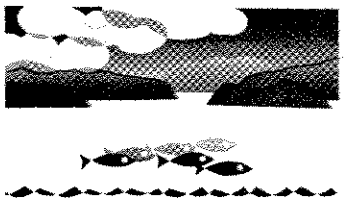

Archipelago Marine Research

#10 - 1140 Fort Street, Victoria, B.C. V8V 3K8 Telephone (604) 383-4535

May 20, 1988

Mr. Jean Lacelle
Director
Science Programs Branch
Science and Professional Services Directorate
12C1, Phase III
Place du Portage
11 Laurier St.
Hull, Quebec
K1A 0J5

Dear Mr. Lacelle:

Please find enclosed 12 copies of a research proposal entitled "The Sea Otter in British Columbia. Population Dynamics and Community Effects" which we wish to submit for review under the Unsolicited Proposal Program. This proposal outlines a program which will examine the effects of sea otters on nearshore resources of British Columbia, and provide estimates of the sea otter population on the west coast of Vancouver Island. The study will be conducted between July 15, 1988 and March 31, 1989. Total cost of the proposal is $67,364.

The following federal and provincial government personnel have been consulted with regards to this project and feel that their mandates will benefit directly from a study of this nature:

Dr. Mike Bigg - Section Head, Marine Mammals, P.B.S.
Frances Dickson - Shellfish Coordinator, D.F.O.
Sue Farlinger - Fisheries Manager, Northern Division, D.F.O.
Dr. Louise Goulet - Coordinator, Ecological Reserves, B.C.
Bill Monroe - Head, Threatened and Endangered Species, B.C.

Upon reviewing the proposed research program, both the Nuu-chah-nulth Tribal Council and the Kyuquot Band Council have indicated that they fully support this project.

Dr. Bigg has indicated that his section (Marine Mammals) will contribute the equivalent of $6,700 to cover the cost of airplane charters and aerial surveyors as a contribution in kind towards support of this project. Dr. Bigg has also agreed to act as Scientific Authority for the project. Archipelago Marine Research is willing to contribute the equivalent of $2,750

towards the costs of two inflatable boats and motors. The total in kind contributions amount to $10,350 or 15% of the proposed total cost of the project.

Hopefully the proposal can be reviewed and assessed by the appropriate agencies by the proposed start up date of July 15, 1988. Please contact me if you have any questions in regards to the proposed work.

Sincerely yours,

Tom Shields

Tom Shields
President

TS:jv

THE SEA OTTER IN BRITISH COLUMBIA
POPULATION DYNAMICS AND COMMUNITY EFFECTS

AN UNSOLICITED PROPOSAL

Submitted to:

Unsolicited Proposal Program
Science Procurement Branch
Science and Professional Servcies Directorate
12C1, Phase III, Placeu du Portage
Hull, Quebec
K1A 0S5

Proposal Submitted by:

Archipelago Marine Research
#11, 1140 Fort St.
Victoria, B.C.
V8V 3K8
May 1988

TABLE OF CONTENTS

SUMMARY

Sea otters play an important role in nearshore marine ecoystems in the north Pacific. As predators of marine invertebrates (sea urchins, abalone, clams and crabs), sea otters may have significant and long lasting effects on British Columbia's nearshore benthic communities. The effects of sea otters on invertebrate populations and community structure in British Columbia has not been comprehensively documented.

This proposal outlines a programme to provide estimates of the sea otter population on the west cost of Vancouver Island and to examine the effects of sea otters on nearshore resources and community structures. The study will be conducted between July 1988 and April 1989. The specific objectives of this study are as follows:

1. Determine size, geographical extent and rate of growth of the B.C. otter population.
2. Assess the effects of sea otters on invertebrate populations and community structure.

A cost effective method to estimate the population size of the B.C. sea otters in B.C. will be developed so that regular population censuses can be conducted in the future by D.F.O. personnel. Estimates of population size, and growth rate are essential management parameters. This information will allow managers to predict the rate of growth and potential range expansion of the B.C. sea otter population.

This study will provide data necessary for Fisheries and Oceans biologists and managers to understand the effects of sea otter foraging on nearshore community structure and invertebrate stocks. Comprehensive work of this nature has not been conducted

in B.C. The total estimated budget to complete the proposed work is $67,634.00. Dr. Mike Bigg, Section Head, Marine Mammals Section, Pacific Biological Station, has agreed to act as Scientific Authority for the project. Together, Dr. Bigg and Archipelago Marine Research have committed $10,350 (15%) of in kind contributions towards the total cost of the project.

TECHNICAL PROPOSAL

INTRODUCTION

Sea otters, much prized for their furs, were hunted to extinction in B.C. from the late 1700's to the early 1900's (Reidman and Estes 1988). Remnant populations in the Aleutian Islands and Prince William Sound provided subsequent seed stock for translocation to Oregon, Washington; British Columbia and Southeast Alaska (Jameson et al. 1982). From 1969 to 1972, 89 sea otters (Enhydra lutris) were reintroduced to Checleset Bay on the west coast of Vancouver Island. This introduced population of 89 otters has grown at an annual rate of 17% (Estes unpub. MS 1988). MacAskie (1985, 1987) estimates that there are presently 400 animals located in two concentrations at Checleset Bay and Bajo Reef (Figure 1).

Sea otters are important predators of marine invertebrates particularly urchins, abalone, clams, crabs and mussels. Sea otters lack the thick blubber of many aquatic mammals and depend on their dense fur for insulation. The resulting high metabolic rate requires that they consume 1/4 - 1/3 of their body weight in food each day (Morrison et al. 1975). Adult sea otters weigh an average of 39 kg. and thus can consume up to 12 kg. of shellfish daily. Populations of otters in both California and Alaska may have significantly reduced commercial stocks of clams, abalone, crabs, and urchins; suggesting that otters compete directly with commercial and recreational fisheries (Estes and VanBlaricom 1985; Estes 1981; Hines and Pearse 1982; Johnson 1982; Kvitek and

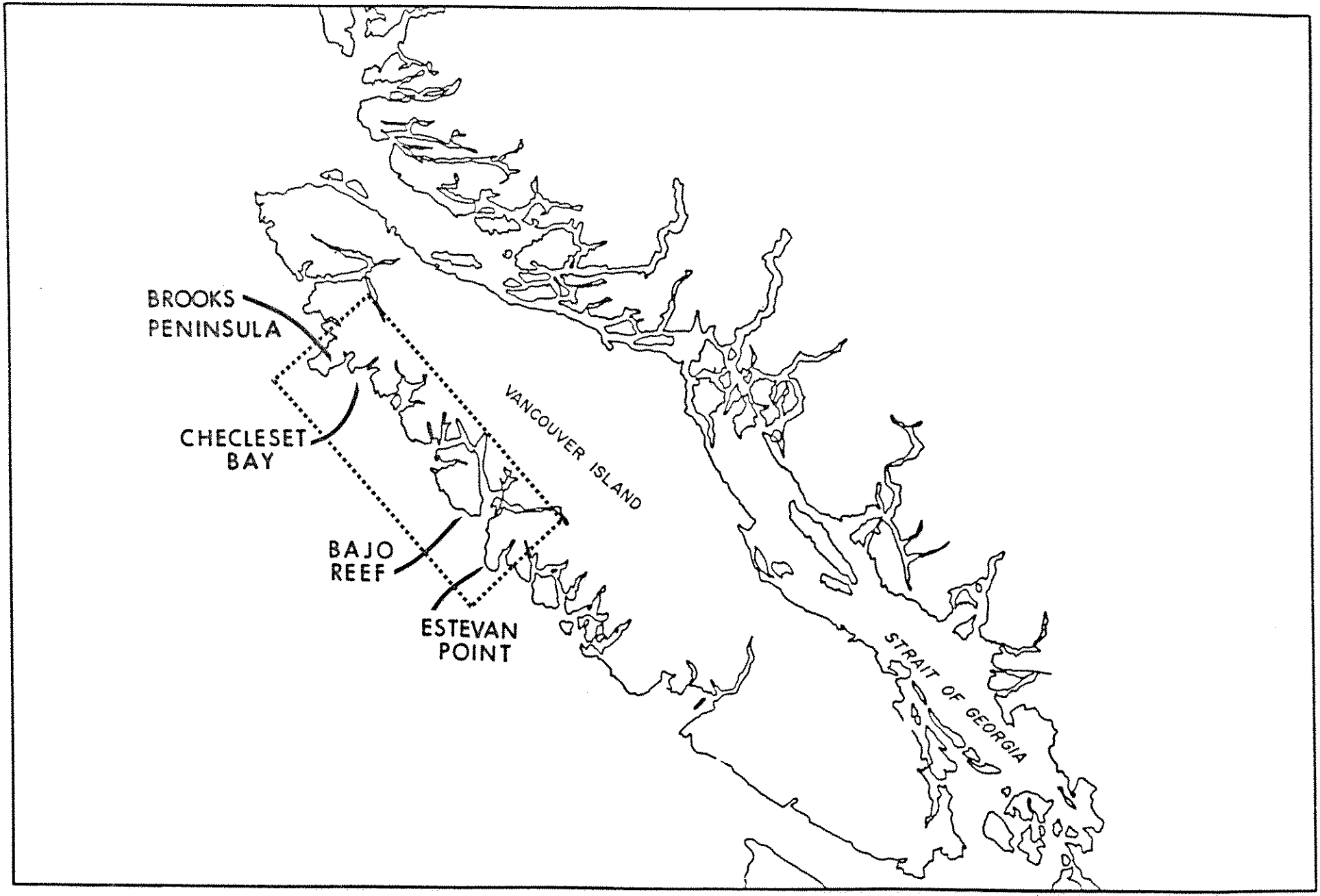

Figure 1. The study area.

Oliver 1988; Pleschner 1984; Stephenson 1977; VanBlaricom 1984, 1987, 1988; Levin 1988).

The preliminary estimate of the 1987 value of major shellfish species, including abalone, geoducs, crabs, horse clams, intertidal clams, sea cucumbers and sea urchins, landed from the west coast of Vancouver Island (areas 23-27) is $5,183,000 (B. Adkins, Fisheries Branch, South Coast Division, pers. comm.). This represents approximately 28% of the total landed value of these species on the B.C. coast. Fisheries for urchins, crabs, clams and abalone between Brooks Peninsula and Estevan Point may be afffected by the expanding otter population. The crab landings from Clayquot Sound comprise the third largest crab fishery in British Columbia. Sea otter foraging has been implicated in the decline of the crab fishery in Prince William Sound, Alaska (Simon-Jackson 1986).

Sea otters have profound effects upon the structure of nearshore communities. By reducing the number of herbirovres, particularly urchins, sea otters are thought to promote the growth of kelp (Simenstad et al. 1978; Estes and Palmisano 1974; Estes et al 1978; Breen et al. 1982; Duggins 1980, 1988). Kelp forests influence the nearshore community, increasing productivity by providing a rich source of detrital and dissolved organic carbon (Duggins 1988) and altering the nearshore environment by attenuating wave motion (Jackson 1984, Jackson and Winant 1983). Many authors have demonstrated the importance of kelp canopies upon species composition of fish (Bodkin 1987, Laur et al. 1988, Leaman 1980) and recruitment of invertebrates (Bernstein and Jung 1983, Gaines and Roughgarden 1985).

At present there is some disagreement amongst scientists as to exact biological influence of sea otters upon nearshore communities (Foster and Schiel 1988, Estes and VanBlaricom 1988). These uncertainties arise from the fact that most of the current information is based largely on anecdotal information drawn from opportunistic studies. The effects of sea otters on nearshore communities have been studied to some extent in Alaska, (Duggins 1980; Dayton 1975; Estes and Palmisano 1974; Estes et al. 1978, 1982; Simenstad et al. 1978; VanBlaricom 1987, 1988; Foster and Schiel 1988; Estes and VanBlaricom 1985). The extent and character of the effects of sea otters varies among different communities and studies.

The existing sea otter populations in British Columbia is the least well known of all North American sea otter populations (Jameson et al. 1982). To date three population censuses MacAskie 1985, 1987, Bigg and MacAskie 1978) and some early habitat studies (Morris et al. 1982, Morris et al. 1978, Breen et al. 1982) are the only published knowledge we have of sea otters in British Columbia.

In addition to the existing population of otters in B.C., a population of some 200 sea otters in the Barrier Islands, Alaska (Pitcher 1987) are only 80 km. from the Queen Charlotte Islands. Based on the present rate of population growth of the Alaskan otter population (Estes unpub. ms.), it is possible that otters from the Alaska population will expand into B.C. waters in the next ten years. In addition conservation organizations have proposed that sea otters from Alaska be translocated to the Queen

Charlotte Islands to establish a second population in B.C. Inevitably, the B.C. sea otter population will increase and expand its range, creating conflict between various interest groups and fishermen. Conflicts between environmental and conservation groups and fishermen over the sea otter issue continue to intensify in California and Alaska, and appear likely in British Columbia. The proposed study will provide a comprehensive estimate of the B.C. sea otter population as well as a detailed description of the impact otters are having on nearshore community structures. With this information, DFO managers and provincial government personnel will be better equipped to make rational decisions regarding the expansion of sea otter populations in British Columbia waters.

The following federal and provincial government personnel have been consulted with regards to this project and feel that their mandates will benefit directly from a study of this nature:

Dr. Mike Bigg - Section Head, Marine Mammals, P.B.S.

Frances Dickson - Shellfish Coordinator, D.F.O.

Sue Farlinger - Fisheries Manager, Northern Division, D.F.O.

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towards support of this project. Dr. Bigg has also agreed to act as Scientific Authority for the project.

Archipelago Marine Research is willing to contribute the equivalent of $2,750 towards the costs of two inflatable boats and motors. The total in kind contributions amount to $10,350 or 15% of the proposed total cost of the project.

STUDY OBJECTIVES

The objectives of the study are to determine:

I. Population Dynamics of the B.C. Sea Otter Population

1. Range of the sea otter population
2. Population size and growth rate
3. Anticipated rate of expansion

II. Effects of Sea Otters on Invertebrate Populations and Community Structure

1. Impact of sea otter foraging on selected invertebrate populations
2. Influence of sea otter foraging on community structure

STUDY PLAN

General

Preliminary survey work has been conducted between Brooks Peninsula and Estevan Point in August and September of 1987. The design of the proposed research is based upon the results of this preliminary work, which indicated that invertebrate species composition and algae distribution and abundance in areas with sea otters was considerably different from those areas without otters. The geographic extent of the otter population was determined by a boat and aerial survey conducted in conjunction with West Coast Whale Research (MacAskie 1987).

Work will be conducted between Brooks Peninsula (50° 50'N, 128°0'W) and Estevan Point (49° 40'N, 126°80'W) on the west coast of Vancouver Island (Figure 2). Otter populations presently occupy areas from Brooks Peninsula to the Mission Group, and from Skuna Bay to Maquinna Point. In this study, two

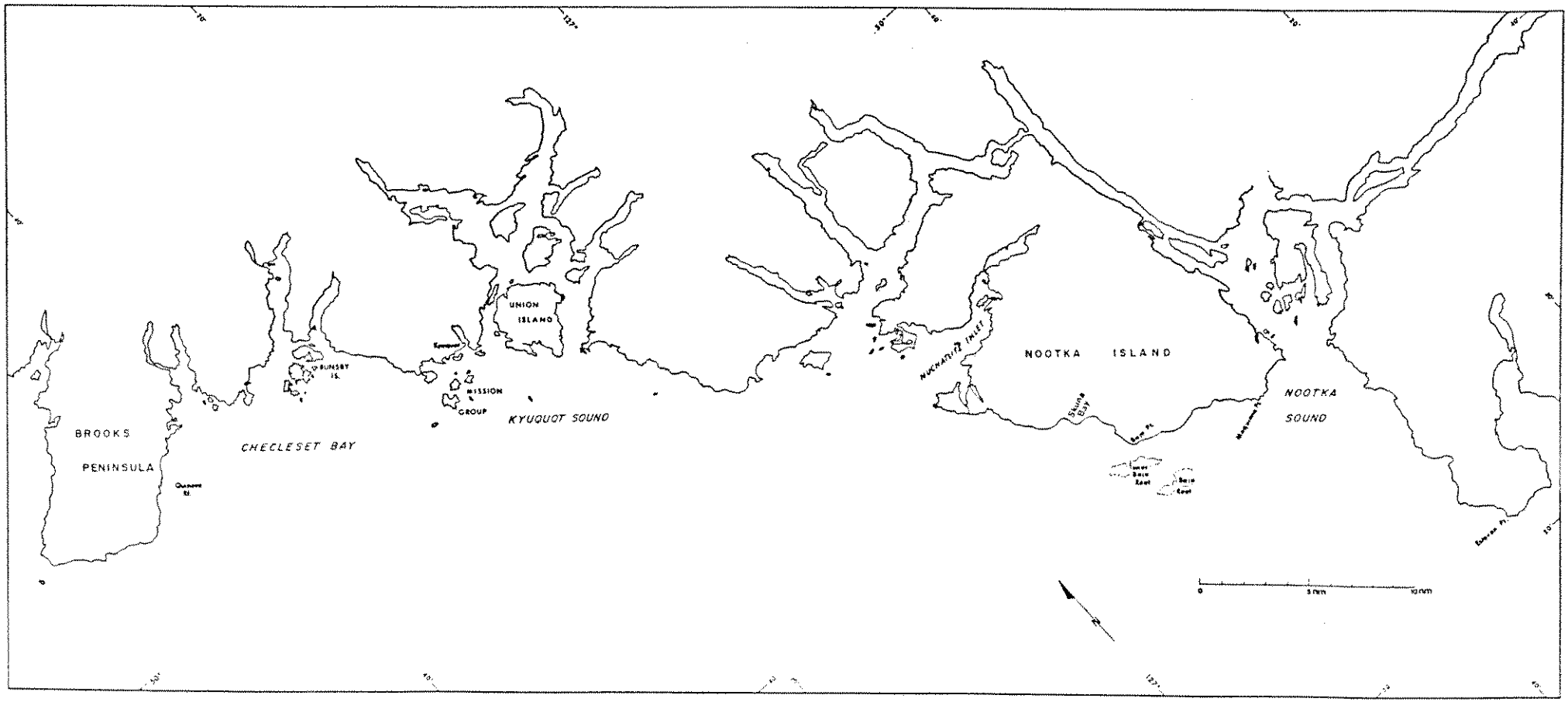

Figure 2. Detailed illustration of the study area.

aerial and boat surveys of the otter population will be conducted throughout the entire study area from Estevan Point to the Brooks Peninsula. Aerial surveys will be conducted in conjunction with the Marine Mammals Sections of the Pacific Biological Station. Boat survey efforts (using two boats) will be concentrated in areas of known sea otter populations from Skuna Bay to Maquinna Point and from Quineex Reef to the Mission Group. Aerial surveys will be conducted through the entire study area. The population surveys (three days each) will be conducted in August 1988 and in March 1989. These surveys will require two observers in the aircraft and two observers in each of the two boats (16 ft. Zodiacs).

Benthic community diving surveys will be restricted to the otter dominated area from the Brooks Peninsula to the Mission Group, and the area presently unoccupied by sea otters between Union Island and Nuchatlitz Inlet.

A subtidal survey of the otter dominated area in Checleset Bay (Brooks Peninsula to the Mission Group) and a comparative survey in the area apparently free of sea otters (Union Island to Nuchatlitz Inlet) will be conducted from July 15 to September 15, 1988. The diving surveys will be conducted by a team of four diver/biologists. Three weeks will be spent at each of the sites. Work will be conducted from inflatable skiffs, working from a base camp in Kyuquot. A larger vessel will be required for 12 days of work in the remote regions of the study area.

Table 1 outlines the task schedule for the proposed work and provides an estimate of the total number of person days required to complete each task.

Table 1. Task Schedule for the Proposed Study.

	July 1988	August 1988	Sept 1988	Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	March 1989	No. of days	No. of person da
A. Population Surveys (includes travel and field work)											
1. Summer surveys		—								5	30
2. Spring surveys									—	5	30
B. Community Surveys											
1. Mobilization\demobilization	—			—						5	8
2. Travel and establish camps	—									2	8
3. Survey otter dominated zone Checleset Bay to Union Island		—	—							21	84
4. Survey otter free zone Union Island - Nuchatlitz Inlet			—	—						21	84
5. Pack up and travel				—						1	4
C. Data Analysis and Report Writing				—					—	22	22
D. Project Management	—	—	—						—	4	4
										86	274

Sea Otter Population Survey

Aerial and boat surveys will be conducted in combination to estimate the size and present geographical extent of the sea otter population between Estevan Point and the Brooks Peninsula. Two survey periods of three days duration will be conducted in August of 1988 and March of 1989. The entire area will be surveyed each day, providing three replicate population estimates per survey period. Semi-annual surveys will yield better data than annual surveys, as distribution and abundance of otters varies in time and space (Geibel and Miller 1984). The absence of canopy kelp in the spring should enhance counting conditions. High overcast and calm sea conditions will be required for censusing.

Surveys will be conducted between 0730 and 1330 when otter activity is minimal and most animals are resting at the surface (Estes and Jameson 1988). Using a Cessna 180 on floats, air counts will be made by two observers, flying 60 metres (200 feet) above the sea surface at a speed of 50 m/sec (Estes and Jameson 1988).

The survey area (Brooks Peninsula to Estevan Point) will consist of the outer coast line and all reefs and islands extending out to a depth of approximately 30 metres (100 feet), the maximum normal foraging depth for sea otters (Estes 1977). The survey area will be divided into sub-areas with boundaries consisting of prominent geographic features.

The position of the observed otters will be recorded by aerial surveyors on maps with subareas clearly defined and

numbered. When large groups of otters are located, photographs will be taken to verify visual counts. This method will be consistent with previous aerial counts (MacAskie 1984, 1987) and will allow comparison with earlier data.

Boat counts will be conducted using two inflatable skiffs. Two observers in each boat will conduct population surveys concurrent with aerial surveys. Observers will use 10X binoculars to locate otters. Frequent stops will be made to search for otters resting or foraging in the Nereocystis beds. Areas not occupied by otters or occupied by low densities of sea otters (based on previous surveys) will not be surveyed because of time and cost. The initial boat surveys will be concentrated in sub-areas of known otter concentrations (see MacAskie 1987). The number and location of subareas covered by the boat crews may change depending on the distribution of sea otters as determined by the initial aerial surveys.

Aerial and boat survey data will be compared to develop a numerical relationship between boat and aerial counts which may allow the estimation of population size based solely on boat counts. In B.C. boat counts have proven to be the more conservative of the two methods and as few as one third of the otters counted by aerial observers may be seen by the boat based surveyors (MacAskie 1987). The presence of Nereocystis in August will reduce the number of sea otters sighted and create a seasonal bias in the population estimate, so seasonal indices (ratio of aerial counts to boat counts) can be developed. Replicate counts will allow the determination of variance of the

population estimate (see Appendix 1 for a discussion of sample size).

A modified mark/recapture estimator method developed by Geibel and Miller (1984) allows the estimation of population size and variance without replicate surveys. This method is similar to a single mark and recovery experiment in which airplane observed otters are "marked" and shore observed otters consist of recoveries of "marked" otters. This method is dependent upon assumptions surrounding the probability of sighting otters from a plane or boat. While some of the assumptions may not hold in B.C., population estimates using this method will also be calculated (no extra field effort or time is required. See Estes and Jameson 1988 and Seber 1982 for a discussion of assumptions). The advantages of the mark/recapture method are that variance can be calculated without replicate sampling of the whole population. In addition less effort can be spent on surveying. The population and variance estimates using this method will be compared to that obtained by combining the replicate counts.

Logistical Constraints

Aerial counts have been used to estimate otter populations in B.C., Alaska, and California (Geibel and Miller 1984, Simon-Jackson 1987, Estes and Jameson 1988). In general, shore-based counts are considered most accurate but are not possible in B.C.., because of the rough terrain, offshore islands, length of coastline and lack of access. Aerial counts may underestimate the population by as much as fifty percent (Geibel and Miller 1984).

A population estimate is most useful if it is unbiased and reasonably precise, however, less precise and biased estimates can be used to monitor population trends. Aerial counts of animals occurring in groups are often subject to large and unknown biases. Usually direct population counts are low as some individuals are invariably missed. To increase precision, counts can be replicated. However, highly variable replicate counts are of little value unless large numbers of estimates are available. In the proposed study, attempts are made to address these problems by replicating surveys in two seasons and employing two survey methods.

In British Columbia boat surveys have produced extremely conservative population estimates; often as low as one third of that obtained by concurrent aerial surveys (MacAskie 1987). Boats provide a poor platform from which to count otters but are inexpensive and provide a minimal estimate of the population. By developing a numerical relationship between aerial and boat counts, boat surveys may provide a method by which to roughly approximately the population size.

Effect of Sea Otter Foraging on Community Structure

The effects of sea otter foraging on nearshore community structure will be assessed by comparing the community structure of areas with and without sea otters. Since marine communities are inherently variable, the objective of this study is to determine the influence of sea otter foraging within this variation. There are two possible approaches to this problem:

1. Areas with and without sea otters can be compared using the presence and absence of otters as an experimental treatment. In this method an adequate number of samples are required to obtain a representative measure of variation within and among sites within treatments. Hypotheses regarding the effects of sea otter foraging on community composition and structure can be tested by comparing sites.

2. The same areas can be compared through time. Areas presently free of otters can be surveyed and changes documented as otters move into these areas. This method permits the removal of the possible confounding influence of spatial variation. The same hypotheses can be tested by examining differences between otter inhabited and otter free areas, as the latter are re-inhabited by otters. The prediction is that the composition and structure of the two communities would converge as otters moved into the previously unoccupied areas.

While the second method allows the removal of spatial variation in the system, it requires the researcher to anticipate the expansion of the sea otter into the study areas within the constraints of the study period. The first method allows us to examine the effects of otter foraging by comparing experimental treatments (with and without otters) in a short period of time. Using Method 1 "Baseline data" is generated from the survey of the otter-free site and can be used in a study of the second type if desired.

In this study, the first method will be used to examine the apparent effects of sea otter foraging on nearshore community

structure. Preliminary observations of this and other otter inhabited areas (Estes, in prog) indicate that the community changes due to otter foraging are of such a scale that inherent variation may be of little consequence (i.e. there will be no sea urchins at the otter-dominated site, but highly variable densities of urchins at the otter-free site). To facilitate future work statistical methods will be used to document the sample size necessary for particular levels of discrimination at various levels of statistical confidence for all surveyed species. Appendix 1 outlines the methods that will be used to determine if the variances are representative within areas and between sites.

Methods

The area presently occupied by sea otters in Checleset Bay (Figure 1) and the otter-free area from Union Island to Nuchatlitz Inlet will be surveyed from July 16 to September 15. In each area 30 sites will be chosen in a randomly stratified manner (Appendix 2 for methods). Twenty of these sites will be sampled from rock-bottomed environments and 10 from soft-bottomed benthos.

In areas of rocky substrate, divers will work at depths of 6-8 metres (20-25 ft). Depths were chosen based on logistic constraints (bottom time and surge) and observations from the preliminary survey. Divers will swim a predetermined random number of kicks and drop a 1/2 square metre quadrat to the bottom. All major species of invertebrates and discrete species

of algae will be counted. A total of 20 quadrats will be censused in this manner at each site.

Sample unit size and sample effort is based on preliminary survey work conducted in September 1987 (see Appendix 1). All urchins found within the quadrats will be identified to species, counted and collected. Urchins test diameter will be measured on the surface and returned to the substrate after measurement. Abalone (Haliotis kamshatkana) will be counted and sampled for length.

Soft bottomed environments will be assessed for commercial clam species (Panope abrupta, Tresus capax, Saxidomus giganteus) and crab species (Cancer magister). To enumerate clams, only protruding siphons will be counted one metre on either side of a 30 metre transect laid out randomly across the bottom. At each site five transects will be run in depths of 7-11 metres (25-35 ft).

A calibration for non-showing siphons will be made at the initiation of the survey using the methods of Breen and Shields (1983). Siphons of these three species of clams are easily distinguishable.

Crabs will be enumerated as seen. Using a line transect method the distance from the transect and angle from the line will be estimated for each crab sighted. This will account for changes in visibility by providing density estimate of crabs.

This work will be conducted in a manner consistent with research in progress in the Aleutian Islands, Alaska and California (Estes et al. in prog., Duggins et al. in prog.) which

will allow interpretation of the data in a broad geographical perspective.

Data Analysis and Final Report

Sea Otter Surveys

Population estimates of sea otter abundance will be obtained in two seasons using two separate methods. Each survey will be comprised of three replicates (=days). Replicate counts will allow the determination of precision of the population estimate. Statistical methods (see Appendix 1) will be used to document the precision of the estimates and adequacy of the sample size.

Population estimates between the two seasons will be compared using a Mann-Whitney U Test (Sokal and Rholf 1969), to determine if a seasonal bias in population census occurs. Significant differences between seasons may indicate a seasonal bias (the population would not be expected to change significantly in size between season, but surveying conditions might). Combined aerial and boat surveys may allow the development of a numeric relation between aerial and boat surveys, and allow for the approximation of a minimum population size based on less expensive boat surveys.

Population trends will be examined by comparing the population estimates of this survey with previous estimates. Rate of population growth and range expansion over time will be determined to examine the rate of geographic expansion.

Diving Surveys

All data on species abundance from the diving surveys will be compared (by species) between areas with and without sea otters. Data will be tested for normality and homogeneity of variance. If both of these requirements of parametric statistics are fulfilled, data will be examined using a parametric comparison test (chi squared test). In the event that the requirements of a parametric test are not met, data will be compared using a nonparametric test (Kruskal Wallis, Elliott 1977). Data will be compared by species to determine how sea otter foraging has affected the abundance of selected species of invertebrates and algae (the null hypothesis is that there will be no difference between treatment effects - the presence or absence of sea otters). The precision of abundance estimates for each species will be documented (Appendix 1).

Size frequency data for both urchins and abalones will be plotted as size frequency histograms and compared using a Kolmogorov-Smirnov goodness of fit test (Sokal and Rholf 1969). This data will document the differences in size frequencies between areas. Otter foraging has been shown to affect the size distribution of urchins and abalone (Estes et al 1974; Estes and Duggins in press discussed in Hines and Pearse 1982). Initial observations indicate that this may not be the case in this geographic region (Breen et al 1982, Watson pers. obs.).

By statistically comparing data from areas with and without sea otters, the apparent effects of otter foraging on invertebrate and algal abundance as well as subsequent community structure will be examined. Data collected from areas presently

free of otters will provide baseline data for any subsequent studies on the community effects of otter foraging.

Uniqueness of Proposed Research

Their diet of economically important invertebrates brings sea otters into direct competition with commercial and recreational shellfisheries. Sea otters already present an important and controversial problem for fisheries managers in California and Alaska. The effect of sea otters on invertebrate populations and community structure in British Columbia has not been comprehensively documented. This study offers federal and provincial fisheries personnel a unique opportunity to develop an understanding of the effects of sea otter foraging on nearshore communities as well as the opportunity to better understand the rate of population growth and anticipated expansion of the B.C. sea otter population.

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MANAGEMENT PROPOSAL

General

This work will be carried out by Archipelago Marine Research (AMR). Dr. Mike Bigg, Section Head, Marine Mammal Section, Pacific Biological Station of DFO has agreed to act as Scientific Authority for this project. The key elements to successful management of this project are:

1. A capable and experienced project team.
2. Effective liaison with federal and provincial personnel concerned with the proposed work (Marine Mammal Section, DFO, south coast and north coast shellfish managers; B.C. Ecological Reserves; and Threatened and Endangered Species, B.C.).
3. Efficient financial management and adequate corporate expertise.

Project Team

The project team combines skill and experience in sea otter survey techniques and subtidal survey techniques using SCUBA. All members of the study team have experience in conducting subtidal surveys under adverse conditions (resumes are presented in Appendix 3).

A. Project Coordinator - Jane Watson

Ms. Jane Watson will act as project coordinator for this study. She will be responsible for coordinating and implementing the overall study plan. This will include communication with the Scientific Authority and other interested federal and provincial biologists and managers to insure that the main objectives of this study are efficiently carried out.

Ms. Jane Watson is uniquely qualified to act as project coordinator for this study. Ms. Watson has participated in a

number of AMR projects involving SCUBA survey work in remote areas. Included are herring spawn surveys on the west coast of Vancouver Island, central coast and Queen Charlotte Islands.

Ms. Watson, a Canadian citizen, is presently a PhD candidate at the University of California at Santa Cruz. She is studying the demography of kelp communities within the sea otter dominated areas on the west coast of Vancouver Island. Ms. Watson conducted a five week preliminary survey of the entire sea otter range on Vancouver Island's west coast last summer. She is, therefore, thoroughly familiar with the proposed study area. As a result of last summer's research, Ms. Watson is well acquainted with the most efficient and economical means to conduct field work in this remote area.

From a scientific perspective, Ms. Watson is also uniquely qualified. Her thesis advisor, Dr. Jim Estes, is considered by many to be the leading authority in the field of sea otter-nearshore community interactions. Working with Dr. Estes, Ms. Watson has spent two field seasons studying sea otter-nearshore community interactions in the Aleutian Island, Alaska. Ms. Watson is presently participating in an ongoing sea otter transplant research program in the Channel Islands, California.

Dr. Estes will consult with Ms. Watson throughout the course of this study. He will advise Ms. Watson regarding matters of scientific design and data analysis.

Based on her experience with sea otter research and familiarity with the west coast of Vancouver Island, Ms. Watson offers the knowledge of relevant scientific techniques and

practical experience required to successfully accomplish the proposed tasks.

B. Diver/Biologists

Anne Stewart

Ms. Anne Stewart has extensive experience in subtidal, biological survey work. In addition, she is well acquainted with the B.C. sea otter population. With over 500 logged hours of research diving, Ms. Stewart has participated in many remote field research projects including herring spawn surveys on the west coast of Vancouver Island central coast and Queen Charlotte Islands.

Ms. Stewart participated in most of the original surveys of sea otter nearshore community interactions on the west coast of Vancouver Island. As a result, she is one of the few authors of published information regarding the B.C. otters (see Breen et al 1982).

In addition to Ms. Stewart, there will be two more diver/biologists. These people will have a minimum of 200 hours of logged research diving experience. In addition, they will have a background in marine biology, and they will have experience in working under remote field conditions.

Project Management

Mr. Tom Shields, president of AMR, will be responsible for overall project management. He will oversee the project to ensure that the goals and objectives of the project are fulfilled and carried out in accordance with the proposed task schedule.

Mr. Shields will maintain contact with the Scientific Authority throughout the study period. He will also be responsible for all matters of a contractual nature, including monitoring project costs and submitting monthly claims for progress payment to the Department of Supply and Services.

Corporate Experience and Capability

Archipelago Marine Research is a Canadian company registered in British Columbia and located in Victoria. The business is wholly owned by three partners, who are either Canadian citizens or landed immigrants. The firm was established in 1978 and has been conducting fisheries-related contract work on Canada's west coast for ten years (AMR project summary - Appendix 4). Collectively the three partners have over thirty years experience in fisheries contractual work on the west coast. The company employs additional staff on a project by project basis, amounting annually to approximately ten marine and fisheries biologist person-years. Support staff include a full time secretary/office manager and part time accountant.

Archipelago Marine Research provides fisheries and marine biological service to both public and private sector clients. The company conducts projects primarily on the west coast but has also operated in the Canadian Arctic, Alaska and Washington State. The primary focus is in the fields of fisheries resource assessment, analysis of fisheries resource use as well as shellfish and finfish mariculture.

The company and its personnel are highly skilled and experienced in the efficient execution of field research

(particularly diving-related programs) under difficult logistical and environmental constraints. AMR has had direct involvement in many projects which have provided the company and its personnel with experience in all aspects of the proposed research project.

The company has designed and conducted various types of diver surveys throughout coastal British Columbia and the Canadian Arctic. These include quantitative surveys for herring spawns, abalone, geoduc and other shellfish species. In 1986 the company carried out a study of overwintering chinook salmon in the Nicola/Thompson rivers of interior British Columbia.

The company is in a sound financial position and is capable of meeting the monthly cash requirements of a project of this scope. The company routinely manages projects with monthly cash flow requirements in excess of $30,000. The firm has retained an excellent credit rating with two Royal Bank branches in the Victoria area and letter of reference is available from our current bank manager upon request. Should funding for this project be secured, contracts which would jeopardize the ability of the firm to financially execute this proposed program will not be undertaken.

PRICE PROPOSAL

Description of Costs

The total estimated cost for the proposed study is $67,634.00. The following is thought to be a realistic breakdown of these costs. Categories of labour are charged out on a daily basis and computed according to the following formula:

	daily rate (100%)	=	daily wage and benefits (65%)	+	overhead (29%)	+	profit (6%)
A.	Project Manager						
	250	=	162.50	+	72.50	+	15.00
B.	Project Coordinator						
	185	=	120.25	+	53.65	+	11.10
C.	Diver/Biologists						
	160	=	104.00	+	46.40	+	9.60

Aircraft charter rates are based on quotes from commercial companies. Archipelago Marine Research equipment rental rates are based on a graded (high, medium, low) rate of depreciation which is used for all company contracts. The categories of depreciation are based on historic equipment lifetime for commercial usage. These rates are as follows:

High depreciation - 0.67% of capital cost/day
Moderate depreciation - 0.50% of capital cost/day
Low depreciation - 0.33% of capital cost/day

Material costs are based on the best possible estimate of direct costs given the present understanding of the project.

Method of Payment

Archipelago Marine Research will submit monthly Claims for Progress Payment (DSS 1111) over the course of the project. Our usual terms of 30 days will apply to payment of claims for

progress payments. Interest on overdue accounts is charged at a rate of 1.5% per month. We acknowledge a 10% holdback on labour costs until submission of the final report to the Scientific Authority.

Summary of Costs

The following provides a detailed summary of costs anticipated for the proposed project. Table 3 provides a breakdown of these costs on a monthly basis over the duration of the project.

1.	**Labour**		
A.	Aerial Surveys		
	i. Summer 1988		
	Field work	6 biologists x 3 days x $160/day	$ 2,880.00
	Travel	6 biologists x 2 days x 160/day	1,920.00
	ii. Spring 1989		
	Field work	1 project coordinator x 3 days x $185/day	555.00
		5 biologists x 3 days x $160/day	2,400.00
	Travel	1 project manager x 2 days x $185/day	370.00
		5 biologists x 2 days x 160/day	1,600.00
B.	Benthic Community Surveys		
	i. Mobilization/Demobilization	1 project coordinator x 5 days x $185/day	925.00
		1 biologist x 3 days x $160/day	480.00
	ii. Field work	1 project coordinator x 45 days x $185/day	8,325.00
		3 diver/biologists x 45 days x $160/day	21,600.00
C.	Data Analysis and Report Writing		
		1 project coordinator x 22 days x $185/day	4,070.00
D.	Project Management		
		1 project manager x 4 days x $250/day	1,000.00
		Subtotal Labour	**$46,125.00**
2.	**Support Vessel**		
		estimated 12 days @ $200/day	**2,400.00**
3.	**Food**		
	a. Aerial surveys		
		60 person days @ $12.00/day/person	720.00
	b. Benthic community surveys		
		4 persons x 45 days x $12/day/person	2,160.00
		Subtotal Food	**2,880.00**

4. Fuel		
a. Aerial surveys		
estimated 120 gals. @ $2.60/gal.		312.00
b. Benthic community surveys		
outboards and support vessel		
estimated 320 gals. @ $2.60/gal.		832.00
Subtotal Fuel		**1,144.00**
5. Accommodation		
Aerial surveys		
estimated 26 person days @ $35/night		**910.00**
6. Equipment Rental		
a. Aerial surveys		
2 boats with motors x 10 days x $25/day		500.00
2 trucks 2 trips @ $250/trip		1,000.00
b. Benthic community surveys		
45 days @ $125/day		5,625.00
i. dive equipment (personal dive gear, scuba tanks, compressor, oxygen kit, miscellaneous spare parts		
ii. generator		
iii. miscellaneous camping equipment		
iv. two 16 ft. inflatable boats and outboard motors		
v. truck rental		
Subtotal Equipment Rental		**7,125.00**
7. Air Charter		
185 Cessna on floats		
estimated 6 days @ $1,000/day		**6,000.00**
8. Materials		**750.00**
survey equipment		
expendible camping gear		
stationary and data sheets		
miscellaneous		
9. Administration		**300.00**
communications		
report production		
TOTAL COSTS		**$67,634.00**

Table 2. Project costs summarized on a monthly basis.

Budget Category	July 1988	August 1988	September 1988	October 1988	November 1988	December 1988	January 1989	February 1989	March 1989
Labour	10,828	24,974	1,605						8,718
Support Vessel	2,400								
Food	712	1,808							360
Fuel	275	713							156
Accommodation		455							455
Equipment Rental	1,738	4,453							934
Air charter		3,000							3,000
Materials	600	100							50
Administrative	100	100							100
TOTALS	16,653	35,603	1,605						13,773

Contributions in Kind

Dr. Mike Bigg, head of the Marine Mammals section at the Pacific Biological Station, has agreed to contribute the equivalent of $7,600 towards the costs of the air charter time and manpower required to conduct both aerial surveys. This consists of an estimated $6,000 for the air charters and $1,600 for the aerial survey labour requirements (10 person days @ $160/day).

Archipelago Marine Research is willing to contribute the equivalent of $2,750 towards the cost of the two inflatable dive boats and motors (55 days x 2 boats x $25/day/boat).

The total in kind contributions amount to $10,350 or 15% of the proposed total cost of the project.

APPENDIX 1

Statistical Methods to Determine Sample Size and Accuracy of Estimate

The following description of statistical methods was taken from Elliott (1977). As the dispersion of many species of organisms may be contagious, a large variation is encountered in sampling populations, and small samples may be statistically inaccurate. Since it is usually impractical to take large sample numbers, it is frequently necessary to make a compromise between statistical accuracy and effort (Elliott 1977).

The following method can be used to determine the sample size necessary for a particular level of precision. The magnitude of error that can be tolerated in the population estimate must be determined. The percentage error can be expressed as the standard error of the mean or confidence limits of the mean. For a given variance (S^2) the standard error is a function of the number (n) of sample units in each random sample. The ratio of standard error to the mean is an index of precision (D). By convention a 20% error can be tolerated in most samples. So using the following formula the number of samples required for a given level of precision can be determined:

$$D = 0.2 = \frac{\text{standard error}}{\text{mean}} = \frac{1}{\bar{x}} \sqrt{\frac{S^2}{n}} = n = \frac{S^2}{D^2 \bar{x}^2}$$

However, when D is the relative error in terms of percentage confidence limits of the mean, the above formula must be multiplied by t (where t is found in the Students t Distribution. t = 2 for 95% probability of D). If we can tolerate 95% confidence limits of $\pm$ 40% of the mean (standard error of 20% of

the mean), then D = 0.4 and the sample size needed to obtain an estimate of the population means within ±40% of the true value is given by the general formula:

$$n = \frac{t^2 s^2}{D \bar{x}^2} = \frac{2^2 s^2}{(0.4)^2 \bar{x}^2} = \frac{25 s^2}{\bar{x}^2}$$

This formula is used iteratively, using new values for t each time, the new number of samples is calculated until the number of samples stabilizes (iteration is only required when the sample size is less than 30). These formulae can be used to determine the precision of our estimates, as we sample, or can be used to determine the number of samples required for a given accuracy.

Using this method we will (concurrent with sampling) determine the sample size required to gain a 20% precision or the precision level that our sample size is at (ie. too many samples are required to reach a reasonable level of precision).

In this study the number of samples required for a given level of precision will vary between areas and species. The absence of urchins in otter dominated areas will require that very few samples be collected to gain a high degree of precision. In areas with otters, a much higher number of samples may be required because of the greater variability of urchin density.

A second method to determine if the sample variances are representative, is to plot sample variance against sample size and look for an asymptote. This is done by drawing five sample units at random and calculating the mean then drawing five more sample units and calculating the mean for ten units. Continue to increase the samples size and plot means for 5, 10, 15 ... units

against the sample size. When the value ceases to fluctuate and reaches an asymptote, a suitable sample size has been reached. This method can be used to determine if the number of samples being used at each site is adequate. Since this can only be done after the sampling at each site is complete, this method is of limited use.

Results of Preliminary Urchin Sampling

Results from 94 quadrats taken from 2 areas without sea otters indicate that 119 quadrats 1/2 m^2 will provide a sample with 95% confidence and 20% precision (ie. you have 95% confidence that the means generated by 110 samples will be within 20% of each other). Summary of the calculations is as follows:

$\bar{x} = 3.8 \qquad s^2 = 17.98$

$$n = \frac{s^2 t^2}{D^2 \bar{x}^2} = \frac{(17.98)(2)^2}{(0.2)^2 (3.8)^2} = 119.86$$

Since these samples were taken from six sites over two areas, variance between sites is probably greater than will be encountered in the proposed research. While this sample size is suitable for urchins, data are not available for the other species.

Rationale for Sample Unit Size

Preliminary sampling was used to determine the efficiency of three sample unit sizes. An investigator should chose the sample unit which will yield the greatest precision for available resources, while keeping in mind the level of effort required to use the sample unit. Optimum sample unit size may be compromised by the sampling effort required to use the sample unit

(allocation of effort). Often in sampling, conclusions reached about the distribution of the species in question are a function of the quadrat size (Elliott 1977, and see Pringle 1984 for discussion).

While the results of this preliminary experiment were not statistically analyzed, it was apparent that of the three quadrat sizes tested only the 1/2 square metre quadrat was suitable. This conclusion was reached in the following manner:

1 m^2 quadrats

Quadrats were too large to count organism accurately in survey conditions. These quadrats were so large that small organisms were too abundant to count.

1/4 m^2 quadrat:

Quadrats were so small that most units did not sample the target species at all (numerous zeros). Some organisms exceeded the size of the sample unit.

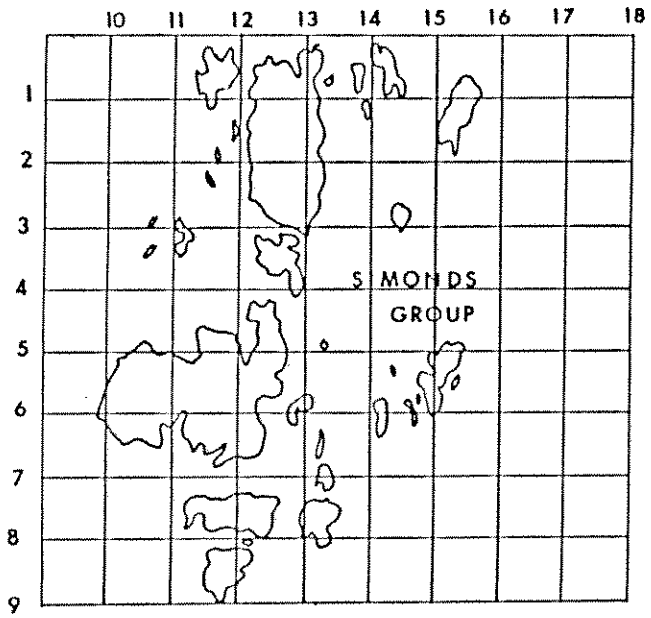
Due to these observations, the 1/2 m^2 quadrat was deemed most appropriate for a study of this nature.

APPENDIX 2

Selection of Survey Sites

Thirty survey sites will be chosen randomly from both an area with and without sea otters. To avoid any bias in the choosing of sites of a certain aspect or exposure, a numbered grid (see below) will be placed over a chart of the study area. Areas designated with and without sea otters will be defined on the basis of the 1987 sea otter survey (MaCaskie 1987).

Numbers will be randomly drawn from a table of random numbers until 20 sites from rocky environments (as indicated by the hydrographic chart) are chosen. Ten soft bottomed sites will be drawn in a similar manner. If during the field work a preselected site, designated hard or soft bottomed is deemed unsuitable based on substrate type, it will be dropped and a replacement site drawn in the same manner.



SELECTION OF SURVEY SITES

APPENDIX 3

RESUMES OF KEY PERSONNEL

RESUME - JANE WATSON - DECEMBER 1987

PERSONAL:

Full name: Jane Catherine Watson — Female / Single

Address: c/o 2791 W 13th Ave.
Vancouver, B.C.
V6K 2T5

Born: April 5 1959
Height: 5' 10"
Weight: 145 lbs.

Telephone: (604) 383-4535 (message)
(604) 733-6092 (message)
(408) 429-4050 (UCSC office phone)

EDUCATION:

Bachelor of Science: 1981 - University of British Columbia
Honours Marine Biology (First Class)

Thesis: The life cycle and morphogenesis of Costaria costata

Coursework included nine months field study at Bamfield Marine Station.

WORK EXPERIENCE:

Ph.D Candidate: U.C. Santa Cruz, Ca.
Advisor: Dr. J. Estes
Thesis Work: Examination of the effects of sea otter foraging on nearshore community structure in B.C..

Research Assistant: U.C. Santa Cruz, U. of Washington.
June - July 1987, May - September 1986
Supervisors: Drs. J. Estes., D. Duggins and C. Simenstad
Location: Aleutian Islands, Ak..

Duties: Research and diving assistant in a project examining the effects of sea otter foraging on nearshore productivity.

Marine Educator: Bamfield Marine Station
August 1984 - May 1986
Supervisor: Dr. Ron Foreman

Duties: Responsible for all aspects of the Field Trip programme.
Booking and scheduling all groups.
Designing instructional programmes.
Field and Laboratory instruction.
Designed and wrote a teachers manual.

Biologist/Diver: Archipelago Marine Research
June-July 1985
Supervisor: Tom Shields
Location: Liverpool Bay, N.W.T.

Duties: Diving to estimate quantities of herring spawn.
Responsible for samples and lab records.
Identification of marine algae.

Biologist Fisheries and Oceans
March-July 1984
Supervisor: Dr. Glen Jamieson
Location: Moresby Is., Q.C.I., Kitkatla, B.C.
Nanaimo

Duties: Working with fishermen to assess kelp quality in the spawn-on-kelp fishery.
Report writing and data analysis.

Biologist/Diver: BIOS Project, LGL Ltd.
August 1983
Supervisor: William Cross
Location: Cape Hatt, Baffin Is., N.W.T.

Duties: Diver/Biologist for oil spill research projects
Diving survey of marine plants and animals

Biologist/Diver: Archipelago Marine Research/Fish. & Oceans
March 1983-August 1983
Supervisors: Tom Shields, Dr. G. Jamieson
Location: Moresby Island, Q.C.I.

Duties: Monitoring the spawn-on-kelp fishery.
Working with fishermen sampling spawn-on-kelp product.
Data analysis and report writing.

Biological Technician: Fisheries and Oceans
August 1982 - May 1983
Supervisor: Dr. G. Jamieson

Duties: Design and implementation of several field programmes.
Data analysis and report writing.

Biologist/Diver: Archipelago Marine Research
March 1982 - May 1982
Supervisors: Howard McElderry, Brian Emmett
Location: Barkley Sound, North Coast, B.C.

Duties: Diving to estimate herring spawn for stock assessment.
Identification of marine algae.

Biological Technician: Dobrocky Seatech Ltd.
June 1981 - March 1982
Supervisor: Gordon O'Connell
Location: Sidney, B.C.

Duties: Identification of deep water molluscs.
Benthic sampling on board the FRV Parizeau.
Field sampling for water quality analysis.

Assisted Boat and Diving Officer: Bamfield Marine Station
June - August 1980
Supervisor: Bob Baden
Bamfield, BC.

Duties: General boat and motor operation and repair.

Archaeological Field Technician: Heritage Conservation Branch
Summers 1974 - 1979

Duties: Archaeological excavation and lab work.
Surveying and mapping.

ADDITIONAL SKILLS: **NAUI SCUBA diver:** Over 1000 hours logged.
Maintaining and operating small boats and engines.
Fiberglass boat construction and repair.
Photography.
WCB. Industrial First Aid C Ticket.
Basic surveying and mapping.

REFERENCES:

Dr. R. DeWreede, (228-6785)
Botany Deptartment,
University of BC.,
Vancouver, B.C.

Brian Emmett, (383-4535)
Archipelago Marine Res.,
#4-1140 Fort Street,
Victoria, B.C.
V8V-3K6

Dr. R. Foreman, (228-2133)
Botany Department,
University of B.C.,
Vancouver, B.C..

OVERSEAS VOLUNTEER EXPERIENCE

Diver/Biologist: University of Sidney, Australia.
January - February 1984
Supervisor: Dr. P. Sale
Location: One Tree Island, Great Barrier Reef.

Duties: Assisted in a variety of coral reef fish recruitment studies.

Diver/Biologist: James Cook University, Townsville, Australia.
January 1984.
Supervisor: Dr. D. Hopley
Orpheus Island, Great Barrier Reef.

Duties: Assisted as a biologist in a research project examining reef composition and growth.

Diver/Biologist: University of Auckland, New Zealand.
November - December 1983
Supervisor: Dr. B. Creese, Dr. D. Schiel
Location: Leigh Marine Laboratory

Duties: Assisted in a variety of benthic ecology research projects involving herbivore / algae interactions.

RESUME

ELIZABETH ANNE STEWART

Personal Data

Address: Box 17, Bamfield
B.C., V0R 1B0
Canada

Birthdate: March 21, 1955
Birthplace: Comox, B.C.
Citizenship: Canadian
S.I.N.: 714-245-974
Health: Excellent

University Education

1972/1973	3^{o} degre, Etudes pour L'Etranger Universite de Nice Nice, France
1973/1976	Biology University of Victoria Victoria, B.C.
1976	Simon Fraser University Fall Program Bamfield Marine Station Bamfield, B.C.
1977 - 1978	B.Sc., Marine Biology Option (with distinction) University of Victoria Victoria, B.C.

Employment Summary

August 1987 - present
Anne Stewart Nature Tours
Box 17
Bamfield, B.C.

Naturalist/Biologist. Conduct nature tours in Barkley Sound for groups of 2 to 20. Included are hikes to various scenic and historical sites and boat tours to observer grey whales.

June 1986 - Present
Butterfield and Robinson
70 Bond Street
Toronto, ON M5B 1X3

Resource person. Conduct helicopter nature tours of the B.C. coast (Port Hardy to the Queen Charlotte Islands). Special emphasis place on native cultures and interpretation of coastal flora and fauna. Also participate in tours through Europe with emphasis on architecture and culture.

September 1987 - April 1988	Bamfield Marine Station Bamfield, B.C.
	Biological technician. Part-time assistance in all aspects of the field trip program. Field and laboratory instruction.
January 1985 - January 1987	Bamfield General Store Box 52, Bamfield, B.C. V0R 1B0
	One of two partners in the store. Active in all aspects of running the business. From supervising employees to ordering, bookkeeping to day-to-day running the store.
May - November 1984	Canadian Benthic Ltd. Box 97, Bamfield, B.C. V0R 1B0
	Algologist. Responsible for microalgal production in bivalve hatchery/nursery.
October 1981 - December 1983	Canadian Benthic Ltd. (address as above)
	Biologist. Duties included participation at all levels in an intensive, shellfish mariculture project. Work ranged from algal culture, spawning and raising juvenile littleneck clams to monitoring water quality and growth of adult and juvenile clams and scallops.
June - October 1981	L.G.L. 44 Eglington Ave. Toronto, ON
	Diver/Biologist. Participation in field program in Lancaster Sound, Baffin Island in the BIOS oil spill study. Duties included diving support, sample design, collection and identification of benthic algae and invertebrates, laboratory analyses of samples collected and collation of data.
April - March 1981, 1984, 1985, 1986	Archipelago Marine Research #11, 1140 Fort Street Victoria, B.C. V8V 3K8
	Diver/Biologist. Participated in all aspects of herring spawn surveys carried out by this company. Work included evaluation of survey

methodology, underwater sampling and observations, identification of marine algae and general laboratory tasks. Survey covered Georgia Strait, Central Coast and Queen Charlotte Islands.

October 1980 - March 1981

Dr. Louis Druehl
Simon Fraser University
Bamfield Marine Station
Bamfield, B.C.

Research Technician. Duties included design and implementation of an in situ water movement monitor system for kombu research farms in Barkley Sound.

January - September 1980

Canadian Benthic Ltd.
Box 97
Bamfield, B.C.
V0R 1B0

Biologist. Duties included planning, coordination and carrying out physiological studies on the agar producing red alga Gracilaria. Research focused on maximization of colloid production.

May - October 1979

Canadian Benthic Ltd.
Box 97
Bamfield, B.C.
V0R 1B0

Technician. Responsible for growth studies and environmental monitoring program in red algal mariculture study.

May - October 1978

Marine Plant Section
Marine Resources Branch
B.C. Provincial Government

Diver/Technician. Duties involved carrying out subtidal research on the impact of commercial harvesting of giant kelp, underwater sampling, photography, algal identification and operation of a mechanical kelp harvester.

May - October 1977

Ecological Reserves Unit
Land Management
B.C. Provincial Government

Field Research Technician and Diver. Conducted subtidal baseline data survey in the Queen Charlottes' nearshore ecosystem; participated

	in seabird breeding colony survey involving circumnavigation of the Queen Charlotte Islands.
January - May 1977	Pacific Biological Station Shellfish and Herring Investigation Nanaimo, B.C.
	Shellfish - Marine bivalve identification under the supervision of Dr. F. Bernard. Herring - Herring spawn survey of southern Georgia Strait, west coast Vancouver Island and northern coast.
May - September 1975, 1976	B.C. Provincial Museum Marine Biology Division Victoria, B.C.
	Summer Student/Technician. Curatorial techniques, library reorganization, invertebrate and fish collection, boat-tending and general apprenticeship.

Contract Work

1981, 1982, 1983	Biological illustration of kelp plants for publication by Dr. Louis Druehl, Simon Fraser University.
1979, 1980, 1982, 1983	Subtidal ecological research focusing on algal communities in Checleset Bay at the site of the sea-otter transplants and at Hippa Island, a proposed site for transplant. Work done with Dr. P. Breen, Pacific Biological Station and Dr. J.B. Foster, Ecological Reserves Unit, B.C. Government.
1984	Guide for National Geographic expedition in Barkley Sound.
1984	Mariculture site assessment for J. Maedel, Bamfield
1984	Biologist/Diver/Guide for C.B.C. "The Nature of Things" while filming a show on the sea otter population at Checleset Bay.

Publications

Stewart, E.A., J.B. Foster, T.A. Carson and P.A. Breen (1982). Observations of sea urchins, other invertebrates and algae in an area inhabited by sea otters. Can. Man. Rep. of Fish. and Aquat. Sci. no. 1655. 28 p.

Breen, P.A., T.A. Carson, J.B. Foster and E.A. Stewart (1982). Changes in subtidal community structure associated with British Columbia sea otter transplants. Mar. Ecol. Prog. Ser., Vol. 7, 13-20.

APPENDIX 4

CONTRACTUAL SUMMARY OF ARCHIPELAGO MARINE RESEARCH

Archipelago Marine Research
Project Description

Project Description	Client	Date
Herring Studies		
Diver surveys of herring spawn on the British Columbia coast	Department of Fisheries and Oceans	1978-1986
Herring impoundment and spawn-on-kelp production in B.C.	Department of Fisheries and Oceans	1982-1984
Preparation of a manual for diving surveys of Pacific herring spawns	Department of Fisheries and Oceans	1985
Assessment of Pacific herring stocks in the Eskimo Lakes region of Liverpool Bay, N.W.T.	Department of Fisheries and Oceans, Winnipeg, Man.	1985
Aerial survey of Pacific herring stocks in the Eskimo Lakes and and Liverpool Bay, N.W.T.	Department of Fisheries and Oceans	1986
Assessment of herring roe-on-kelp potential in Gamble Bay, Washington	Port Gamble Klallam Tribe Kingston, Washington	1986
Processing of herring samples (meristic and reproductive staging data)	Department of Fisheries and Oceans	1987
Groundfish Studies		
Investigation of the Strait of Georgia inshore rockfish fishery	Department of Fisheries and Oceans	1983
A survey of recreational bottom-fishing in the Strait of Georgia	Department of Fisheries and Oceans	1984
A survey of recreational SCUBA diving in the Strait of Georgia	Department of Fisheries and Oceans	1984
Diving survey of inshore rockfish populations in the Strait of Georgia	Department of Fisheries and Oceans	1985
Fecundity estimates for rockfish and ling cod	Department of Fisheries and Oceans	1986

Project Description	Client	Date
Salmonid Studies		
Study of the overwintering habitat of juvenile chinook salmon in the Nicola and Thompson Rivers	Department of Fisheries and Oceans	1985-1986
Shellfish Studies		
Survey of abalone populations on the northern B.C. coast	Department of Fisheries and Oceans	1980
Survey of virgin and harvested geoduc populations on the coast of Vancouver Island	Department of Fisheries and Oceans	1981
Monitoring of oyster spatfall in Pipestem Inlet and Pendrell Sound	Marine Resources Section, Province of B.C.	1981, 1984, 1986
Investigation of mortality and and growth rates of transplanted surf abalone	B.C. Abalone Harvesters Association	1984-1985
Aquaculture Studies		
Development of a mussel and oyster culture facility in Barkley Sound	Self-funded; CEIC employment programmes	1980-1984
Analysis of summer mortality in cultured mussels, (*Mytilus edulis*)	B.C. Science Council	1982-1984
Site assessment in the Strait of Georgia for the commercial cultivation of mussels	Pacific Aquafoods Ltd. Ltd.	1985-1986
An investigation of the use of cultured kelp in the herring roe-on-kelp industry	B.C. Science Council	1985-1987
Finfish aquaculture and roe-on-kelp feasibility in Rivers Inlet	Oweekeno Band Council Rivers Inlet, B.C.	1986
Aquaculture and commercial fisheries resource identification in Desolation Sound/ Johnstone Strait and Island Trust areas	Land Sense Ltd. Burnaby, B.C.	1987

Project Description	Client	Date
Environmental Assessment		
Preliminary surveys of marine resources in the vicinity of Klemtu, B.C.	Kitasu Band Council	1981
A survey of water quality in in the Port Alberni Harbour Region	Port Alberni Harbour Commission	1983
Fisheries Management		
Provision of observers for Japanese and Canadian vessels engaged in the offshore squid fishery	Department of Fisheries and Oceans	1985-1987
Provision of observers for foreign fishing vessels on the Pacific coast	Department of Fisheries and Oceans	1987