. Yet McFarlane (pers. comm.) has suggested that successful recruitment of sablefish (which spawn at the shelf break in spring) can depend upon transport of larvae to protected nearshore "nursery areas". Further, the contrasts between the shelf zooplankton and larval fish community and the community over the continental slope and deep ocean are very clear and quite sharp, occurring over a few 10's of km at about the location of the shelf break. Hargreaves (pers. comm.) has found that the extent of juvenile salmon distributions across the shelf during their northward migration in early summer can be highly variable, and appears to be poorly (at best) related to prevailing hydrographic and current patterns.

The general thrust of these 3 projects is to determine whether these distinct shelf and slope communities can be identified by chemical signals, e.g. stable isotope anomalies, and are these different anomalies consistent up the food web? Second, how much exchange is likely to occur between these two communities, and what are the dominant physical oceanographic processes that are likely to regulate such exchanges? Third, can the constant nature of these communities and their stable isotope anomalies be used as tracers to indicate whether highly migratory fishes, such as juvenile salmon, feed predominately on plankton communities on the shelf or over the slope regions. The answer to this final question has bearing on the dynamics of control of zooplankton biomass and resulting growth and potential survival of these small fishes.

Stable isotopes as tracers of larval fish food-webs during spring of sw Vancouver Island
(R. Ian Perry, Peter A. Thompson and Paul J. Harrison)

This project explores the use of stable isotopes of carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) as tracers of food-web pathways off southwest Vancouver Island during spring 1992. The principal vector is from phytoplankton to larval fishes. The purpose is to determine if these stable isotopes may be used as indicators of the dominant feeding locations of larval and juvenile fishes, i.e. whether feeding occurred predominately on the continental shelf, or at the shelf break and beyond the continental shelf. Although sample analyses are continuing, preliminary results indicate that distinct differences existed in the $\delta^{13}C$ anomalies of several size classes of particulate material (phytoplankton), and in larval fishes, between the continental shelf and the shelf break (e.g. Fig. 26). Carbon isotope anomalies were significantly lower in the La Perouse Bank region in all size classes of particulate material (mean anomaly value of -20.9 over all size classes) compared with samples collected at the shelf break (mean anomaly value of -23.0 over all size classes). A similar pattern occurred for fish larvae, for which the mean carbon anomaly value on the continental shelf was -17.8, while at the shelf break the mean anomaly was -21.7 (these results are based on over 30 larval fish in each region, and are significantly different at the 0.01 probability level (t-test)). These findings

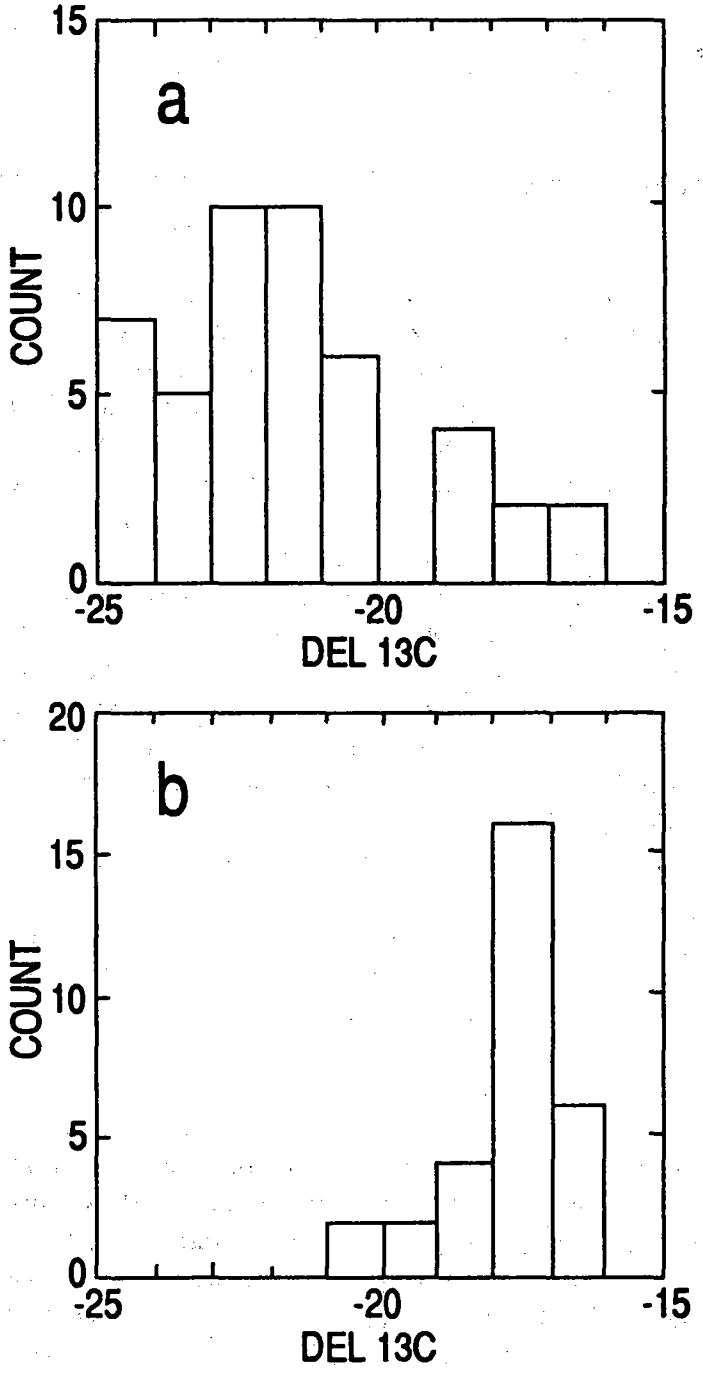

Figure 26. Frequency distribution of the σ^{13}C anomaly in fish larvae collected from (a) the shelf break area, and (b) the La Perouse Bank area, west of Vancouver Island during April 1992.

suggest that different growth conditions for phytoplankton in each of these regions produce different fractionation dynamics for at least the stable carbon isotope, and that these differences are transmitted up the food web to larval fishes, thereby providing an indicator for the location of feeding.

Cross-shelf exchange of neustonic icthyoplankton during the spring tranistion off Vancouver Island (R. Ian Perry and G.A. McFarlane)

Retention of spawning products and transportation to appropriate rearing areas are critical problems affecting the abundance of fish populations, especially in dynamic seasonal upwelling areas. This project examined the roles of the cross-shelf Ekman circulation and the buoyancy-driven coastal current on surface-layer larval fish distributions during spring off the coast of Vancouver Island, focusing on two contrasting years (1988 and 1989). Two principal larval fish communities were identified, associated with the shallow waters over the continental shelf and the deep waters off the shelf. However, there was evidence for considerable exchange of larvae of particular species across the shelf between these communities. The extent of this exchange depended upon interaction of onshore Ekman transport before the start of upwelling and the strength and cross-shelf variation of the shelf circulation. The implications of these processes for the population dynamics of off-shelf and on-shelf fish species are illustrated by sablefish, lingcod, and blue lanternfish. For slope spawners such as sablefish, larvae settling on the continental shelf of SW Vancouver Island could be derived from local or distant (100's of kilometers) spawning populations depending on the relative magnitudes of the cross-shelf Ekman and alongshelf geostrophic currents. Modeling of these larval fish distributions using available circulation models is planned for the next work period.

Juvenile salmon and plankton trophic interactions during early summer migrations on the B.C. continental shelf
(R. Ian Perry , N. Brent Hargeaves, Brenda Waddell, David L. Mackas)

There is considerable debate as to the importance of feeding and growth during early ocean migrations to the survival of juvenile salmon and their recruitment to adult populations. Large numbers of juvenile salmon migrating through an area may also be expected to severely impact local populations of zooplankton and larval fishes. This project is examining the diets and feeding rates of juvenile (mean length 115 mm) pink, chum and sockeye salmon collected from a large number of beam trawl samples off the west coast of Vancouver Island during early summer, 1992. Feeding success and dietary differences were examined on and off the continental shelf, and between the northern and southern areas off Vancouver Island. The 3 salmon species differed overall on both short (stomach contents) and intermediate ($\delta^{13}C$ and $\delta^{15}N$ stable isotope anomaly, e.g. Fig. 27) time scales. Sockeye juveniles had low stable isotope anomalies and stomach contents dominated by euphausiids. Chum juveniles had high ^{15}N anomalies and stomach contents dominated by *Oikopleura sp.* Pink juveniles had high ^{13}C anomalies, but relatively little in their stomachs. Pink salmon also had low stomach content weights relative to the other 2 species, and compared with literature values. Mean zooplankton biomass for the period May-June 1992 was also lower than expected based on the long-term (1979-1991) values.

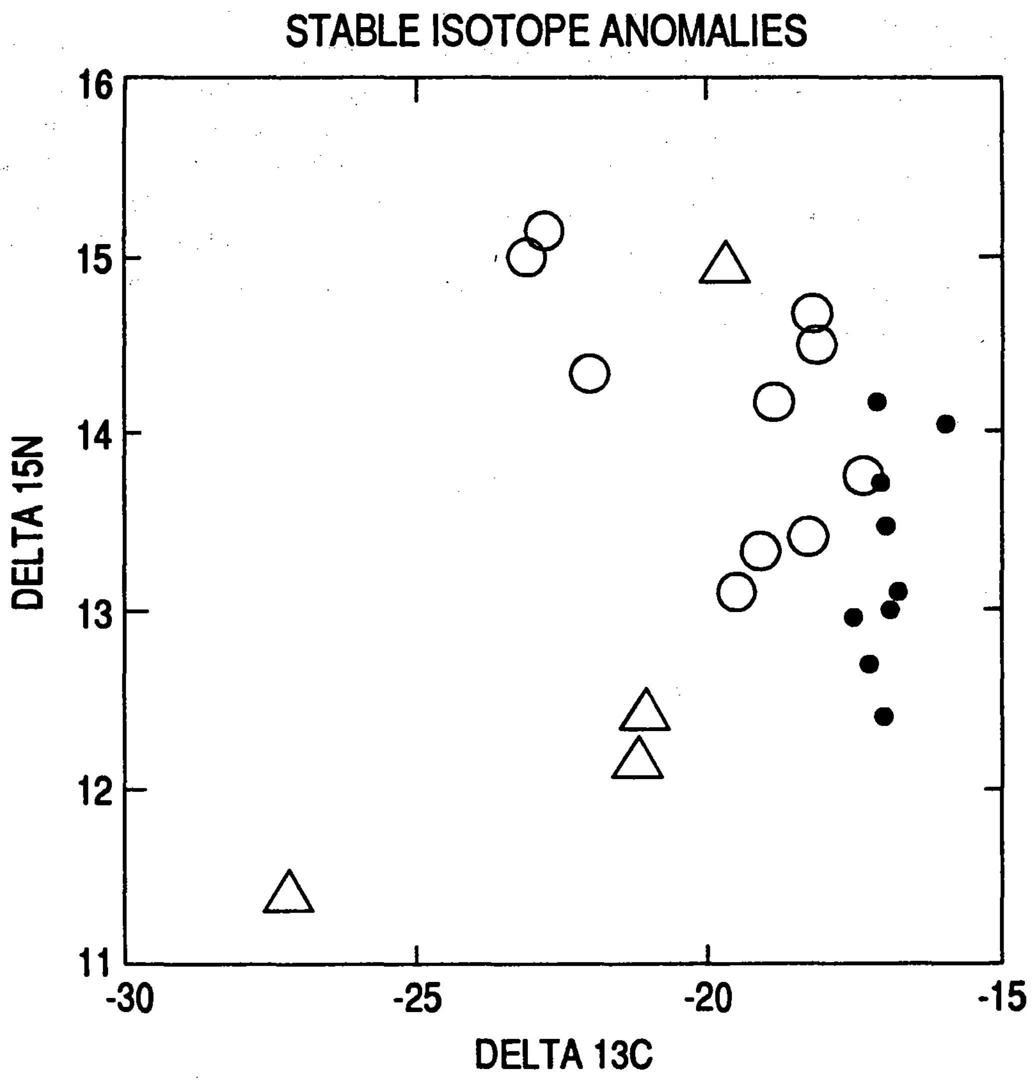

Figure 27. Stable isotope anomalies of nitrogen and carbon in muscle tissue from juvenile salmon (mean fork length 115 mm) collected off the west coast of Vancouver Island during early July 1992. Triangles indicate values for sockeye salmon; circles represent chum salmon; and dots represent pink salmon.

A more detailed sampling program was conducted in June and July 1993, consisting of 30 neuston samples and 6 MOCNESS collections along the west coast of Vancouver Island during June, and a similar number during July in conjunction with the juvenile salmon beam trawl survey. These samples will be used to compare plankton (including larval and juvenile fish) community composition on and off the continental shelf, and between southern (e.g. La Perouse Bank area) and northern (e.g. Brooks Peninsula) areas for examination of juvenile salmon -zooplankton trophic interactions. The samples will also be used to compare vertical distributions of plankton and their diel changes for comparison of juvenile salmon prey selectivity over the diel cycle, and for the ability of neuston samples to represent the prey available to the juvenile salmon.

4. SUMMARY OF ALL LA PEROUSE/MASS SURVEYS

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YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1972	1	CTD 72-10	14	101	LAYMORE	CTD & HYDRO CASTS, XBT'S	08-MAY-72	18-MAY-72	THOMSON RE	LINE P, NE PACIFIC
1977	7	CTD 77-12	2	101	PARIZEAU	CTD & BOTTLE CASTS, NUTRIENTS, CM/TIDE MOORINGS	10-MAY-77	15-MAY-77	THOMSON RE	GEORGIA, JOHNSTONE, DISCOVERY, QC STRAIT, QCS, HECATE
1977	8	CTD 77-13	2	101	ENDEAVOUR	CTD & BOTTLE CASTS, CM/TIDE MOORINGS, SEDIMENT GRABS	11-JUL-77	24-JUL-77	THOMSON RE	GEORGIA, JOHNSTONE, QC STRAIT, QCS, HECATE
1977	9	CTD 77-14	2	101	PARIZEAU	CTD & BOTTLE CASTS, NUTRIENTS	20-SEP-77	28-SEP-77	THOMSON RE	GEORGIA, JOHNSTONE, QC SOUND, QCS, HECATE
1978	11	CTD 78-10	3	101	PARIZEAU	CTD & BOTTLE CASTS, CM MOORINGS, ANEMOMETER (E. PT)	09-JAN-78	19-JAN-78	THOMSON RE	JUAN DE FUCA, HARO, GEORGIA, JOHNSTONE, QC STRAIT
1978	12	CTD 78-12	3	101	PARIZEAU	CTD & BOTTLE CASTS, CM MOORINGS	13-MAR-78	23-MAR-78	THOMSON RE	JUAN DE FUCA, HARO, GEORGIA
1978	13	CTD 78-14	4	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS, DRIFTERS	10-APR-78	17-APR-78	THOMSON RE	JUAN DE FUCA, HARO, GEORGIA
1979	268	CTD 79-50	78	301	ENDEAVOUR	CZO 79-01 CTD AND HYDRO WCVI (CODE)	30-JAN-79	04-FEB-79	FREELAND HJ	WVCI - LAPEROUSE
1979	270	CTD 79-51	9	301	PANDORA II	CZO 79-02 CTD AND HYDRO - WVCI (CODE)	08-MAR-79	08-MAR-79	FREELAND HJ	WVCI - LAPEROUSE
1979	271	CTD 79-52	11	301	VECTOR	CZO 79-03 CTD AND HYDRO - WCVI (CODE)	19-APR-79	19-APR-79	FREELAND HJ	WCVI - LAPEROUSE
1979	15	CTD 79-12	38	101	PARIZEAU	CTD & HYDRO CASTS, WAVE RIDER BUOY, CM MOORINGS	02-MAY-79	12-MAY-79	THOMSON RE	WCVI, JUAN DE FUCA
1979	272	CTD 79-53	60	301	PARIZEAU	CZO 79-04 CTD AND HYDRO - WCVI (CODE)	18-MAY-79	24-MAY-79	FREELAND HJ	WCVI - LAPEROUSE
1979	225	CTD 79-30	45	301	ENDEAVOUR	Ocean ECOLOGY cruise 79-03	22-MAY-79	28-MAY-79	DENMAN KL	LaPerouse, Juan de Fuca
1979	273	CTD 79-54	9	301	PANDORA II	CZO 79-05 CTD AND HYDRO - WCVI (CODE)	21-JUN-79	22-JUN-79	FREELAND HJ	WCVI - LAPEROUSE
1979	226	CTD 79-31	50	301	VECTOR	OCEAN ECOLOGY CRUISE 79-04 - LaPerouse, Juan de Fuca CDRHOS No. 3 (1982)	04-JUL-79	11-JUL-79	DENMAN KL	La Perouse, Juan de Fuca
1979	274	CTD 79-55	7	301	VECTOR(?)	CZO 79-05A (POSSIBLY OE 79-31?) CTD - WCVI - CODE	05-JUL-79	05-JUL-79	FREELAND HJ	WCVI - LAPEROUSE
1979	16	CTD 79-14	115	101	PANDORA	CTD & BOTTLE CASTS (ROSETTE), CM MOORINGS	03-AUG-79	14-AUG-79	THOMSON RE	WCVI, JUAN DE FUCA, JOHNSTONE, QCS, GEORGIA
1979	227	CTD 79-32	99	301	VECTOR	OCEAN ECOLOGY CRUISE 79-05	22-AUG-79	29-AUG-79	DENMAN KL	La Perouse, Juan de Fuca
1979	275	CTD 79-56	11	301	VECTOR(?)	CZO 79-06 (possibly from OE 79-32?) CTD AND HYDRO - WCVI - CODE	25-AUG-79	25-AUG-79	FREELAND HJ	WCVI - LAPEROUSE
1979	17	CTD 79-15	50	101	PARIZEAU	CTD & BOTTLE CASTS (ROSETTE), CM MOORINGS	10-SEP-79	27-SEP-79	THOMSON RE	WCVI
1979	276	CTD 79-57	11	301	PARIZEAU	CZO 79-07 CTD AND HYDRO - WCVI - CODE	12-OCT-79	13-OCT-79	FREELAND HJ	WCVI - LAPEROUSE
1979	277	CTD 79-58	27	301	PARIZEAU	CZO 79-08 CTD AND HYDRO - WCVI - CODE	27-NOV-79	02-DEC-79	FREELAND HJ	WVCI - LAPEROUSE
1980	18	CTD 80-10	66	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS	14-JAN-80	26-JAN-80	THOMSON RE	WCVI, JUAN DE FUCA

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1980	278	CTD 80-50	45	301	PARIZEAU	CZO 80-09 CTD AND HYDRO - WCVI - CODE	07-FEB-80	13-FEB-80	FREELAND HJ	WCVI - LAPEROUSE
1980	279	CTD 80-51	19	301	PARIZEAU	CZO 80-10 CTD AND HYDRO WCVI - CODE	25-MAR-80	26-MAR-80	FREELAND HJ	WCVI - LAPEROUSE
1980	280	CTD 80-52	19	301	PARIZEAU	CZO 80-11 CTD AND HYDRO - WCVI - CODE	22-APR-80	23-APR-80	FREELAND HJ	WVCI - LAPEROUSE
1980	19	CTD 80-11	83	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS, TIDE GAUGES	30-APR-80	16-MAY-80	THOMSON RE	WCVI, JUAN DE FUCA
1980	281	CTD 80-53	11	301	PARIZEAU(?)	CZO 80-12B (OE 80-//) CTD AND HYDRO - WCVI - CODE	04-JUN-80	05-JUN-80	FREELAND HJ	WCVI - LAPEROUSE
1980	282	CTD 80-54	35	301	PARIZEAU	CZO 80-12 CTD AND HYDRO WVCI - CODE	11-JUN-80	12-JUN-80	FREELAND HJ	WCVI - LAPEROUSE
1980	20	CTD 80-13	65	101	ENDEAVOUR	CTD/ROSETTE PROFILES	22-JUL-80	03-AUG-80	THOMSON RE	WCVI, JUAN DE FUCA, ALBERNI INLET
1980	283	CTD 80-55	10	301	PARIZEAU(?)	CZO 80-12A (80-13?) CTD AND HYDRO - WCVI - CODE	25-JUL-80	26-JUL-80	FREELAND HJ	WCVI - LAPEROUSE
1980	229	CTD 80-32	78	301	VECTOR	Ocean Ecology 80-08 CDRHOS No.4 (1982)	29-JUL-80	06-AUG-80	DENMAN KL	La Perouse, Juan de Fuca
1980	284	CTD 80-56	19	301	VECTOR	CZO 80-13 CTD AND HYDRO WCVI - CODE	13-AUG-80	14-AUG-80	FREELAND HJ	WCVI - LAPEROUSE
1980	21	CTD 80-14	86	101	PARIZEAU	CTD/ROSETTE PROFILES	01-SEP-80	21-SEP-80	THOMSON RE	WCVI, JUAN DE FUCA
1980	285	CTD 80-57	51	301	PARIZEAU	CZO 80-14 CTD AND HYDRO - WCVI - CODE	22-SEP-80	24-SEP-80	FREELAND HJ	WCVI - LAPEROUSE
1980	286	CTD 80-58	10	301	PARIZEAU	CZO 80-15 CTD AND HYDRO - WCVI - CODE	22-OCT-80	23-OCT-80	FREELAND HJ	WCVI - LAPEROUSE
1980	287	CTD 80-59	1	301	VECTOR	CZO 80-16 CTD AND HYDRO - WCVI - CODE	27-NOV-80	27-NOV-80	FREELAND HJ	WCVI - LAPEROUSE
1981	288	CTD 81-50	9	301	VECTOR	CZO 81-17 CTD AND HYDRO - WCVI - CODE	06-JAN-81	01-JAN-81	FREELAND HJ	WCVI - LAPEROUSE
1981	289	CTD 81-51	19	301	PARIZEAU	CZO 81-18 CTD AND HYDRO - WCVI - CODE	04-FEB-81	04-FEB-81	FREELAND HJ	WCVI - LAPEROUSE
1981	290	CTD 81-52	10	301	VECTOR	CZO 81-19 CTD AND HYDRO - WCVI - CODE	10-MAR-81	10-MAR-81	FREELAND HJ	WCVI - LAPEROUSE
1981	291	CTD 81-53	19	301	PARIZEAU	CZO 81-20 CTD AND HYDRO - WCVI - CODE	21-APR-81	22-APR-81	FREELAND HJ	WCVI - LAPEROUSE
1981	230	CTD 81-30	55	301	PARIZEAU	Ocean Ecology cruise 81-05	29-APR-81	08-MAY-81	DENMAN KL	La Perouse, Juan de Fuca
1981	292	CTD 81-54	33	301	VECTOR(?)	CZO 81-20A (possibly OE 81-30?) CTD AND HYDRO - WCVI - CODE	29-APR-81	01-MAY-81	FREELAND HJ	WCVI - LAPEROUSE
1981	293	CTD 81-55	78	301	PARIZEAU	CZO 81-21 CTD AND HYDRO - WCVI - CODE	02-JUN-81	09-JUN-81	FREELAND HJ	WCVI - LAPEROUSE
1981	22	CTD 81-05	28	101	PARIZEAU	CTD & HYDRO CASTS, PLANKTON TOWS, XBT'S, CHEMICAL OBS.	17-AUG-81	28-AUG-81	TABATA S	WCVI, LINE P, LINE R
1981	294	CTD 81-56	23	301	PARIZEAU	CZO 81-22 CTD AND HYDRO - WCVI - CODE	05-SEP-81	06-SEP-81	FREELAND HJ	WCVI - LAPEROUSE
1981	295	CTD 81-57	25	301	PARIZEAU	CZO 81-22A (possibly OE 81-??) CTD AND HYDRO - WCVI - CODE	14-SEP-81	17-SEP-81	FREELAND HJ	WCVI - LAPEROUSE

All DATASETS of type: CTD WHERE LATITUDE between 47.5 and 51.0 AND LONGITUDE between 124.5 and 131.0 RESULTS printed to file: lap_ds.LIS

YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1981	23	CTD 81-06	13	101	PARIZEAU	CTD & HYDRO CASTS, PLANKTON TOWS, DRIFTING BUOY, CHEM. (PRECIP.)	19-OCT-81	27-OCT-81	TABATA S	LINE P, LINE R, WCVI
1982	24	CTD 82-01	25	101	ENDEAVOUR	CTD & HYDRO CASTS, PLANKTON, DRIFTERS, XBT'S	18-JAN-82	29-JAN-82	TABATA S	LINE P, LINE R
1982	25	CTD 82-02	31	101	ENDEAVOUR	CTD & HYDRO CASTS, PLANKTON, LOOP CHEM.	15-MAR-82	26-MAR-82	TABATA S	LINE P, LINE R, WCVI
1982	26	CTD 82-03	21	101	PARIZEAU	CTD & HYDRO CASTS, LOOP CHEM., NCAR BUOY, XBT'S	03-MAY-82	14-MAY-82	TABATA S	LINE P, LINE R, WCVI
1982	27	CTD 82-04	27	101	PARIZEAU	CTD & HYDRO CASTS, NEUSTON TOWS, XBT'S	12-JUL-82	22-JUL-82	TABATA S	LINE P, LINE R, WCVI
1982	28	CTD 82-05	18	101	PARIZEAU	CTD & HYDRO CASTS, SEDIMENT TRAPS, PLANKTON	17-SEP-82	29-SEP-82	TABATA S	JUAN DE FUCA, LINE P, LINE R
1982	29	CTD 82-06	31	101	ENDEAVOUR	CTD & HYDRO CASTS, SURFACE OBS., PLANKTON	24-NOV-82	05-DEC-82	TABATA S	LINE P, LINE R, WCVI
1983	30	CTD 83-01	30	101	ENDEAVOUR	CTD & HYDRO CASTS, SEDIMENT TRAPS, PLANKTON TOWS	16-MAR-83	30-MAR-83	TABATA S	WCQC, LINE P, LINE R, WCVI
1983	32	CTD 83-10	9	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS, TIDE GAUGES, WEATHER BUOY	02-MAY-83	20-MAY-83	THOMSON RE	WCVI, QCS, HECATE, WCQC, DIXON
1983	33	CTD 83-11	21	101	ENDEAVOUR	CTD & HYDRO CASTS, PLANKTON TOWS	28-JUN-83	16-JUL-83	THOMSON RE	DIXON, WCQC, WCVI, QCS, LINE P
1983	232	CTD 83-31	37	301	ENDEAVOUR	Ocean Ecology 83-04	29-JUN-83	10-JUL-83	DENMAN KL	La Perouse, WCVI, QC Sound, Hecate Str
1983	296	CTD 83-50	20	301	PARIZEAU(?)	CZO 83-23 (possibly 83-11? OR 83-31?) CTD AND HYDRO - WCVI - CODE	29-JUN-83	01-JUL-83	FREELAND HJ	WCVI - LAPEROUSE
1983	31	CTD 83-02	30	101	PARIZEAU	CTD & HYDRO CASTS, PLANKTON HAULS, DRIFTERS	16-AUG-83	27-AUG-83	TABATA S	WCVI, LINE R, LINE P, QCS
1984	35	CTD 84-01	12	101	PARIZEAU	CTD & HYDRO CASTS	26-APR-84	04-MAY-84	TABATA S	LINE P, LINE R, LINE A, LINE B
1984	233	CTD 84-30	6	301	PARIZEAU	Ocean Ecology 84-02 - Line P / Station P - SUPER 1	12-MAY-84	20-MAY-84	DENMAN KL	LINE P, STN P, NORTHEAST PACIFIC
1984	40	CTD 84-12	149	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS	18-JUN-84	30-JUN-84	THOMSON RE	WCVI
1984	41	CTD 84-13	59	101	PANDORA	CTD & HYDRO CASTS	23-JUL-84	26-JUL-84	THOMSON RE	WCVI
1984	36	CTD 84-02	16	101	ENDEAVOUR	CTD & HYDRO CASTS, SEDIMENT TRAPS	21-AUG-84	31-AUG-84	TABATA S	LINE P, LINE A
1984	42	CTD 84-14	11	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS	11-OCT-84	31-OCT-84	THOMSON RE	DIXON, WCQC, WCVI
1984	37	CTD 84-03	42	101	PARIZEAU	CTD & HYDRO CASTS, DRIFTERS, SEDIMENT TRAPS	07-NOV-84	22-NOV-84	TABATA S	LINE P, LINE J, WCVI
1985	43	CTD 85-01	11	101	ENDEAVOUR	CTD & HYDRO CASTS	11-FEB-85	15-FEB-85	TABATA S	LINE P
1985	51	CTD 85-20	134	101	ENDEAVOUR	CTD PROFILES, CM MOORINGS	05-MAR-85	12-MAR-85	THOMSON RE	WCVI
1985	44	CTD 85-02	70	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS	29-APR-85	16-MAY-85	THOMSON RE	LINE P, WCVI, LINE R
1985	52	CTD 85-30	32	101	OCEAN KING	CTD PROFILES	09-JUN-85	19-JUN-85	THOMSON RE	WCVI

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YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1985	53	CTD 85-41	98	101	VECTOR	CTD & HYDRO CASTS, F.L.Y.	11-JUN-85	20-JUN-85	CRAWFORD W	WCVI
1985	46	CTD 85-10	29	101	PARIZEAU	CTD PROFILES, CM MOORINGS	24-JUN-85	11-JUL-85	THOMSON RE	WCVI, DIXON, WCQC, HECATE, QCS
1985	234	CTD 85-31	53	301	PARIZEAU	OCEAN ECOLOGY 85-02 / OCEAN PHYSICS 85-10 CTD, HYDRO AND CURRENT METERS	24-JUN-85	10-JUL-85	DENMAN KL	La Perouse, WCVI, WCQCI, DIXON ENTR, HECATE STR
1985	54	CTD 85-81	30	101	EASTWARD HO	CTD PROFILES, SABLEFISH SURVEY	11-AUG-85	13-AUG-85	SHAW W	WCVI
1985	48	CTD 85-11	70	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS DEPLOYED, DRIFTERS	24-SEP-85	03-OCT-85	THOMSON RE	ENDEAVOUR, WCVI
1985	45	CTD 85-04	28	101	JP TULLY	CTD & HYDRO CASTS, SEDIMENT TRAPS	29-OCT-85	15-NOV-85	TABATA S	LINE P, WCVI, UNION SEAMOUNT
1985	49	CTD 85-12	57	101	PARIZEAU	CTD PROFILES, CM MOORINGS	18-NOV-85	26-NOV-85	THOMSON RE	WCVI
1986	71	CTD 86-90	5	101	ENDEAVOUR	CTD PROFILES.	13-JAN-86	21-JAN-86	THOMSON RE	GEORGIA, JUAN DE FUCA, WCVI, JERVIS
1986	57	CTD 86-10	37	101	JP TULLY	CTD & HYDRO CASTS, PLANKTON	03-FEB-86	08-FEB-86	THOMSON RE	WCVI
1986	67	CTD 86-80	25	101	GB REED	CTD PROFILES & PLANKTON.	25-FEB-86	03-MAR-86	SHAW W	WCVI
1986	72	CTD 86-91	21	101	ENDEAVOUR	CTD PROFILES	10-MAR-86	26-MAR-86	THOMSON RE	GEORGIA, JUAN DE FUCA, WCVI, JOHNSTONE, JERVIS, ALBERNI
1986	68	CTD 86-81	54	101	GB REED	CTD PROFILES, ...	03-APR-86	07-APR-86	SHAW W	WCVI
1986	55	CTD 86-01	16	101	JP TULLY	CTD & HYDRO CASTS, XBT'S, SAIL, SEDIMENT TRAPS, AES BUOY	15-APR-86	26-APR-86	TABATA S	LINE P
1986	58	CTD 86-11	95	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS, PLANKTON	17-APR-86	24-APR-86	THOMSON RE	WCVI
1986	69	CTD 86-82	22	101	GB REED	CTD PROFILES, ...	11-MAY-86	15-MAY-86	SHAW W	WCVI
1986	59	CTD 86-12	54	101	JP TULLY	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS	10-JUN-86	21-JUN-86	THOMSON RE	ENDEAVOUR
1986	64	CTD 86-30	138	301	PARIZEAU	CTD/TRANSM. & HYDRO CASTS (Ocean Ecology 86-03 CTD/Rosette)	12-JUN-86	02-JUL-86	DENMAN KL	La Perouse, WCVI
1986	60	CTD 86-13	36	101	ENDEAVOUR	CTD/TRANSM. & HYDRO CASTS	14-JUL-86	18-JUL-86	THOMSON RE	WCVI
1986	70	CTD 86-83	25	101	GB REED?	CTD PROFILES	12-AUG-86	26-AUG-86	SHAW W	WCVI
1986	61	CTD 86-14	17	101	WE RICKER	CTD & HYDRO CASTS, SURF. TOWS FOR PLASTIC, GILL? NETS	18-AUG-86	12-SEP-86	BERNARD F	NE PACIFIC, LINE P
1986	65	CTD 86-31	143	301	PARIZEAU	CTD/TRANSM. & HYDRO CASTS. (Ocean Ecology 86-04 CTD/Rosette)	18-AUG-86	24-AUG-86	DENMAN KL	WCVI, La Perouse
1986	62	CTD 86-15	89	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS.	08-SEP-86	19-SEP-86	THOMSON RE	ENDEAVOUR, WCVI

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1986	56	CTD 86-03	28	101	PARIZEAU	CTD & HYDRO CASTS, XBT'S, DRIFTERS, PRODUCTIVITY	13-OCT-86	30-OCT-86	THOMSON RE	WCVI, LINE P
1986	63	CTD 86-16	54	101	PARIZEAU	CTD & HYDRO CASTS, CM MOORINGS.	09-NOV-86	11-NOV-86	THOMSON RE	WCVI
1987	77	CTD 87-10	57	101	ENDEAVOUR	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS, PLANKTON	11-FEB-87	19-FEB-87	THOMSON RE	WCVI
1987	87	CTD 87-82	21	101	OCEAN KING	CTD PROFILES (PBS)	15-FEB-87	21-MAR-87	TANASACHUK R	WCVI
1987	78	CTD 87-11	42	101	ENDEAVOUR	CTD/TRANSM. & HYDRO CASTS, CYCLESONDE	10-MAR-87	15-MAR-87	THOMSON RE	WCVI
1987	88	CTD 87-83	40	101		CTD PROFILES, SABLEFISH/PLANKTON (PBS)	14-MAR-87	23-MAR-87	TANASACHUK R	WCVI
1987	73	CTD 87-01	10	101	ENDEAVOUR	CTD & HYDRO CASTS, SEDIMENT TRAPS, XBT'S	30-MAR-87	09-APR-87	TABATA S	LINE P
1987	79	CTD 87-12	80	101	JP TULLY	CTD/TRANSM. & HYDRO CASTS, CYCLESONDE/RCM MOORINGS, SAIL	21-APR-87	28-APR-87	THOMSON RE	WCVI
1987	89	CTD 87-84	30	101		CTD PROFILES (PBS)	26-APR-87	30-APR-87	TANASACHUK R	WCVI
1987	86	CTD 87-81	30	101	JP TULLY	CRAB SURVEY, CTD PROFILES, DRIFTERS	05-MAY-87	23-JUN-87	JAMIESON G	WCVI
1987	85	CTD 87-80	11	101	WE RICKER	CTD, PLANKTON (BONGO), GILL NETS, LONG LINES, SAIL	26-MAY-87	05-JUL-87	HARGREAVES B	LINE P
1987	83	CTD 87-34	13	301	PARIZEAU	CTD & HYDRO CASTS, NET TOWS, DRIFTERS, CO2, GEODYNE BUOY	27-MAY-87	09-JUN-87	DENMAN KL	LINE P, NE PACIFIC
1987	84	CTD 87-41	35	101	PARIZEAU	CTD CASTS, NEUSTON/MILLER/TUCKER TOWS, DRIFTERS, SAIL	15-JUN-87	26-JUN-87	THOMSON RE	WCVI
1987	80	CTD 87-13	107	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS, RDI & CTD PROFILES	29-JUN-87	10-JUL-87	THOMSON RE	WCVI, ENDEAVOUR
1987	235	CTD 87-35	101	301	PARIZEAU	Ocean Ecology 87-05 CTD/Rosette	14-JUL-87	23-JUL-87	DENMAN KL	WCVI, La Perouse
1987	90	CTD 87-85	64	101		CTD PROFILES (PBS)	21-AUG-87	29-AUG-87	TANASACHUK R	WCVI
1987	81	CTD 87-14	86	101	ENDEAVOUR	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS, RDI DOPPLER TEST	01-SEP-87	12-SEP-87	THOMSON RE	WCVI, ENDEAVOUR
1987	74	CTD 87-02	36	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, AES BUOY & DRIFTERS, THERMISTOR CHAINS, NUTRIENTS, SAIL, XBT'S	22-SEP-87	16-OCT-87	TABATA S	LINE P, NE PACIFIC
1987	82	CTD 87-15	20	101	PARIZEAU	CTD PROFILES, CM MOORINGS, PRIMARY PRODUCTIVITY	16-NOV-87	19-NOV-87	THOMSON RE	WCVI
1987	76	CTD 87-04	12	101	PARIZEAU	CTD & HYDRO CASTS, PRODUCTIVITY, SEDIMENT TRAPS	24-NOV-87	09-DEC-87	TABATA S	LINE P, NE PACIFIC
1988	104	CTD 88-81	18	101	WE RICKER	CTD PROFILES, SABLEFISH SURVEY (PBS)	11-FEB-88	17-FEB-88	SHAW W	WCVI
1988	99	CTD 88-50	55	101	PARIZEAU	CTD/TRANSM. PROFILES, ADCP CURRENT PROFILES	15-FEB-88	18-FEB-88	FREELAND HJ	WCVI
1988	105	CTD 88-82	17	101	WE RICKER	CTD PROFILES, XBT, SABLEFISH SURVEY	02-MAR-88	10-MAR-88	SHAW W	WCVI

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YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1988	106	CTD 88-83	40	101	WE RICKER	CTD PROFILES, SABLEFISH SURVEY	07-APR-88	15-APR-88	SHAW W	WCVI
1988	94	CTD 88-11	108	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, DRIFTERS, CM MOORINGS	12-APR-88	22-APR-88	THOMSON RE	WCVI
1988	91	CTD 88-01	41	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, PRIMARY PROD.	02-MAY-88	19-MAY-88	TABATA S	LINE P, WCVI
1988	100	CTD 88-51	72	101	PARIZEAU	CTD PROFILES, LORAN DRIFTERS, PLANKTON, RDI DOPPLER CM, SAIL	23-MAY-88	03-JUN-88	FREELAND HJ	WCVI
1988	103	CTD 88-80	9	101	WE RICKER	CTD PROFILES, SAIL, LONGLINE/GILLNET TEST FISHERIES, XBT'S	01-JUN-88	12-JUL-88	HARGREAVES B	NE PACIFIC
1988	101	CTD 88-52	50	101	PARIZEAU	CTD PROFILES, DRIFTERS, SAIL	14-JUN-88	23-JUN-88	CRAWFORD WR	WCVI
1988	92	CTD 88-02	37	101	PARIZEAU	CTD & HYDRO CASTS, RDI DOPPLER CM, SEARCH FOR NEPCS MOORING, CO2	28-JUN-88	14-JUL-88	TABATA S	LINE P, WCVI
1988	95	CTD 88-12	113	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, RDI DOPPLER CM, DRIFTERS, CM MOORING	14-JUL-88	21-JUL-88	THOMSON RE	WCVI
1988	98	CTD 88-30	76	101	PARIZEAU	CTD/TRANSM. PROFILES, PLANKTON, DRIFTERS, ADCP	10-AUG-88	19-AUG-88	DENMAN KL	WCVI, La Perouse
1988	108	CTD 88-85	59	101	WE RICKER	CTD PROFILES, GROUNDFISH (HAKE) SURVEY	12-AUG-88	15-AUG-88	WARE D	WCVI
1988	96	CTD 88-14	81	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS	22-AUG-88	02-SEP-88	THOMSON RE	WVCI, ENDEAVOUR
1988	97	CTD 88-15	49	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORING, RDI DOPPLER CM	27-SEP-88	07-OCT-88	THOMSON RE	WCVI
1988	102	CTD 88-53	99	101	PARIZEAU	CTD/TRANSM. PROFILES, SAIL, RDI DOPPLER CM, PLANKTON	24-OCT-88	03-NOV-88	FREELAND HJ	WCVI
1988	93	CTD 88-03	43	101	PARIZEAU	CTD & HYDRO CASTS, SEDIMENT TRAPS, PRODUCTIVITY	29-NOV-88	13-DEC-88	TABATA S	LINE P, WCVI
1989	109	CTD 89-01	12	101	JP TULLY	CTD & HYDRO SURVEY; SAIL	13-FEB-89	26-FEB-89	TABATA S	LINE P
1989	117	CTD 89-80	15	101		CTD-12 PROFILES, LING COD SURVEY	18-MAR-89	21-MAR-89	RICHARDS L	WCVI
1989	237	CTD 89-81	36	310	unknown	PBS cruise - AML CTD-12 - DATA FROM BILL SHAW	07-APR-89	17-APR-89	SHAW W	WCVI
1989	112	CTD 89-10	57	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS, AMBIENT NOISE DRIFTERS	18-APR-89	26-APR-89	THOMSON RE	WCVI, GEORGIA, JUAN DE FUCA
1989	110	CTD 89-02	15	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, RDI DOPPLER CM, SEDIMENT TRAPS	01-MAY-89	12-MAY-89	TABATA S	LINE P
1989	116	CTD 89-50	69	101	PARIZEAU	CTD/TRANSM. PROFILES, DRIFTERS, PLANKTON HAULS	23-MAY-89	26-MAY-89	FREELAND HJ	WCVI
1989	113	CTD 89-11	43	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, CM MOORINGS	27-MAY-89	09-JUN-89	THOMSON RE	WCVI, JUAN DE FUCA
1989	236	CTD 89-30	53	301	PARIZEAU	Ocean Ecology Cruise 89-06 (CTD/Rosette, net tows, BIONESS etc)	08-AUG-89	14-AUG-89	DENMAN KL	LaPerouse, WCVI

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YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1989	114	CTD 89-12	87	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, RDI DOPPLER CM, CM MOORINGS	15-AUG-89	25-AUG-89	THOMSON RE	WCVI
1989	111	CTD 89-03	22	101	PARIZEAU	CTD/TRANSM. & HYDRO CASTS, SEDIMENT TRAP MOORINGS, RDI DOPPLER CM, CM MOORINGS, DRIFTERS, XBT'S	03-OCT-89	22-OCT-89	TABATA S	LINE P
1989	115	CTD 89-13	31	101	PARIZEAU	CTD/TRANSM. PROFILES, RDI DOPPLER CM, CM MOORINGS	22-OCT-89	27-OCT-89	THOMSON RE	WCVI, JUAN DE FUCA
1990	120	CTD 90-10	25	101	J P TULLY	CTD SURVEY, PLANKTON HAUL	29-JAN-90	09-FEB-90	THOMSON RE	WCVI
1990	129	CTD 90-81	28	101	W E RICKER	CTD SURVEY, NET HAULS	21-MAR-90	15-DEC-90	SHAW B	WCVI
1990	121	CTD 90-11	104	101	PARIZEAU	CM RECOVERY/DEPLOYMENT, CTD SURVEY	17-APR-90	24-APR-90	THOMSON RE	WCVI
1990	238	CTD 90-31	24	301	PARIZEAU	Ocean Ecology 90-03 CTD/Rosette, JGOFS sediment traps/RCM , BIONESS, net tows	25-APR-90	02-MAY-90	DENMAN KL	WCVI, LaPerouse, Brooks Peninsula
1990	118	CTD 90-01	35	101	PARIZEAU	CTD SURVEY, CM & SEDIMENT TRAP MOORINGS RECOVERY/DEPLOYMENT	10-MAY-90	29-MAY-90	TABATA S	LINE P
1990	122	CTD 90-12	97	101	PARIZEAU	CTD & RDI-ADCP SURVEY, DRIFT NETS, CM MOORING RECOVERY/DEPLOYMENT	11-JUN-90	21-JUN-90	THOMSON RE	WCVI
1990	123	CTD 90-13	17	101	PARIZEAU	CTD CURVEY	28-JUN-90	13-JUL-90	CRAWFORD WR	HECATE STRAIT, DIXON ENTRANCE
1990	125	CTD 90-30	2	101	WESTERLY WIND	CTD SURVEYS IN SUPPORT OF SURFACE CURRENT MEASUREMENTS BY LORAN-C DRIFTERS	05-JUL-90	28-AUG-90	CRAWFORD WR	DIXON ENTRANCE, HECATE STRAIT
1990	239	CTD 90-32	73	301	JP TULLY	Ocean Ecology 90-04 JGOFS sediment traps, BIONESS, net tows etc.	18-JUL-90	25-JUL-90	DENMAN KL	WCVI
1990	128	CTD 90-80	46	101	W E RICKER	CTD SURVEY, NET HAULS	26-JUL-90	06-AUG-90	HARGREAVES B	WCVI
1990	126	CTD 90-50	1	101	PARIZEAU	CTD & RDI-ADCP SURVEY, DRIFTER TRACKING	30-JUL-90	15-AUG-90	FREELAND H	COBB SEAMOUNT, WCVI
1990	119	CTD 90-02	13	101	PARIZEAU	CTD & RDI-ADCP SURVEY, DRIFTER TRACKING, CM & SEDIMENT TRAP RECOVERY/DEPLOYMENT	22-AUG-90	06-SEP-90	TABATA S	LINE P
1990	124	CTD 90-14	71	101	PARIZEAU	CTD & RDI-ADCP SURVEY, CM MOORING RECOVERY/DEPLOYMENT	01-OCT-90	12-OCT-90	THOMSON RE	WCVI
1990	240	CTD 90-33	43	301	PARIZEAU	Ocean Ecology 90-06 end JGOFS sediment traps/rcm , BIONESS, net tows etc	12-OCT-90	18-OCT-90	DENMAN KL	WCVI
1991	152	CTD 91-01	11	101	PARIZEAU	CTD AND CM MOORING ALSO SAIL, VM-RDI	07-JAN-91	19-JAN-91	CRAWFORD WR	QC SOUND, WCVI
1991	171	CTD 91-81	39	101	WE RICKER	HAKE SURVEYS (with CTD's) (PBS 91-03)	02-FEB-91	27-FEB-91	SAUNDERS M	LAPEROUSE, WASHINGTON, OREGON, CALIFORNIA AND STR OF GEORGIA
1991	153	CTD 91-03	43	101	JOHN P TULLY	CTD'S, HYDRO'S SAIL - (COCC91-01) WOCE REPEAT HYDROG	19-FEB-91	11-MAR-91	FREELAND H	JUAN DE FUCA, LINE P, WCVI, LINE R

YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1991	154	CTD 91-04	5	101	PARIZEAU	CTD'S , CM MOORINGS ?, SAIL, RDI	21-FEB-91	25-FEB-91	CRAWFORD WR	QC SOUND
1991	180	CTD 91-82	2	101	WE RICKER	ROCKFISH SURVEYS (?)	11-MAR-91	27-MAR-91	LEAMAN B	STR OG GEORGIA, QC SOUND, WCVI
1991	172	CTD 91-83	4	101	WE RICKER	HERRING SURVEY (?) (PBS 91-03)	11-APR-91	16-APR-91	HAY D	STR OF GEORGIA, LAPEROUSE, WCVI
1991	155	CTD 91-08	28	101	PARIZEAU	CTD, HYDRO, MOORING OEP, SAIL, RDI, PLANKTON, TEST NEW GUILDLINE CTD	29-APR-91	10-MAY-91	FREELAND HJ	WCVI, LINE P,LINE R,JUAN DE FUCA
1991	173	CTD 91-84	4	101	WE RICKER	SHELLFISH (PRAWNS/SHRIMP?) (PBS 91-04)	30-APR-91	11-MAY-91	BOUTILLIER J	LAPEROUSE, WCVI
1991	174	CTD 91-85	2	101	WE RICKER	ROCKFISH (?) (PBS 91-05)	23-MAY-91	24-MAY-91	LEAMAN B	LAPEROUSE, WCVI, QC STRAIT
1991	156	CTD 91-10	86	101	PARIZEAU	CTD, HYDRO, SAIL, RDI - CRD , LAPEROUSE CM MOORING , PLANKTON TOWS	27-MAY-91	07-JUN-91	THOMSON RE	LAPEROUSE, WCVI, QC SOUND
1991	161	CTD 91-12	69	101	PARIZEAU	CTD/ADCP/TUCKER TRAWLS , HYDROS AT VENTS; JOINT CTD SURVEY WITH HARGREAVES (WE RICKER) MET BUOY DEPLOYED IN BARKLEY SOUND	15-JUL-91	26-JUL-91	THOMSON RE	ENDEAVOUR RIDGE, JUAN DE FUCA, WCVI
1991	176	CTD 91-87	36	101	WE RICKER	Bernard-Sigmund trawls for juvenile salmon ; CTD's (PBS 91-07)	16-JUL-91	01-AUG-91	HARGREAVES B	LAPEROUSE, WCVI
1991	177	CTD 91-88	21	101	WE RICKER	LAPEROUSE CTD's AND PLANKTON TOWS (PBS 91-08)	14-AUG-91	18-AUG-91	SAUNDERS M	LAPEROUSE, WCVI
1991	178	CTD 91-89	60	101	WE RICKER	BERNARD-SIGMUND TRAWLS FOR JUVENILE SALMON; CTD'S (PBS 91-09)	09-SEP-91	26-SEP-91	HARGREAVES B	LAPEROUSE, WCVI
1991	163	CTD 91-14	72	101	PARIZEAU	CRD MOORINGS, CTD, HOT VENT SCINT MOORING RECOV, HYDRO, LAP MOORINGS, SAIL, RDI, PLANKTON TOWS	05-OCT-91	15-OCT-91	THOMSON RE	JUAN DE FUCA, ENDEAVOUR RIDGE, WCVI, QC SOUND, LAPEROUSE
1991	179	CTD 91-90	14	101	WE RICKER	HAKE SURVEY (?) CTD AND PLANKTON TOWS	10-OCT-91	30-OCT-91	SAUNDERS M	STR OF GEORGIA, LAPEROUSE, WCVI, WCQCI, QC SOUND
1991	167	CTD 91-15	12	101	ENDEAVOUR	CTD, HYDRO, CM DEPLOYMENT (QUIET EDDY) STN P SEDIMENT TRAPS, TEST ARCTIC CTD PROBE	17-OCT-91	01-NOV-91	FREELAND HJ	LINE P, NE PACIFIC
1992	194	CTD 92-01	12	101	J P TULLY	WOCE PR-6 REPEAT HYDROGRAPHY LINE P/ STATION P CTD'S, HYDRO'S, CO2, NUTRIENTS	03-FEB-92	12-FEB-92	FREELAND HJ	LINE P / STATION P
1992	199	CTD 92-06	12	101	ENDEAVOUR	CTD'S AND HYDROS LINE P/ STNP ALSO REFERRED TO AS COCC9202	27-MAR-92	12-APR-92	FREELAND HF	LINE P / STATION P
1992	202	CTD 92-10	46	101	JP TULLY	CTD'S, moorings, plankton tows,SAIL(?)	14-JUN-92	21-JUN-92	THOMSON RE	LaPerouse, WVCI
1992	206	CTD 92-81	43	312	WE RICKER	CTD'S, BEAM TRAWL FOR JUVENILE SALMON (PBS 92-06)	16-JUN-92	02-JUL-92	HARGREAVES B	WCVI, LAPEROUSE
1992	204	CTD 92-12	2	101	ENDEAVOUR	SQUID tows, HYDRO's coring, dredging, video	06-JUL-92	23-JUL-92	THOMSON RE	Endeavour Ridge
1992	216	CTD 92-82	67	312	WE RICKER	CTD'S, BEAM TRAWLS FOR JUVENILE SALMON (PBS 92-08)	30-JUL-92	02-SEP-92	SAUNDERS M	WCVI, LAPEROUSE

YEAR	DSID	DATASET	NSTN	AGY	VESSEL	CRUISE_DESCRIPTION	STARTDATE	END_DATE	SCIENTIST	GEOGRAPHIC_AREA
1992	208	CTD 92-15	13	101	JP TULLY	CTD'S, NUTRIENTS, CO2, HYDROS, SEDIMENT TRAPS	09-SEP-92	29-SEP-92	FREELAND HJ	STN P, LINE P, Z, R, NE PACIFIC
1992	212	CTD 92-85	21	310	WE RICKER	CTD, SAIL, SABLEFISH TRAPS (PBS 92-10)	13-OCT-92	05-NOV-92	SAUNDERS M	WCQCI, WCVI, LAPEROUSE, GEORGIA STR
1992	210	CTD 92-19	81	101	JP TULLY	CTD'S, CURRENT METERS, HYDROS, PLANKTON, ZOOPLANKTON ACOUSTICS (OE 92-05)	22-OCT-92	19-NOV-92	THOMSON RE	WCVI, LAPEROUSE, GEORGIA STR
1992	214	CTD 92-22	52	101	ENDEAVOUR	CTD, HYDROS, PLANKTON TOWS (OE 92-06)	07-DEC-92	11-DEC-92	MACKAS D	WCVI, LAPEROUSE

182 rows selected.

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