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Sea Cucumber Phase 1 Fishery Progress Report

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ABSTRACT

This paper provides a progress report following the implementation of an adaptive management regime in 1997 in the sea cucumber fishery. The information being collected in this Phase 1 fishery includes population abundance estimates from transect surveys, effects from varying exploitation-rates in experimental fisheries, recovery from small-scale depletion in removal experiments, and size distribution from biological samples. Methods and results from programs underway are described.

Density estimates from transect surveys, in number of animals per metre of shoreline, varied from 2.6 in Laredo Inlet (PFMA 6) to 13.6 in the Bella Bella area (PFMA 7). The precision of estimates was also variable, from plus or minus 60% in the Gulf Islands (PFMA 17) to 12% in Tolmie Channel (PFMA 6). Results from repeat surveys were consistent in Jervis Inlet (PFMA 16) but varied by 40% between surveys in both Tolmie Channel and Laredo Inlet.

Aspects of survey and experimental fishery results are discussed in relation to factors, such as spatial variation in sea cucumber productivity and migration behavior, that affect the variability and reliability of the data. Recommendations for further research includes studies to monitor the seasonal distribution of sea cucumber populations, and the development of a time-series of recruitment indices in selected habitats and areas of the coast.

RÉSUMÉ

Ce document est un rapport d’étape qui fait suite à la mise en œuvre, en 1997, d’un régime de gestion adaptive d'une pêche de l’holothurie. L’information recueillie durant la première étape de cette pêche comprend des estimations de l’abondance des populations, calculées à partir de relevés par transect, ainsi que des données sur l’incidence de divers taux d’exploitation lors de pêches expérimentales, sur le rétablissement des stocks à la suite d’épuisements à petite échelle provoqués dans des expériences de retrait et sur la distribution de la taille à partir d’échantillons biologiques. On y décrit également les méthodes utilisées et les résultats obtenus dans les programmes en cours.

Les estimations de la densité, découlant des relevés par transect et exprimées en nombre d’animaux par mètre de rivage, variaient de 2,6 dans le secteur de Laredo Inlet (zone 6) à 13,6 aux environs de Bella Bella (zone 7). La précision des estimations s’est également révélée très variable, équivalant à plus ou moins 60 % dans le secteur de Gulf Islands (zone 17) et à 12 % dans celui de Tolmie Channel (zone 6). Les résultats des relevés de répétition ont corroboré les estimations pour Jervis Inlet (zone 16), mais il y a eu une différence de 40 % entre les relevés pour les deux secteurs de Tolmie Channel et de Laredo Inlet.

Certains points concernant les résultats des relevés et des pêches expérimentales sont discutés en rapport avec des facteurs, tels la variation spatiale de la productivité de l’holothurie et son comportement migratoire, qui ont une incidence sur la variabilité et la fiabilité des données. On recommande d’étendre les recherches incluant le suivi de la répartition saisonnière des populations de l’holothurie et à l’élaboration de séries chronologiques d’indices de recrutement dans des habitats ciblés et en divers endroits de la côte.

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1.0 INTRODUCTION

Sea cucumbers (*Parastichopus californicus)* are harvested by divers, who remove the animals from the substrate by hand. The product forms are frozen muscle strips and dried skins. These products are supplied to Asian markets, primarily in China. Initial landings were small, but interest developed rapidly after an experimental fishery in 1980, and by 1988, annual landings exceeded 1,900 t. Varieties of control measures were implemented, including licence limitation, area closures, arbitrary quotas, and individual quotas. These had the beneficial effect of more controlled harvests, higher quality fishery-dependent data and increased fishery value. Still, the knowledge of the biology, distribution and population dynamics required to assess the stocks and fishery impacts, and to recommend sustainable quotas is lacking.

Phillips and Boutillier (1998) examined catch data and provided quota options to managers, based on a stock assessment work to date. Although the quota recommendations were not used because of a number of known problems with logbook data and area calculations, the paper was valuable for describing the small amount of known biological information, and providing a series of recommendations regarding the scale of fishery management and fishery data collection.

Following the development of a three-phased approach for dealing with new and developing invertebrate fisheries by Perry *et al.* (1999), a Phase 0 'collection of existing information' was conducted and a proposed framework for a Phase 1 fishery, 'fishing for information', was presented (Boutillier *et al*. 1998). Recommendations from this paper were to:

1. Implement the most conservative fixed exploitation management strategy for the sea cucumber fishery in B.C. waters.
2. Keep the present management system of IQ's and adapt the present quotas over an area that would sustain it according to conservative estimates of fixed exploitation as defined in the theoretical Phase 0 management plan. This would mean developing an annual quota for an appropriately sized area. The size of the area would depend on size of animals in the areas chosen, the density estimate used and the exploitation rate selected.
3. Break up the quotas into as small a spatial scale as logistically possible, e.g. Pacific Fishery Management Areas (PFMA) or Subareas.
4. Do not allow expansion of the fishery until there is sufficient data collected for B.C. waters to determine the impact of the present fishery.
5. Develop with industry a cost neutral way of obtaining reliable data for the Phase 1 evaluation of the fishery.
6. Address other research initiatives where logistically possible and implement in a cost neutral fashion.

These recommendations were incorporated into an adaptive management plan that was implemented for the 1997 sea cucumber fishery**.**
As outlined in Boutillier *et al.* (1998), the main features to be considered and evaluated in a Phase 1 implementation are 1) improvement of estimates of abundance, 2) testing the appropriateness of exploitation rates, and 3) examining the suitability of alternative production models. The current adaptive strategy incorporates transect surveys for density and biomass

estimation, experimental fishing to examine the effects of harvest on sea cucumber populations, and biological sampling. Projects are funded by industry through the sale of experimentally harvested product.

This paper is a progress report on the sea cucumber Phase 1 fishery, after its second year. The objectives are to describe the survey and experimental programs underway, to present initial results, and provide recommendations for on-going work or modifications to the experimental approach. Further objectives are to give a clear direction and understanding for managers, Industry and First Nations on policy, expectations and responsibilities.

1.1 Biological Features

Summaries of the biology of sea cucumbers are made by Boutillier *et al.* (1998), Phillips and Boutillier (1986) and Campagna and Hand (1999). The life history characteristics of importance to understanding productivity of sea cucumbers are largely unavailable. No method has yet been found to age the animals, and therefore basic parameters for stock assessments (natural mortality, growth rate, and age at recruitment) are speculative. Even their size structure is hard to measure, since the animals undergo annual fluctuations in body mass, and in addition, can change body shape when handled.

Sea cucumbers are animals of limited motility, but there is widespread anecdotal information and personal observations from researchers that sea cucumbers undergo seasonal bathymetric migrations. If such were the case, an understanding of the factors involved would be crucial to designing surveys and interpreting survey data.

1.2 History of Fishery Management

The first commercial landings of sea cucumbers were recorded in 1971. Harvest was initially regulated under a "C" licence. In 1983, the "Z-D" fishing licence was introduced. There was no limitation on the number issued and by 1990, there were 215 eligible fishermen. The fishery expanded rapidly after 1980, and annual landings exceeded 1,900 tonnes round weight (700 t split weight) in 1988. Area-closures and arbitrary regional quotas were first implemented in 1986. This did little to limit the fishery, since landings and the number of licences issued continued to increase and quota over-runs were common. This, and concerns stemming from declining catch per unit effort in some areas, led to arbitrary quota reductions in 1989, the implementation of licence limitation in 1991 and further quota reductions in 1993. From 1993 to 1996, a three-year rotation was introduced in the South coast to allow for a two-year period of recovery between harvests. The fishery is no longer rotational. Currently, 85 licences are eligible for participation in the fishery.

A pilot Individual Quota (IQ) program was introduced in 1995, which included a 2% allocation of the total allowable catch (TAC) for aboriginal use, and an equal share of the remaining TAC among licence holders. Under this program, fishermen were required to develop and fund a catch monitoring and validation program to ensure that area quotas and IQs were not exceeded.

The B.C. coast remained divided into five management areas and each licence is designated to an area prior to the fishing season. The PFMA's open to harvest in recent years are shown in Table 1. In 1996, Queen Charlotte Island (QCI) licences were re-designated to either the Central Coast or Prince Rupert District. This licence re-allocation was in response to higher costs associated with fishing and transporting sea cucumbers from QCI. Options to increase the future economic viability of fishing the QCI are being discussed.

1.3 Management Issues

During harvest operations, fishermen will remain at a harvest site until catch per unit effort is unacceptably low. The concentration of annual fishing effort in relatively small areas may lead to localized depletion of sea cucumber stocks. The impact of localized depletions on sea cucumber populations, and on the ecosystem in general, and the mechanisms involved in the re-establishment of populations are not understood.

2.0 ADAPTIVE MANAGEMENT

An adaptive management plan was developed and implemented in the sea cucumber fishery in 1997. Under this plan, the precautionary coast-wide TAC of 233 t (split weight) was applied to only 25% of the coast in non-contiguous harvest areas, to be harvested annually in the IQ fishery (Figures 1 to 4). A further 25% of the coastline is reserved for research and experimental harvest that may be undertaken by stakeholders under guidelines developed by the Department through consultation with industry and First Nations. The remaining 50% of the coastline are excluded from any commercial harvest for the foreseeable future in support of the risk averse approach to this data limited fishery.

2.1 Individual Quota Fishery

Subareas comprising approximately 25% of the total B.C. coastline were selected for fishing in consultation with the Pacific Sea Cucumber Harvesters Association (PSCHA) and First Nations (Table 1). The approximate ratio of 1996 north coast to south coast landings was maintained in the selection of area to open in the north coast and south coast in 1997. The quota was calculated over this 25% of the B.C. coast by assuming a density of 2.5 sea cucumbers per metre of shoreline, an exploitation rate of 4.2% and a mean individual split weight ranging from 263 to 327 grams, depending on the area. The estimate of density is the minimum of the lower 90 % confidence limits from all large-scale surveys conducted in Southeast Alaska (the nearest location which has been comprehensively surveyed) and is considered to be conservative for B.C. waters. The exploitation rate is the most conservative of estimates used in Alaska and Washington State sea cucumber management. Mean weight estimates are from biological sampling of B.C. harvested product (Boutillier *et al.* 1998).

Of the 8,642 km of shoreline that is open, 78% is in the North Coast (north of Cape Caution), 16% is in the South Coast inside waters and 6% in West Coast of Vancouver Island. The large concentration of open areas in the north coast (PFMA 3-10) is a result of the closure of the

Queen Charlotte Islands in 1996. To date, sea cucumbers have been harvested from roughly 55% of the total B.C. shoreline length, as measured on a PFMA Subarea basis. Of the 8,642 km of open shoreline, 63% has sustained some level of fishing in the past.

Implicit in the use of a single density estimate of 2.5 sea cucumbers per metre of shoreline (c/m-sh) for all of B.C. is the assumption that every metre of shoreline is equally productive. Survey results and reports from fishermen indicate that a relationship exists between habitat and sea cucumber density and size distribution. Approximately 70% of the open area is comprised of the more productive channel/passage-type habitat, whereas only 35% of the closed area is of this type. Similarly, approximately 75% of the landings have come from channel/passage habitat (Fig.5).

Provisions have been made in the management plan to allow industry to undertake density surveys in the areas open to commercial harvest, in order to provide the basis for potential IQ increases. Biomass estimates in these surveyed areas are calculated from the lower 90% confidence limit of density estimates. TAC's are then calculated with the risk-averse 4.2% exploitation rate. Increased TAC's are set only for the area surveyed, and are to remain in effect for four years only, at which time a re-survey must be conducted. To date, two surveys have been conducted. In May 1998, a survey was conducted by the PSCHA and the Heiltsuk Fisheries Program in Bella Bella, PFMA 7-15, 7-17 and 7-30 (Fig. 3, shown as yellow) (Campagna and Hand in prep). The data collected formed the basis of a quota increase for the 1998 fishery (Table 1). In May 1999, a second survey was conducted in PFMA 6 around Gil and Gribbell Islands. These data will be used to calculate new IQ's for the 1999 fishery, not presented here. Since there is a schedule of re-survey every four years, it is expected that no more than four areas, or approximately 18% of the open shoreline, will be fished with an increased TAC.

2.2 Experimental Fishing Areas (EFA)

To date, four EFA's have been initiated, one in the Strait of Georgia, two in the central coast and one on the West Coast of Vancouver Island. The EFA in Jervis/Sechelt Inlets (PFMA 16, Fig. 4) is located in a channel/island-type habitat. The EFA in Laredo Inlet (PFMA 6-19, Fig. 3) occupies a steep-sided fjord habitat, while the Tolmie Channel EFA (PFMA 6-20, Fig. 3) is located in a steep-sided channel habitat. The West Coast of Vancouver Island (PFMA 25-08, 25-09, Fig. 3) occupies both a channel-type and an inlet type of habitats. Each EFA includes 50 km of shoreline and, since there are time-commitments involved in the maintenance of these experiments, there is a limit to the total number that can be undertaken. It is expected that only a small fraction of the 25% of the B.C. shoreline that is allocated for experimental harvests will be utilized for experimental fishing.

3.0 METHODS AND PROTOCOLS OF PHASE 1 PROGRAMS

Since the sea cucumber fishery is ongoing, a collaboration structure is already in place, i.e. the licensed fishermen. In addition, First Nations are interested and some Aboriginal Fisheries Programs (e.g. Kitasoo and Cowichan) have been active in surveying sea cucumber populations in their local waters. Some fisheries data exists, and the general distribution of the species and locations of major aggregations are known. In each research project, commercial fishermen play an important role in providing background information on distribution and behaviour as well as hands-on expertise in diving and vessel operation. Vessel and diver costs of research activities are covered by the sale of experimentally fished product. To date, these revenues have been just sufficient to meet costs. Participation in research activities by industry and First Nations is an important part of building trust and gaining support of management decisions.

Transect surveys are conducted to improve estimates of density, and for the subsequent calculation of sea cucumber abundance. Survey results are used in the design of experimental fisheries and are used as the basis for increased TAC's in the IQ fishery. An additional component of the initial surveys was intensive transect sampling in small plots, followed by complete harvest. This provided a means of testing how well the random transect method estimated population size, provided estimates of individual sea cucumber weight, and provided a future opportunity to monitor the recovery of a small area from total depletion. It also provided initial funding to cover survey costs through the sale of the harvested product.

The available fishery data is insufficient to determine sustainable yields or optimum effort levels because of a lack of extremes in fishing level, combined with inadequate geo-referencing and/or lack of time-series data (Phillips and Boutillier 1998). Experimental fisheries are designed and conducted to gather empirical data on the potential of sea cucumber stocks by examining the behaviour of sea cucumber stocks under varying exploitation rates. It is hoped that results from these long-term experiments can either verify or refute the current assumption of sea cucumber longevity.

3.1 Abundance surveys

Since the initiation of the adaptive management approach in 1997, transect surveys have been conducted in 5 locations in B.C. by the PSCHA, either in conjunction with First Nations or with contracted third-party participation (Table 2). Survey methods are described in detail in Campagna and Hand (1999). In addition to, and pre-dating these surveys, seven areas in the central coast have been surveyed by the KFP. Survey protocols used by the KFP were developed in consultation with Fisheries and Oceans Canada and were based on survey designs used by researchers in Alaska (Cripps and Campbell in prep.). The recent surveys conducted by DFO/PSCHA follow the same design.

Transects laid perpendicular to bathymetric contours are used, with various modifications, to measure the density of many benthic invertebrate species for stock assessment purposes (Waddell *et al.* 1997, Campbell *et al.* 1998, Kronlund *et al.* 1998). Surveys are usually stratified if information is available on the animal's distribution. Since sea cucumber distribution not well enough understood to incorporate meaningful strata, they are surveyed using a simple random design. Field methods consist of counting the number of sea cucumbers to a distance of two metres on either side of the transect line to a depth of approximately 60 feet gauge depth. Auxiliary information is also noted, such as depth, substrate type, algal type and percent algal cover and these data are recorded for every 5 m length along the transect line.

Each transect is considered as one sample point and density is expressed as the number of animals per metre of shoreline.

A survey area has been defined as encompassing 400 km of shoreline, as this is an area that can be surveyed in about two weeks time. Initial surveys, in the Gulf Islands and Jervis Inlet (Campagna and Hand 1999), were a two-stage design, where six sites within the 400 km survey area were selected at random. Within each of these sites, 10 transect positions were selected at random. The survey conducted in the Bella Bella area (Campagna and Hand in prep.) followed a one-stage design, where transect positions were randomly selected within the entire 400 (approximate) km survey area. An average transect spacing of 2 km was determined from the data collected by the Kitasoo Fisheries Program in the central coast (Cripps and Campbell in prep) to provide reasonable accuracy. The re-surveys conducted in Jervis Inlet, Tolmie Channel and Laredo Inlet were of a random design, within selected sites.

3.2 Removal Experiments

Within each of the Gulf Islands and Jervis Inlet surveys, three small (200-m shoreline length) sites were selected to represent a low density, medium density and high density population (Campagna and Hand 1999). These plots were transect-surveyed with a set of 5 randomly-placed transects, to estimate mean density and 95% confidence intervals, and 5 systematically-placed transects, to examine small-scale spatial distribution. After the surveying was complete, the site was fished as completely as possible. The systematic transect lines were used to grid the area into six blocks to be fished independently, in order to aid fishers' search efficiency and to allow records of removals to be kept at a finer scale. These intensive sites were designed to provide a means of testing how well the random transect method estimated population size and to obtain estimates of individual sea cucumber weight. These intensive sites also provide an opportunity to monitor the recovery of a small area from total depletion and provide initial funding for the survey through sale of the product. Intensive sites were not incorporated into surveys conducted in other areas.

3.3 Experimental Fisheries

Each EFA consists of five 10-km lengths of shoreline; one for each of four exploitation rates, plus a control. The exploitation rates of 2%, 4%, 8% and 16% were chosen to span the current rate of 4.2%, in use for the IQ fishery. Attempts were made to select the sites within each EFA to be as consistent as possible in terms of exposure, current, substrate, and slope in order to minimize the impact that these features may have on the results. The manner in which the sites were located within each EFA varied between locations. For the Jervis Inlet EFA, the six previously-surveyed sites were examined in terms of physical features and sea cucumber density, and the site with the lowest density was excluded as being the greatest outlier. The sites in the Tolmie Channel EFA utilised all of the 50-km of shoreline that had been previously surveyed by the KFP (Cripps and Campbell in prep). Sites within Laredo Inlet were located to make best use of the data from transects that had been completed over 138 km of shoreline by the KFP (Cripps and Campbell in prep). In all EFA's, exploitation rates were randomly assigned to the experimental sites.

Prior to fishing, each site was intensively surveyed to estimate total abundance. Projected sample sizes to produce density estimates with 15% precision (ratio of standard error to the mean, assuming a normal distribution) were determined from the first set of survey data. Transects were randomly positioned within each site and were completed as described in Section 3.1.1.

Immediately following the survey, experimental quotas were calculated for each site from the mean density estimate, in cucumbers per metre of shoreline, the shoreline length of 10 km and the assigned exploitation rate. Quotas were calculated and landings monitored on a piece count basis, to eliminate the error from mean weight estimates. During harvest, the number of sea cucumbers landed, effort, depth, substrate, algal cover, visibility and geo-reference data were collected. Harvest activities were undertaken as convenient to fishermen; no attempt was made to spread the fishing effort evenly within the sites.

Exploitation-rate experiments are projected to continue for at least 10 years (5 years after the first 4-yr old recruits enter the fishery). The schedule of re-surveying of the experimental sites differs with the level of exploitation. It is anticipated that a difference in density should be detectable after two years of fishing in the 8% and 16% sites and after four years of fishing in the 4% and 2% sites. These estimates are very rough and ignore potential effects of immigration, emigration, and recruitment. Nonetheless, the schedule seems reasonable for now, but will be modified if necessary as more information is collected. A likely occurrence may be the closure of high exploitation-rate sites if or when it becomes depleted.

3.4 Biological Sampling

Samples of sea cucumbers were taken from survey areas and processed for round weight, split drained weight, muscle weight and skin weight. Samples were taken from randomly selected survey transects in the Bella Bella area, in Tolmie Channel and Laredo Inlet. For Bella Bella, three transects in each Statistical Subarea were randomly selected and in Tolmie Channel and Laredo Inlet, two transects in each experimental site were randomly chosen. After the transect was surveyed, 50 animals were picked along the transect line, with no regard for size. No attempt was made to include juveniles in the sample, since they are cryptic and not truly represented in the survey data.

Small pieces of muscle are being collected and preserved for potential future DNA studies.

4.0 RESULTS

4.1 Abundance Surveys

4.1.1 Gulf Islands

A survey was conducted in the Gulf Islands in November and December, 1997, by the PSCHA and the Cowichan Fisheries Program (Fig. 4, shown in blue, Table 3) (Campagna and Hand 1999). A total of 60 transects were completed, of which 28 had 0 sea cucumbers. The overall average number of sea cucumbers per metre of shoreline (c/m-sh) was 3.10 over all sites.

Densities varied between sites from 5.6 to 0.13 c/m-sh (Table 3). The animals in this survey area were highly aggregated, and the 95% confidence bounds were often greater than 100% of the mean density estimate. Although sea cucumbers were found on all substrates, the highest densities were found on boulder/cobble. There was generally increasing density with depth.

Portions of the Gulf Islands area were first fished in 1983 and it was open to fishing as recently as 1996. A total of 386 t (split weight) has been harvested from the Subareas included in the 400 km survey area. Geo-referencing of fishing events was poorly recorded and it is not possible to relate landings exactly to survey results. Since the pre-fishery biomass of sea cucumbers in this area is not known, it is not possible to say whether the low density and very patchy distribution is a result of harvest removals. In any case, it does not appear to be a good candidate for either experimental fishing or for an open fishery, despite the fact that the overall density is higher than the conservative estimate of 2.5 c/m-sh assumed for the open fishery.

4.1.2 Jervis Inlet

A survey was conducted in the Jervis Inlet and Sechelt Inlet area in January 1998, by the PSCHA and a contracted third party participant (Fig. 4 shown as hot pink, Table 3). Like the Gulf Islands survey, the protocol was a two-staged random design. A total of 70 transects were completed over 6 sites, only two of which had 0 sea cucumbers. Sixteen of the transects in one site were replicates, and these were averaged to produce a single observation for each of the 8 transect locations. The overall density for all sites was 9.5 c/m-sh and densities varied between 3.6 and 15.5 (Table 3). Confidence bounds were within 25% of the mean density estimate. Densities were significantly higher on mixed hard and soft substrates and complex boulder substrates than on soft or smooth bedrock substrates.

The re-survey of the five selected sites prior or experimental fishing was conducted in January 1999. A total of 107 transects were completed (Table 3). Mean densities by site were similar to the first survey conducted a year earlier and were well within the 90% confidence bounds of the original data.

Landings have been recorded for the Jervis/Sechelt area in 1983, 1986, 1987 and 1988 for a total of 53 t split weight. Sea cucumber beds have been reported in only two of the six sites but, again, this data may not be complete.

4.1.3 Tolmie Channel

Most of Tolmie Channel consists of smooth shoreline with the occasional small cove. The substrate is mainly moderate to steep bedrock or boulder, but the occasional gentle sand and shell habitat was present. The Kitasoo Fisheries Program conducted a transect survey in a 50-km shoreline-length area of Tolmie Channel in August, 1996, as part of their on-going resource inventory (Tables 2 and 3) (Cripps and Campbell in prep). In their survey, transects were systematically placed at 2 km intervals from a random starting position. The overall density estimate from 28 transects completed was 20.36 c/m-sh. Twenty-five of these transects formed the design basis for the experimental fishery in this area.

The pre-experimental fishery survey of the area was completed in September, 1998, by the PSCHA and a contracted third-party participant. The purpose was to verify the density estimates from the previous survey and to increase the precision of estimates to a target of 15%. The sample size was increased from five transects per 10-km site to 15 to 20 transects, depending on the variability of the original data. The overall density from the re-survey in 1998 was estimated to be 12.6 c/m-sh, with 95% confidence intervals within 12% of the mean (Table 3). This result is 40% less than the mean obtained two years earlier.

Since there was no fishery in the time between the first and second surveys, a reasonable explanation of this large change in density may be animal migration, since sea cucumbers have that reputation. There is only a small indication from the depth distribution that such may be the case. The highest densities were found between 1-5 m in 1996, whereas the population was more evenly distributed in 1998 and approximately 20% of transects were observed to have animals deeper than 60 feet.

4.1.4 Laredo Inlet

Laredo Inlet is a fjord with a narrow opening into Laredo Sound. The hills on either side are steep to vertical and are forested to the water edge. It was surveyed by the Kitasoo Fisheries Program in May 1997, when systematic transects were placed at 2-km intervals over 138 km of shoreline (Cripps and Campbell in prep). The density estimated over all transects was 4.73 c/m-sh. The best sections of the inlet, in terms of consistency of habitat type and the number of previous transects completed, were selected to be included in the EFA. The experimental sites were located on five straight stretches of steep shoreline. Mean density estimates from these five subsets was 4.30 c/m-sh and ranged individually from 2.40 to 7.42 (Table 3).

These sites were re-surveyed with increased sample sizes in September, 1998, by the PSCHA and a contracted third-party participant. The overall mean density estimate from the repeat survey was 2.58 c/m-sh which was, like Tolmie Channel, 40% less than the original estimate (Table 3). In many of the sites, the new estimate of density was less than the lower 90% confidence bound.

As with Tolmie Channel, a change in bathymetric distribution is suspected, although there is little or no substantiating evidence. The depth distribution was similar between surveys, with highest densities at medium depths. If the suspected sea cucumber migration is seasonal, then the different time of year that the surveys were conducted may play a part. This is not supported, however, by results from replicate surveys conducted by the Kitasoo Fisheries Program in Sheep Pass and Griffin Pass (Table 2) where no significant difference in mean density was detected between the seasons (Cripps and Campbell, in prep).

Laredo Inlet is ecologically different from other areas surveyed. Overall, the invertebrate and algal communities were not diverse, and it was noted in both 1997 and 1998 that there was a thick layer of brackish water on the surface resulting from the several major rivers which flow into the inlet year round.

4.1.5 Bella Bella

The mean density estimates obtained from the survey of the Bella Bella area were the highest obtained of all the recent DFO/PSCHA surveys at 13.6 c/m-sh (Table 4) and were comparable to other surveys conducted in the central coast by the Kitasoo Fisheries Program (Table 2). A report of this survey is in preparation. Modified quotas for the IQ fishery were calculated from the lower 90% confidence bound of the mean estimate and these replaced the precautionary quota for only the areas surveyed. The Subareas were grouped into cucumber Management Areas (Table 1) and managed on that basis. Fishing activities were fairly evenly distributed throughout the three Subareas A re-survey of the Bella Bella area is scheduled for 2002.

4.2 Removal Experiments

Mean density estimates from the randomly located transects, with 90% confidence bounds, are shown in Table 5. In the Gulf Islands, the density of sea cucumbers harvested from the high, medium and low sites all fell within the 90% confidence bounds of the mean density estimates. In Jervis Inlet, however, the data were less well behaved. In the high density site, the density harvested was only two-thirds of the estimated mean density from transects, although the confidence interval was wide enough to include the low value. There were suspicions that the animals may have fled in response to sensing viscera in the water (Campagna and Hand 1999). In the medium and low density sites, however, the density estimated from transect data underestimated sea cucumber abundance.

4.3 Experimental Fisheries

4.3.1 Jervis Inlet

Two vessels were involved in the harvest. Each vessel had a biologist observer on board to monitor activities closely. Harvest amounts per site varied between 1,327 and 14,683 animals (Table 6). Fishers reported differences in habitat and sea cucumber distribution between the sites. Sites that were on the edge of the Strait of Georgia had a different bottom structure, more vegetation in the shallows and a deeper distribution of animals than the sites located in the inlets. In at least one site, sea cucumbers were seen deeper than harvest depths.

The proportion of the 10 km of shoreline fished to achieve the experimental quota varied between sites, depending on the exploitation rate. Fishermen worked as they would normally if harvesting an IQ. Therefore, it is expected that a re-visit of the harvest locations would show a relative absence of animals. An exception is Site 8 on the west side of Sechelt Inlet, where it was reported that the smaller animals seen were avoided because of market preference, and that this had the effect of increasing the length of shoreline that had to be covered to fill the quota.

4.3.2 Tolmie Channel

Two vessels participated in harvest activities during October, 1998. Harvest amounts per site varied between 2,222 and 12,978 sea cucumbers (Table 6). Fishermen experienced similar difficulties in finding the sea cucumbers to fill the experimental quotas.

4.3.3 Laredo Inlet

Two vessels participated in harvest activities during October, 1998. Harvest amounts per site varied between 282 and 2,566 sea cucumbers (Table 6). Fishermen reported difficulty in filling the experimental quotas without covering extensive areas of shoreline. Since the harvest was completed immediately following the abundance survey, it seems unlikely that the cucumbers had disappeared. A more likely explanation is that the steep-sided rocky shores of the inlet were very unlike the gently-sloped shores of soft substrate that fishermen usually target. The poor search success may be due to inexperience in harvesting a steep-sided habitat type.

4.4 Biological Sampling

Biological data were collected during the surveys in all areas except the Gulf Islands (Table 7). Mean split weights from Laredo Inlet and Tolmie Channel are similar at 258 g and 271 g, respectively. The mean split weight for both combined is 266 gm with 95% confidence bounds of 245 gm and 288 gm. These are within 8% of the mean and are considered reasonably accurate. Analyses indicate that increased precision would result if fewer animals were sampled over a larger number of transects (Fig. 6), however the increased cost of doing so may not be warranted.

Samples collected from Bella Bella were more intensively sampled (Table 7). Mean round weight was more variable and the difference between round and split weight was larger than from Tolmie and Laredo. Calculated 95% confidence bounds are within 22% of the mean. With these more variable data, increasing the number of transects would be warranted (Fig. 6). Recovery (muscle plus skin weight) was on average 93% of split weight.

The mean split weight from Jervis Inlet is 250 gm, with 95% confidence bounds within 16% of the mean.

5.0 DISCUSSION

The sea cucumber abundance data collected in British Columbia varies dramatically between survey locations. Results are contrasted from the Gulf lslands with a low density of 3.1 c/m-sh and highly aggregated populations, to Bella Bella where densities were the highest measured in B.C. to date at 13.6 c/m-sh. Densities in the Bella Bella area are comparable to the mean density of 11.7 c/m-sh obtained from 1,837 transects completed in Alaska from 1990 to present (John Clark, ADF&G, pers. comm.).

Survey results from the Gulf Islands suggest that the area is depleted. While the overall density is 3.1 c/m-sh, which is larger than the precautionary estimate of 2.5, the majority of animals are found in small but dense aggregations. Total landings from the Subareas included in the survey area are approximately 386 t (split weight). It has been almost ten years since harvest activities have occurred in areas where transect data were collected, and there is no obvious sign of recovery. Whether this failure is due to poor recruitment success resulting from low spawning stock densities or from poor survival of juveniles is unknown. If the former, this area may be a good candidate for enhancement through the relocation of recruits collected elsewhere (oyster farms, areas of high settlement). Total landings from the Bella Bella area are similar to the Gulf Islands at 351 t split weight. In fact, PFMA 7-17 was closed to harvest in 1997 because landings were thought to have been excessive. The fishery was re-opened when survey results indicated that densities were relatively high. The Gulf Islands and Bella Bella seem to be at opposite extremes in their response to approximately the same level of harvest.

Early results from surveys and experimental fishing have shown large differences in density, distribution and size structure of sea cucumber populations between the different habitat types included to date. Care must be taken to continue to include the full spectrum of habitats in survey and experimental activities in order to test and quantify the relationship with productivity. It is possible that a single exploitation rate may not be appropriate for the entire B.C. coast.

The reliability of survey results comes into question when repeat surveys over a short time-period are in such disagreement, as happened in Tolmie Channel and Laredo Inlet. Large changes in sea cucumber density over time have also been observed in Alaska (John Clark, Alaska Department of Fish and Game, pers. comm.). The cause for these differences is not known, but sea cucumbers do have some mobility and may migrate. Studies in California on *P. parvimensis* have shown the animals to migrate to deeper water from August to November (Muscat 1983). Information on the seasonal distribution of *P. californicus* is inconclusive. They are reported to migrate to shallow water to spawn from early April to August (Lambert 1997). In the central coast, surveys conducted in the same areas at different times of the year and found no significant difference between densities (Cripps and Campbell in prep). Studies have been conducted to investigate distributions in relation to depth and substrate (Zhou and Shirley 1996) and on daily movements associated with feeding (Da Silva *et al.* 1986) but these do not address seasonal behaviour. A directed effort at studying the seasonal distribution patterns may prove informative. Density surveys conducted through at least one year in one or more well-chosen locations would be relatively easy to do and may provide useful information on sea cucumber distribution that can be related to season. It is also important to keep the timing of surveys consistent, to attempt to control for potential variability due to season.

Sea cucumbers populations do not lend themselves well to random survey designs and conventional statistical approaches. The distribution of animals over time can be unpredictably variable and, in space, can be highly aggregated so that density data are usually skewed. In addition, since density is expressed as number of animals per metre of shoreline, slope (and therefore transect length) would be expected to have an impact on density estimates. Survey designs should consider this, and techniques that are more appropriate to spatially-structured stocks should be investigated. The use of ancillary information, for example substrate type, to increase the precision of density estimates should be investigated. The potential for remotely-collected habitat data, geostatistical analysis and GIS for mapping extensive areas of sea bed is currently being investigated for benthic invertebrates in general.

An increased understanding of recruitment mechanisms and the area of larval dispersal is necessary to address concerns over the spatial pattern of commercial fishing and the potential for, and seriousness of, serial depletion. An investigation of the historical time-series of geo-referenced commercial harvest data is currently underway, using GIS, to investigate the temporal pattern of fleet behaviour.

Recommendations:

- Initiate study areas that are surveyed throughout the year to examine seasonal migration, perhaps including a tagging program.
- Set up study plots in 'nursery areas' to investigate whether settlement can be measured and, if so, initiate monitoring of inter-annual recruitment patterns. Investigate spat collectors, either opportunistic (oyster farms) or designed, to collect an index of larval abundance over a range of habitat types. Recruitment success in the Gulf Islands should be a priority.
- Initiate studies to investigate the spatial scale of populations and stocks through DNA analysis.
- Investigate the potential for localized enhancement of depleted areas.

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Table 1. History of Cucumber Management Areas (CMA) in the commercial sea cucumber fishery since the implementation of IQs.

Year	CMA	Description	PFMA's	Mean Weight (gm)	km of shoreline	Calculated Quota (lb.)[1]	Area Quota (lb.)	No. of Licences
1995	WCVI	W coast Van. Is.	25, 24-7	-	-	-	60,490	10
	ECVI	E coast Van. Is.	12, 13-7 to 13-12, 13-24 to 13-43	-	-	-	60,490	10
	CC	Central Coast	7-26 to 7-28, 8-2, 8-4	-	-	-	133,078	22
	PRD	Pr. Rupert Dist.	3, 4	-	-	-	133,078	22
	QCI	Queen Charlotte Is.	2-3 to 2-10	-	-	-	127,029	21
							514,165	85
1996	WCVI	W coast Van. Is.	26-2 to 26-10, 27-2, 27-3, 27-7	-	-	-	60,490	10
	ECVI	E coast Van. Is.	18-6, 18-1 to 18-5, 18-9 to 18-11, 19-3 to 19-6	-	-	-	60,490	10
	CC	Central Coast	7-12, 7-13, 7-15, ptn. 7-17, 7-22 to 7-24	-	-	-	193,568	32
	PRD	Pr. Rupert Dist.	5-16 to 5-19, 5-24, 6-5, 6-9, 6-10	-	-	-	199,617	33
							514,438	85
1997	24A	N. Clayoquot	24-4 to 24-6, 24-14	322	239	17,841	16,012	6
	24B	S. Clayoquot	24-7 to 24-10	322	272	20,232	20,282	
	12A	N. Q.C. Str.	12-9 to 12-11, 12-13, 12-16	318	386	28,419	25,120	9
	12B	S. Q.C. Str.	12-7, 12-8, 12-17, 12-40, 12-41	318	479	35,261	29,321	
	13A	Quadra/Cortes	13-12 to 13-16	318	274	20,158	19,841	6
	13B	N. Area 13	13-17 to 13-20, 13-23	318	241	17,756	16,453	
	7A	Bella Bella	7-12 to 7-16, 7-18 to 7-24	263	1,368	83,303	58,070	32
	7B	Hunter/Price	7-27, 7-28, 7-30 to 7-32, 8-2 to 8-7, 8-13, 8-14, 8-16	263	1,335	81,204	135,498	
	5A	Banks/Pitt	5-13 to 5-22, 6-5	263	1,231	74,900	58,070	32
	6A	Gil/Trutch	5-24, 6-6 to 6-10, 6-12, 6-26 to 6-28	263	986	60,046	135,498	
					6,811	439,120	514,165	85

Table 1, cont'd.

Year	CMA	Description	PFMA's	Mean Weight (gm)	km of shoreline	Calculated Quota (lb.)[1]	Area Quota (lb.)	No. of Licences
1998	24A	N. Clayoquot	24-4 to 24-6, 24-14	322	239	17,841	15,750	5
	24B	S. Clayoquot	24-7 to 24-10	322	272	20,232	20,000	
	12A	N. Queen Charlotte Str.	12-9 to 12-11, 12-13, 12-16	318	386	28,419	29,321	8
	12B	S. Queen Charlotte Str.	12-7, 12-8, 12-17, 12-40, 12-41	318	479	35,261	27,879	
	13A	Quadra/Cortes	13-12 to 13-16	318	274	20,158	19,600	5
	13B	N. Area 13	13-17 to 13-20, 13-23	318	241	17,756	16,150	
	7A	Bella Bella	7-2, 7-3, 7-12 to 7-14, 7-16, 7-18 to 7-24, 7-31, 7-32	263				
		IQ Survey[2]	7-15, 7-17	337				
		Total			1,649	172,102	160,101	40
	7B	Hunter/Price	7-25 to 7-28, 8-2 to 8-7, 8-13, 8-14, 8-16, 9-1, 9-2, 9-12	263				
		IQ Survey[3]	7-30	337				
		Total			1,927	125,899	125,899	
	5A	Banks/Pitt	4-3, 5-1, 5-2, 5-4, 5-5, 5-7, 5-11 to 5-22, ptn. 5-23	263	1,491	90,774	90,525	27
	6A	Gil/Trutch	5-24, 6-2, 6-3, 6-5, 6-6 to 6-12, 6-14 to 6-16, 6-26 to 6-28	263	1,684	102,525	102,525	
					8,642	630,967	607,750	85

[1] Multiply shoreline length by 2.5 c/m-sh by mean weight by 4.2% exploitation rate.
[2] Quota for 7-15 and 7-17 calculated with mean densities of 6.6 and 13.4 c/m-sh, respectively.
[3] Quota for 7-30 calculated with a mean density of 11.9 c/m-sh.

Table 2. List of transect surveys conducted in British Columbia for sea cucumber abundance estimation.

Location	PFMA	Date	Survey Type	Mean Density (c/m-sh)	Conducted by	Remarks
SOUTH COAST						
Gulf Islands	17, 18	Nov. 1997	two stage, random	3.1	PSCHA & Cowichan Band	- not currently being fished
Jervis Inlet	16	Jan. 1998	two stage, random	9.5	PSCHA	- used to design EFA
		Jan. 1999	random	9.77	PSCHA	- used to calculate experimental quotas
CENTRAL COAST						
Tolmie Channel	6	Aug. 1996	systematic	20.4	Kitasoo Fisheries Program	- used to design EFA
		Sept. 1998	random	12.6	PSCHA	- used to calculate experimental quotas
Laredo Inlet	6	May 1997	random	4.7	Kitasoo Fisheries Program	- used to design EFA
		Sept. 1998	random	2.6	PSCHA	- used to calculate experimental quotas
Bella Bella	7	May 1998	one stage, random	13.6	PSCHA and Heiltsuk Fisheries Program	- used to calculate increased TAC
DATA FROM OTHER SOURCES						
Sheep Pass	7	Sept.1993	random	18.8	Kitasoo Fisheries Program	
		Apr. 1994	systematic	16.7		
Griffin Passage	7	Sept. 1993	random	14.2	Kitasoo Fisheries Program	
		Apr. 1994	systematic	13.6		
Alexander Inlet	6	Oct. 1994	systematic	9.8	Kitasoo Fisheries Program	
Kitasu Bay	6	Oct. 1994	systematic	11.5	Kitasoo Fisheries Program	
Meyers Passage	6	Aug. 1996	systematic	13.9	Kitasoo Fisheries Program	
Green Inlet	6	Aug. 1996	systematic	14.7	Kitasoo Fisheries Program	
Matheson Channel	7	Aug. 1997	random	14.3	Kitasoo Fisheries Program	

Table 3. Summary of results from abundance surveys conducted from November 1997 to January 1999.

Date/Location	Site[1]	PFMA	# of Transects	Density (c/m-sh)	90% C.I. (c/m-sh)	Range (c/m-sh)	Comments/Reference
GULF ISLANDS							
Nov/Dec, 1997	1	17-1,17-2	10	5.55	0.3 - 15.5	0 - 50.75	- Broadbrush survey.
	2	17-17	10	5.05	0.03 - 13.5	0 - 45.0	- No EFA planned.
	3	17-4	10	0.60	0.05 - 1.55	0 - 5.0	- Campagna and Hand
	4	18-4, 18-6	10	5.35	3.12 - 7.7	0.25 - 12.5	1999.
	6	17-6, 17-9	10	0.13	0.0 - 0.28	0 - 0.75	
	8	17-1, 18-2	10	1.90	0.85 - 3.1	0 - 7.0	
		Total	**60**	**3.10**	**1.48 - 5.13**	**0 - 50**	
JERVIS INLET							
Jan, 1998	1	16-12	10	6.53	4.30 - 9.13	1.5 - 19.25	- Broadbrush survey.
	2	16-6, 16-7	10	3.58	1.83 - 5.60	0.25 -13.5	- Survey data used to
	3	16-11	12	11.73	5.10 - 20.11	0 - 32.0	design intensive surveys
	4	16-16	10	15.53	11.13 - 20.25	4.5 - 33.75	for experimental fisheries
	5	16-6, 16-7	10	10.90	7.15 - 14.88	2.5 - 26	- Campagna and Hand
	6	16-16,17,18	10	8.48	5.40 - 11.90	0.75 - 21.75	1999.
		Total	**62**	**9.53**	**7.53 - 11.68**	**0 - 34**	
Jan, 1999	1 (2%)	16-12	26	7.20	4.76 - 9.70	0.25 - 27.75	- Survey data used to
	3 (16%)	16-11	16	9.30	6.31-12.78	0 - 24.25	calculate experimental
	4 (4%)	16-16	15	16.47	11.10 - 21.57	0 - 36.75	fishery quotas.
	5 (0%)	16-6, 16-7	25	8.44	6.45 - 10.39	0.25 - 24.75	
	6 (8%)	16-16,17,18	25	10.05	5.73 - 14.38	0 - 51.5	
		Total	**107**	**9.77**	**8.10 - 11.42**	**0 - 51.5**	

[1] Percentages refer to the exploitation rate used in the experimental fisheries.

Table 3, cont'd.

Date/Location	Site[1]	Number Transects	Density (c/m-sh)	90% C.I. (c/m-sh)	Range (c/m-sh)	Comments
LAREDO INLET – PFMA 6-19						
May, 1997	1	4	2.81	2.3 – 3.3	2.8 - 3.0	Data collected by Kitasoo
KITASOO FISHERIES	2	5	2.40	1.0 – 3.8	1.5 - 4.3	Fisheries, used to design
	3	6	7.42	4.6 – 10.3	3.3 - 12.5	intensive surveys and
	4	4	4.44	3.6 – 5.3	3.75 – 5.5	experimental fisheries
	5	4	4.44	1.3 – 7.6	1.5 - 8.0	
		24	**4.30**	**3.5 - 6.1**	**1.5 - 12.5**	
Sept/Oct, 1998	1 (8%)	15	2.07	0.92 - 3.3	0 - 9.3	Re-survey and experimental
DFO/PSCHA	2 (0%)	15	2.42	1.7 - 3.2	0 - 5.3	Fishery
	3 (4%)	15	3.80	2.5 - 5.2	0.25 - 12.8	
	4 (16%)	15	3.25	2.2 - 4.6	1.5 - 12.8	
	5 (2%)	16	1.45	0.73 - 2.3	0 - 4.75	
		76	**2.58**	**2.1 - 3.1**	**0 - 12.8**	
TOLMIE CHANNEL – PFMA 6-20						
Aug. 1996	1	5	17.25	10.8 - 23.65	4.5 - 34.5	Data collected by Kitasoo
KITASOO FISHERIES	2	5	11.30	7.7 -14.9	7 - 22.5	Fisheries, used to design
	3	5	30.10	22.65 - 37.55	17.2 - 47.8	intensive surveys and
	4	5	17.20	10.51 - 23.89	6.5 - 34.0	experimental fisheries
	5	5	25.90	18.9 - 32.9	11.5 - 45.8	
		25	**20.35**	**15.8 - 25.2**	**15.8 - 25.2**	
Sept, 1998	1 (16%)	20	8.61	6.9 - 10.4	1.5 - 18.25	Re-survey and experimental
DFO/PSCHA	2 (4%)	15	13.48	9.4 - 18.0	1.0 - 28.0	Fishery
	3 (8%)	15	17.03	13.2 - 20.8	5.5 - 31.0	
	4 (2%)	22	11.89	9.5 - 14.3	6.0 - 33.5	
	5 (0%)	15	13.40	10.2 - 16.6	2.8 - 26.3	
		87	**12.56**	**11.2 - 14.1**	**1.0 - 33.5**	

[1] Percentages refer to the exploitation rate used in the experimental fisheries.

Table 4. Summary of survey results, calculated quotas and commercial harvest amounts from the Bella Bella area for the 1998 fishery.

Date/Location	PFMA	No. of Transects	Density (c/m-sh)	90% C.I. (c/m-sh)	Calculated Quota (lb.)	Harvest (lb. split wt.)	Comments
BELLA BELLA							
May, 1998	7-15	66	8.48	6.6-10.5	21,879	10,592	- Lower 90% est. of density
	7-17	113	15.86	13.4-18.3	71,470	74,141	used to calculate additional
	7-30	18	18.03	11.9-25.5	10,846	2,339	regular quota.
	All	197	13.62	11.87 - 15.31	104,189	87,072	- Report in preparation

Table 5. Results of intensive site survey and harvest results in the Gulf Islands and Jervis Inlet areas.

Date	Site[1]	PFMA	No. of Transects	Density as Surveyed (c/m-sh)	90% C.I. (c/m-sh)	Range (c/m-sh)	Harvest (lb. split wt.)	Density as Harvested (c/m-sh)
Gulf Islands								
Nov, 1997	L	17-16	5	3.50	0.7 - 7.1	0.25 - 11.25	782	4.68
	M	17-16	5	25.85	19.4 - 32.7	10.5 - 42.5	4,055	30.75
	H	29-5	5	75.15	50.4 - 99.1	32.5 - 104.75	7,586	71.65
Jervis Inlet								
Jan, 1998	L	16-11	5	16.10	12.1 - 21.1	7.7 - 22.3	2,055	23.35
	M	16-16	5	20.90	14.39 - 28.1	9.5 - 34.0	3,578	32.30
	H	16-11	5	77.70	45.9 - 116.4	22.0 - 142.3	3,608	50.23

[1] L is low density , M is medium density and H is high density site.

Table 6. Experimental quotas and harvest amounts by site from Jervis Inlet, Tolmie Channel, and Laredo Inlet.

Experimental Fishery	Site	Exploitation Rate (%)	Mean Density (c/m-sh)	Experimental Quota (pieces)	Harvest (pieces)
Jervis Inlet	1	2	7.20	1,440	1,433
	3	16	9.30	14,880	14,727
	4	4	16.47	6,588	6,570
	5	0	8.44	100	104
	6	8	10.05	8,040	7,979
	Total		9.77	31,048	30,813
Tolmie Channel	1	16	8.61	13,776	12,385
	2	4[1]	13.48	5,392	4,920
	3	8[1]	17.03	13,624	12,978
	4	2[1]	11.89	2,378	2,222
	5	0	13.40	0	0
	Total		12.56	35,170	32,505
Laredo Inlet	1	8	2.07	1,656	1,656
	2	0	2.42	0	0
	3	4	3.80	1,520	1,577
	4	16	3.25	5,200	2,566
	5	2	1.45	290	282
	Total		2.58	8,666	6,081

[1] Harvest amounts monitored by weight; all remaining sites were monitored by piece counts.

Table 7. Summary of results of biological sampling.

Location	Site	Transect	Number Sampled	Average Weight (g)	
				Round	Drained
Laredo Inlet, 1998	0	26	45	532	243
	4	38	50	568	225
	4	46	50	613	266
	8	8	50	773	305
	16	56	50	749	298
	16	60	50	502	209
		All	295	623	258
Tolmie Channel, 1998	0	155	50	570	217
	0	157	44	507	234
	2	131	43	613	286
	2	149	50	537	265
	4	104	50	666	309
	4	107	50	930	284
	8	125	50	900	317
	8	127	50	987	326
	16	81	50	418	217
	16	92	47	536	254
		All	484	666	271
Bella Bella, 1998	-	18	48	1198	383
	-	106	50	832	272
	-	217	51	967	300
	-	111	50	666	260
	-	118	47	1019	399
	-	169	50	747	272
	-	7	51	762	264
	-	35	50	1114	349
	-	198	26	589	209
		All	424	977	337
Jervis Inlet, 1999	0	60	53	-	215
	0	73	51	-	295
	2	10	53	-	212
	2	16	53	-	222
	4	47	52	-	283
	4	50	58	-	186
	8	85	50	-	288
	8	103	51	-	259
	16	37	51	-	163
	16	41	51	-	378
		All	523		250