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Development of a Fishery for Tanner Crab (*Chionoecetes tanneri*) off the Coast of British Columbia

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Abstract

The deep water Grooved Tanner crab (*Chionoecetes tanneri*) is being investigated as one of several species proposed as new fisheries off the coast of British Columbia. Investigation of the fishery potential of this species has been following the Phased approach for the provision of scientific information for new and developing fisheries (Perry et al. 1999). Phase 0 (Pillips and Lauzier 1997) and Phase One Framework papers (Boutillier et al. 1998) have been reviewed by the Pacific Scientific Advice Review Committee (PSARC). This paper is a progress report on studies initiated to determine the distribution and abundance of *C. tanneri* over its entire geographic range off the coast of British Columbia.

The results of a Department of Fisheries and Oceans (DFO) area swept trawl survey and partial results of a distributional trap survey being conducted by the fishery proponents are summarized. Using these two sources of data we calculated biomass estimates for five Pacific Fisheries Management Areas (PFMA) off the west coast of Vancouver Island (WCVI). The mean size at 50 % maturity for male *C. tanneri* was estimated to be 112 mm carapace width (CW). This is proposed as an experimental size limit for the species, consequently, biomass estimates were computed for the population as a whole and for male *C. tanneri* larger than 112 mm. The total estimated biomass of male crabs larger than 112 mm CW for the five completed areas of the coast is 630 metric tonnes.

A depletion experiment is proposed for one PFMA (Area 125) off the WCVI to test assessment methodology, develop a separate biomass index and investigate population responses to harvesting. We recommend a harvest of 100 metric tonnes of male tanner crab larger than 112 mm from PFMA 125 during this experiment.

Also presented are the results of investigations into the incidental mortalities of *C. tanneri* in other fisheries. We identify the current deep-water slope rockfish fishery as the most significant source of incidental fishing mortality. An unknown incidental fishing mortality is also attributable to the sablefish trap fishery. Based on the incidental bycatch of *C. tanneri* by the groundfish trawl fishery in 1999 it is anticipated that this gear type will harvest approximately 120 metric tons of *C. tanneri* in 2000.

Résumé

Le crabe (*Chionoecetes tanneri*), qui vit en eau profonde, compte parmi les différentes espèces qui pourraient être l'objet de pêches nouvelles au large de la Colombie-Britannique. L'examen du potentiel de pêche de ce crabe se fait selon l'approche par étapes de la prestation de renseignements scientifiques sur les pêches nouvelles et émergentes (Perry *et al*., 1999). Le Comité d'examen des évaluations scientifiques du Pacifique (CEESP) a passé en revue les documents-cadres des étapes 0 (Pillips and Lauzier, 1997) et 1 (Boutillier *et al*., 1998). Le présent document est un rapport d'étape des études menées pour établir la répartition et l'abondance de *C. tanneri* dans l'ensemble de son aire de répartition au large de la Colombie-Britannique.

Le résultat d'un relevé au chalut par aires balayées mené par le ministère des Pêches et des Océans (MPO), ainsi que les résultats partiels d'un relevé de répartition au casier de *Chionoecetes tanneri* en voie d'être exécuté par les promoteurs de cette pêche. À l'aide de ces deux sources de données, les auteurs ont fait des estimations de la biomasse dans cinq secteurs de gestion des pêches du Pacifique situés au large de la côte ouest de l'Île de Vancouver (COIV). Ils ont aussi estimé d'après les données biologiques recueillies lors du relevé au chalut mené par le MPO que la taille moyenne des mâles à maturité 50 % se chiffrait à 112 mm. Ayant choisi cette longueur comme la limite de taille expérimentale de l'espèce, ils ont fait une estimation de la biomasse totale des mâles de plus de 112 mm dans les cinq secteurs de gestion. Celle-ci se chiffrait à 630 tonnes métriques.

Les auteurs proposent que soit menée une expérience de pêche dans le secteur de gestion 125, situé au large de la COIV, pour vérifier la méthode d'évaluation, obtenir un autre indice de la biomasse et établir les réactions de la population à la pêche. Ils y recommandent des prises de crabes mâles de plus de 112 mm se chiffrant à 100 tonnes métriques.

Sont aussi présentés les résultats d'études de la mortalité accidentelle de *C. tanneri* imputable à d'autres pêches. Les auteurs considèrent la pêche du sébaste, actuellement menée dans les eaux profondes du talus, comme la plus importante source de mortalité par pêche accidentelle. La pêche de la morue charbonnière à la trappe est aussi une source de mortalité par pêche accidentelle inconnue de ce crabe. D'après les prises accidentelles de *C. tanneri* réalisées lors de la pêche du poisson de fond au chalut en 1999, on prévoit que ce type d'engin récoltera environ 120 tonnes métriques de *C. tanneri* en 2000.

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1.0 Introduction

This paper constitutes a progress report on the ongoing Phase 1 prerequisites for the development of a fishery for the deep water Tanner crab *Chionoecetes tanne*ri, hereafter referred to as Tanner crab unless otherwise specified. The request for working paper (Appendix 1) states four questions that need to be addressed in the course of this document.

- What are the results of the DFO trawl survey and Industry trap survey of Tanner crab.
- What is the current estimate of abundance and stock condition for Tanner crabs.
- What is the potential annual harvest of Tanner crabs and what is the current annual level of incidental mortalities.
- What are the current options for a commercial fishery and what potential allocation conflicts might arise from such a fishery.

Brief summaries of the methods and results of the surveys will be presented. Methods employed to estimate the abundance of Tanner crab and calculate total allowable removals (TAR) or harvest are described. We also identify other sources of by-catch and mortality identified through data mining projects. We will discuss the benefits and shortcomings of the current assessment methodology, the potential gear conflicts and habitat/ecosystem impacts of deep-water fisheries and possible management approaches to the fishery. At the end of the paper we present recommendations for the future assessment and development of this fishery and identify further research needs.

1.1 History of Development

A Memorandum of Understanding (MOU) between the Federal Government of Canada and the Provincial Government of British Columbia was signed in December 1995. The intent of this memorandum was to develop new fisheries to partially compensate for reduced opportunities in traditional fisheries. Emphasis was placed on involving local communities and diversifying the fishing industry. Development of any new fishery was to follow a competitive business approach and was to proceed in a manner that was cost neutral to the Department. The deepwater Tanner crab, *Chionoecetes tanneri*, was one of four species initially identified as having potential to meet these criteria. An experimental fishery in 1987 through 1989 indicated that harvestable quantities of Tanner crab existed off Vancouver Island and reports from the sablefish trap fishery and museum collections indicated a coastwide distribution. Therefore, it was decided to evaluate the species following the "Phased" approach described by Perry et al. (1999).

1.2 Objectives for the Development of a New Fishery

1.2.1 Departmental objectives

The objectives for establishing a fishery for Tanner crabs (or any new fishery) as stated in the MOU between the Federal Government of Canada and the Provincial Government of British Columbia signed in December 1995 are to:

- Diversify British Columbia fisheries and seafood production to ensure conservation of stocks and realize the optimal sustainable use of fisheries resources and fish culture.
- Encourage a competitive business approach to fisheries and aquaculture diversification, and maximize marketing opportunities.
- Diversify the seafood sector in British Columbia to promote employment opportunities, foster community development and secure social and economic stability.
- Encourage public and private sector co-operation in fisheries diversification, including new arrangements between regional communities, harvesters and growers.

1.2.2 Biological objectives

From a biological perspective, the goal in developing a fishery for *C. tanneri* is to maintain a viable, healthy and productive stock(s) throughout its natural range in British Columbia. Specific objectives for Tanner crab are:

- Ensure that the population or sub-populations of Tanner crabs along the B.C. coast do not become biologically threatened throughout their ecological range.

- Ensure production of sufficient progeny, after accounting for all sources of mortality, to reproduce the population(s) throughout their ecological range.

- Ensure that a fishery for Tanner crab does not violate the above two objectives for other ecologically related species.

1.3 The Phased Approach

Development towards a sustainable fishery requires the collection of sufficient biological data to:

- Determine a risk averse level of harvest

- Detect changes to the stock dynamics from any cause in time to prevent long term decline or collapse of the stock through over-exploitation.

The developmental framework adopted for the Tanner fishery involves three “Phases”, described in detail in Perry et al. (1999). Briefly these are:

Phase 0. Information review stage: A complete review of existing literature and data is undertaken for the target species, related species and other species from similar habitats or exploited with similar gear. Information gaps, which will impact on the assessment or management of the proposed fishery, are identified.

Phase 1. Gathering new information: Activities are undertaken to address the information gaps identified in the Phase 0 review. These activities can include but are not limited to experimental fisheries, fishery independent surveys, biological sampling programs, and laboratory analysis. The purpose of these studies is often to determine the distribution or abundance of the target species; appropriate harvest technology; and incidental impacts on the habitat or other species.

Phase 2. Fishing for commerce: the resource is harvested under experimental management regimes to ascertain the productivity of the stock in question; determine whether the species or stock can sustain a commercially viable fishery; and test the effectiveness of the capture technique. Ongoing monitoring and biological sampling is an integral part of this phase in the development of the fishery.

2.0 Assessment Framework

2.1.1 Phase 0 Recommendations

Following the Phase 0 review (Phillips and Lauzier 1997) a number of information gaps were identified. These were an understanding of the distribution and abundance of the species in Canadian waters, stock unit composition, and knowledge of its life history. Features such as molt timing, presence of a terminal molt, longevity, reproductive biology, recruitment, and mortality rates are not known for BC.

2.1.2 Phase 1 Framework Recommendations

A subsequent paper described a framework for the development of a commercial Tanner crab fishery (Boutillier et al. 1998). The following were identified as pre-requisites to such a fishery:

- A structured trap survey would be undertaken to gain information on stock distribution. Fishermen would fish a specified number of sets in specified areas and depths, with effort and catch recorded and biological samples taken.

- The Department would undertake an area swept trawl survey, designed using the stock distribution information, to estimate stock levels.

- Pending the results of the surveys, a multi-year experimental fishing plan would be developed based on distribution and an index of relative density. The plan will include dividing the coast up into three zones: no fishing in 50 % of the estimated habitat, fishing at a fixed exploitation rate in 25 % of the area and experimental harvests at various levels to test population responses and assumptions made regarding mortality in the remaining 25 %.

2.2 Framework Implementation

Following the framework paper it was necessary to identify interested proponents who would carry out the distributional trap survey. This resulted in a Request for Proposals (RFP) being circulated amongst fishermen, communities and aboriginal groups requesting submissions from interested parties. The RFP specified the survey design, and requested that interested parties identify participants, sources of funding and linkages between the fishing communities, aboriginal groups, and fishermen. Once the proposals were received and reviewed the West Coast Sustainability Association (WCSA) was selected as the agency to administer the distributional trap survey. DFO agreed to limited harvest opportunities to conduct test marketing and evaluate processing facilities. Precautionary harvest levels were to be computed by area once the trap survey for that area had been completed. The three areas are the West Coast of Vancouver Island (WCVI), Queen Charlotte Sound (CC) and the West Coast of the Queen Charlotte Islands (WCQCI) (Fig 1).

Due to delays in developing and sending out the RFP, gearing up for the trap survey, availability of vessels and time required for training observers, the opportunity to carry out the DFO trawl survey preceded the distributional trap survey by some 6 months, and was conducted between July 21st and August 3rd, 1999.

The industry trap survey began in late 1999. Following completion of the WCVI survey area precautionary harvest estimates were developed for selected Pacific Fisheries Management Areas (PFMA, Fig. 2) off the WCVI. In general terms this process involved estimating biomass from the area swept trawl survey, weighting the biomass estimates by statistical area using the relative trap catch rates between areas. Then applying a fixed exploitation rate to the weighted estimates of biomass.

2.3 Chronology of Tanner crab Investigations to date

1987-1989	Experimental Fishery undertaken by two vessels operating off the west coast of Vancouver Island.
1992	Moratorium placed on new invertebrate fisheries.
December 1995	MOU Federal/Provincial Governments for Development of New Fisheries. Tanner crab was selected as 1 of 4 species with fishery potential, Flying squid, Venus clam and chub mackerel were also proposed.

April 1996	The "Phased Approach to Fisheries Development" presented to the Invertebrate Subcommittee of the Pacific Stock Assessment Review Committee (PSARC) (Perry et al, 1999).
June 1997	Tanner crab Phase 0 Review presented to PSARC (Phillips and Lauzier 1997).
June 1998	A framework paper for the development of a Tanner crab fishery presented to PSARC (Boutillier et al. 1998).
Oct 1998	Community meetings and consultation begin as part of the process of developing a Request for Proposals (RFP).
December 1998	Funding for survey gear and staff (biologists) positions in place.
March 1999	RFP sent out.
June 1999	West Coast Sustainability Association (WCSA) chosen to manage distributional trap survey and to provide scientific data to DFO.
July 1999	Swept area trawl survey undertaken using the CCG Science vessel "WE RICKER" off the west coast of Vancouver Island.
November 1999	Observer training conducted in Prince Rupert through the community fisheries development center by WCSA and DFO.
December 1999	The Fisheries Minister announces commencement of the distributional trap survey. Weather delays the start of the survey by two weeks. The survey begins in PFMA 125 and proceeds north and south from that point with the objective of surveying the west coast of Vancouver island then the west coast of the Queen Charlotte Islands and the central coast.
January 2000	First batches of data delivered to DFO.
February 2000	First crab landings to test processing facilities and presentation of product for local consumption in Ucluelet.
February 2000	Biomass estimate computed for the west coast of Vancouver Island; west coast of Vancouver Island survey complete; precautionary quota of 40,200 Kg (88624 lbs.) set for PFMA 126 to test plant facilities – Initially two vessels undertake to harvest Tanner crab, neither captain has had previous experience fishing for Tanner crab. One experienced captain agrees to finish fishing the assigned quota. Several vessels leave the survey due to other commitments.

March 2000	The survey begins off the West Coast of the Queen Charlotte Islands, one vessel working from Rennell Sound north to Langara Island.
April 2000	The survey extended to the end of April, to facilitate data collection from the west coast of the Queen Charlotte Islands. The survey protocol is modified, for the remainder of the survey every second block will be surveyed. The rationale for this was to broaden the coverage that could be achieved in the time remaining.
April 28, 2000.	Last of the trap gear hauled and the survey terminated pending review by PSARC. The west coast of the Queen Charlotte Islands was only partially completed.
May 8th , 2000.	The last batch of data is delivered to PBS.
May 29th 2000	The last batch of dockside validation data delivered to PBS.
June 7th 2000	This review submitted to the Invertebrate subcommittee Chair of the Pacific Scientific Advice Review Committee (PSARC) for review.
June 20th 2000	This paper reviewed by PSARC

Joint Federal/Provincial funding allowed purchase of the required trawls, extra steel warp and 30 crab traps. In addition, two DFO funded Resource Management Biologists, one Stock Assessment Biologist and one Research Scientist were hired to expedite the development of this and other new invertebrate fisheries.

3.0 Methods

3.1 Biomass Estimation

3.1.1 Trawl survey

3.1.1.1 Survey design.

An area off the WCVI was surveyed (Fig. 3). The reason for selecting this area was that this was where the experimental commercial fishery took place in 1987 through 1989. There were several advantages to operating in this area with untried gear in previously un-surveyed depths. Firstly, data were available from the commercial groundfish trawl fishery showing where Tanner crab had been caught between 1996 and 1998. Equally important, was that these areas were known to be trawlable. An additional reason for working in this area was that it was apparent from discussions with the proponents that this would be a desirable area in which to commence a future commercial fishery.

A systematic survey design was selected for the survey since there were insufficient data to warrant a random or random stratified design. Scheaffer et al. (1996), states that when little is known of the distribution and/or abundance of a particular species it is more efficient to conduct a systematic survey than a random or random stratified survey in terms of gathering a basic understanding of the target species distribution. When selecting trawl locations a simple systematic design was employed to distribute sampling effort over as much of the study area as possible. Transects stratified by depth were placed perpendicular to the continental slope with the goal of placing one trawl in each depth stratum across each transect (i.e. tows were directed along isobaths). The depth range covered was 400 to 1200 m divided into 5 depth strata defined as 400 - 560, 560 - 720, 720 - 880, 880 - 1040, 1040 – 1200 m. Depth selection was based on the depth distribution reported in the literature (Pereyra 1966; Tester and Carey 1986; Somerton and Donaldson 1996). Transect placement was accomplished by measuring the length of the study area in a line parallel to the continental slope and dividing by the number of transects (tows) that could be completed in the available ship time. This resulted in a sub-unit length within which a random starting point was selected. Specifically, the overall length of the study area was 43.4 nautical miles (Nmi); it was determined we could complete 7 transects (or 35 tows) in the allotted time. We divided 43.4 Nmi by 7 transects to arrive at a sub-unit length of 6.2 Nmi. A random starting point of 2.5 was generated between 0 and 6.2. Thus we placed the first transect 2.5 Nmi from the southern boundary of the study area, within the first sub-unit and transects every 6.2 Nmi thereafter, resulting in transects at 2.5, 8.7, 14.9, 21.1, 27.3, 33.5, and 39.7 Nmi.

Research trap sites were selected based on the results of the trawl portion of the survey. One string of 15 traps was deployed in each depth stratum along the southern most transect. The intent was to collect trap catch rate data with nearly simultaneous trawl data to explore the relationship between the two.

3.1.1.2 Vessel and gear

The CCGS WE RICKER, (WER) a 2500 hp, 57.3 m steel stern trawler was used for the survey. A Campelen 1800 shrimp trawl was used for all trawl sets made during the survey. The net has a 29.5 m (97‘) headline rigged with 80, 203 mm (8 “) deep water plastic floats rated for 1800 m depth, and a footrope of 19.5 m (64’). The net was fished using a 356 mm (14”) rockhopper goundline built of sets of three rubber disks separated by iron and rubber spacers. Polyethylene web was used throughout to build the net with mesh size ranging from 80 mm in the wings and square to 60 mm in the bellies to 44 mm in the intermediate and codend. The net was equipped with a 7 mm knotless mesh codend liner for this survey. For a complete description of the Campelen 1800 trawl and its performance characteristics see McCallum and Walsh (1997) and Walsh and McCallum (1997). This net was selected because it has been used on the east coast of

Canada to conduct multi-species trawl surveys of both groundfish and Snow crab (*C. opilio*) and has proven both versatile and durable.

Trapping was also performed during the survey using conical, top loading, traps. Traps were meshed with 70 mm (2 3/4") stretched mesh web. Traps were not equipped with escape rings but were rigged with rot panels. Traps where spaced 50 – 100 m apart in strings of 15 on 22 mm (7/8") polypropylene groundlines. Each trap was baited with 1 kg of herring and 1 kg of fish offal.

3.1.1.3 Data collected

Fishing location, depth, net opening and duration were recorded for each tow of the net or set of trap gear during the survey. All catches were sorted to the lowest taxonomic level possible and the weight by species recorded. All crabs caught, either by trawl or by trap, were identified to species and weighed in aggregate to produce a total weight by species by tow. Additional biological information collected included: sex, individual weights (to the nearest gram), maximum carapace width exclusive of spines, shell condition (age), injuries, missing limbs, claw length and claw height for male crabs over 50mm, 5th abdominal segment width for female crabs over 50mm, presence or absence of eggs and egg color, and presence of grasping marks for female crabs.

Biological information collected and shell age determinations closely followed the protocol laid out in the "Alaska Sea Grant Field Manual for *Chionoecetes* Crabs" (Jadamec et al. 1999). We did however use our own sex, shell condition and injury code numbering system to remain consistent with those used for Dungeness crabs at the Pacific Biological Station. When catches were composed of less than 200 crabs, all crabs were sexed, individually weighed and measured, larger catches were randomly sub-sampled. Samples of all crab species caught were frozen and several specimens were preserved in formalin. On-board dissections were carried out on 10 newly molted female crabs to check for presence of spermatophores in the spermatotheca.

3.1.2 Distributional trap survey

3.1.2.1 Distributional trap survey design

Boutillier et al. (1998) outlines the survey design. The B.C coast from the Canada/US border, 48^{o} 06' N, in the south to Canada/US border, 54^{o} 22' N, in the north, was divided into blocks of 3 minutes latitude. This resulted in 121 blocks. Each block was further subdivided into 5 depth strata from (Fig. 1). The boundaries of the depth strata were 400 – 520, 520 – 640, 640 – 760, 760 – 880, 880 – 1000 m.

Each depth strata was to be fished with a string of 20 identical traps, resulting in 100 individual trap sets per block. The precise location of the trap set within a block and a specific depth stratum was to be at the discretion of the vessel skipper. Detailed biological information was to be collected on the target species (Tanner crab) and all other potentially commercial crab species. All other fish and invertebrates were to be identified and weighed by trained on-board observers. Additionally the vessel master was to complete a detailed logbook, which recorded set location, depth and total estimated weight of Tanner crab by string.

3.1.2.2 Trap Survey Gear

In consultation with the proponents, the traps selected were pyramidal stacking traps 52" at the base and approximately 42" high constructed of steel frames covered by 70 mm (2 3/4") synthetic mesh. Crabs enter the trap via a plastic or fiberglass funnel on the top of the trap, which also prevents their escape. For the purpose of the survey, no escape ports were required, however there was a panel on the side of the trap laced shut with biodegradable twine to allow crabs to escape if the trap were lost.

The traps were fished on a groundline, buoyed at both ends. Trap spacing was standardized to 50 fm (~100m) with 20 traps to a string. Bait load was standardized to 0.5 kg of squid per trap contained in a bait bag. Soak times were to be as close to 24hrs as was practicable.

3.1.2.3 Survey logistics

The choice of gear was made to allow one vessel with 100 traps to fish one block per day under ideal conditions. It was estimated that with 10 participating vessels each assigned an equitable share of the survey, it would require 2-3 weeks per vessel to complete the entire survey. The anticipated season for the survey was fall/winter, to avoid reported spawning aggregations in early spring (Pereyra 1966; Griffin and Edwards pers. com).

3.1.3 Analysis

3.1.3.1 Biomass estimation computations

Biomass for Tanner crabs was estimated using stratified random sampling methods (Cochran 1977). While this was not a random stratified design we assumed a randomly distributed population within strata to permit using stratified random sampling estimators (Scheaffer et al. 1996). The point estimate of biomass is unaffected by this discrepancy. The consequence of using random stratified methods on data collected using a systematic design is an incorrect estimate of the true variance. The notation used for the various estimators is provided in the following table (from Workman et al. 1998):

Symbol	Description
H	Stratum index
I	Haul index
C_{hi}	Observed catch in haul i for stratum h
k_{hi}	Area of bottom fished in haul i for stratum h
N	Total number of sampling units in the population

N_h	Total number of sampling units in stratum h
n	Number of units in the sample, or sample size
n_h	Number of units in the sample from stratum h
y_{hi}	Adjusted catch in haul i for stratum h
$\bar{y}_h$	The estimated mean in stratum h
$\bar{y}_{st}$	The estimated population mean
$\hat{t}_{st}$	The estimated population total

The adjusted catch or density is calculated as follows: let C_{hi} be the catch observed in haul i for stratum h and the area of bottom fished in each haul, k_{hi},

$$y_{hi} = \left(\frac{1}{k_{hi}}\right) C_{hi} \quad .$$

The area of bottom fished was computed as the product of the distance towed and the average net opening. Distance towed was calculated from the start and end positions of each tow using a great circle algorithm. The effective path width of the net was considered to be the distance between the wingtips of the net measured using either the Simrad ITI or the FS300 trawl eye.

The stratified random sampling estimators were applied to the set of adjusted observations, y_{hi}, to compute total biomass for Tanner crabs. Estimators of the mean catch per area and the total biomass are given by

$$\bar{y}_{st} = \frac{1}{N}\sum_{h=1}^{H} N_h \bar{y}_h \quad ,$$

and

$$t_{st} = N\bar{y}_{st} = \sum_{h=1}^{H} N_h \bar{y}_h \quad ,$$

respectively, where

$$\bar{y}_h = \sum_{i=1}^{n_h} \frac{y_{hi}}{n_h} \quad .$$

A non-parametric bootstrap procedure (Efron and Tibshirani 1993) was used to generate confidence intervals about the mean estimate of biomass. Bootstrapping was conducted by randomly drawing a sample of size N from the observed data at random with replacement, and computing the stratified estimate of the total from each resample. For each resample, a sample of size n_h was drawn independently from each stratum. A total of 1000 estimates were generated to yield a bootstrap distribution. Confidence limits were calculated using bias-corrected and adjusted (BCa) percentiles of 0.025 and 0.975 (Efron and Tibshirani 1993).

Biomass computations not only require estimates of catch density but also habitat area against which to apply those estimates. For this analysis ARCVIEW GIS was used to generate those area estimates. Input data (position and depth) were extracted from Natural Resource Maps obtained from the Ocean Mapping Section of the Canadian Hydrographic Service. These data were used to build a Digital Elevation Matrix or DEM, a computer model of the ocean bottom. The DEM was generated from the point data by building a Triangulated Irregular Network model or TIN from the point data and converting the TIN to a grid. The resultant DEM was then partitioned into relevant strata or areas and masked to exclude areas that were not part of the continental slope (Fig 1). Area estimates for each stratum and PFMA are then generated.

3.1.3.2 Weighting factors

Assuming the relationship between the trap catch rates and trawl densities is linear we use the relative trap catch rates between PFMA to scale biomass estimates derived from the trawl survey data. First we use the biological data collected during the trap survey to compute the proportion (p_i) of male crabs larger than 112 mm CW for each set of gear.

$$p_i = \frac{n_i > 112mm}{n_i} \quad .$$

Where n_i >112 mm is the number of male Tanner crabs larger than 112 mm in a given biological sample from a given set of gear, and n_i is the total number of male Tanner crabs in the same sample. The total catch (t_i) of males is then computed by string by summing the individual trap catches within a string:

$$t_i = \sum_{1}^{a} c_a \quad ,$$

t_i is then multiplied by p_i to arrive at the estimated total catch of males larger than 112 mm by string (c_i).

$$c_i = t_i p_i \quad .$$

Because the number of traps per string varied, the estimated total catch of males larger than 112 mm was divided by the number of traps per set to arrive at an average trap catch per string (□).

$$\hat{c} = \frac{c_i}{k_i} \quad ,$$

where k_i is the number of traps in given string of gear. A Reference Trap Catch Rate (RTCR) was then computed by taking the mean of all □ that occurred in the trawl survey area

$$RTCR = \frac{\sum \hat{c}_{survey}}{j_{survey}} ,$$

where j_{survey} is the number of sets that occurred in the survey area. We then compute the mean trap catch rate (TCR_{PFMA}) by PFMA and divi(. / the reference trap catch rate to arrive at a weighting to apply to the estimates of biomass for each PFMA.

$$W_{PFMA} = \frac{TCR_{PFMA}}{RTCR}$$

We then multiply the estimated biomass for a given area by the weighting factor for that area to arrive at the weighted estimate of biomass.

$$\hat{t}_{PFMA} = \hat{t}_{st} W_{PFMA}$$

Observed differences in trap catch rates were assumed to be representative of real differences in crab abundance between areas.

3.2 Sources of Mortality

In the Phase 0 Assessment for Tanner crabs (Phillips and Lauzier 1997) the groundfish trawl fishery and the sablefish trap fishery were identified as potential sources of fishing mortality.

3.2.1 Groundfish trawl by-catch

Observers are mandatory in the domestic groundfish trawl fishery as a condition of license. Observers collect detailed species catch information and are trained to identify and quantify by-catch. The groundfish observer database housed at the Pacific Biological Station was initially queried to identify trawlable areas where Tanner crab were caught as by-catch. This information was used in designing the DFO trawl survey. Subsequently the total by-catch of Tanner crabs in the groundfish trawl fishery was summarized by year and statistical area.

3.2.2 Sablefish trap fishery

There is no mandatory observer coverage on sablefish trap vessels. However, DFO has undertaken annual trap surveys as part of the ongoing assessment of Sablefish. Early surveys did not record the by-catch of invertebrates, however recent surveys not only identify the by-catch of Tanner crab but also the by-catch of King Crabs. These data were plotted to determine the distribution of Tanner crab by-catch in the sablefish fishery.

It is not possible at present to quantify the total catch of Tanner crabs in the commercial sablefish fishery.

3.3 Ecosystem Considerations

3.3.1 Species diversity by trawl

3.3.1.1 Research trawl survey

Species diversity was recorded during the DFO Trawl survey by sorting the entire catch to the species level. The procedure was as follows: once the net was retrieved the cod-end was emptied into a hopper on deck, which fed a conveyor system below deck. The catch was then sorted off the belt into baskets by species. The catch of each species was weighed using a MAREL 2200 motion compensated digital scale. Weights were recorded to the nearest 100 grams. Weights to the nearest gram for species caught in small quantities (<1 kg) and for individual crabs were obtained by using a smaller motion compensated MAREL scale. Species not readily identifiable to species were preserved in formalin or frozen for later identification.

3.3.1.2 Commercial groundfish trawl

The observer determines species composition of the catch by sub-sampling. In general the observer will select 5 baskets of approximately 25 kg each at random from the entire catch and these are sorted to species. A weight and or count is obtained for each species in the sub-sample and the total catch is estimated by visual or volumetric means. Smaller organisms or non-commercial species can be missed by this method. Consequently, a great many species impacted by this fishery may not be recorded or quantified.

3.3.2 Species diversity by trap

3.3.2.1 Sablefish trap

Currently there is no requirement to identify or record the by-catch in the sablefish trap fishery. The quality of by-catch data collected during DFO trap surveys has not been consistent therefore the diversity of species impacted by this fishery is unknown.

3.3.2.2 Tanner crab trap

Research trap catches were sorted to lowest taxonomic group and quantified. All observers participating in the Tanner crab trap survey were trained and are required to identify and quantify the entire catch. Thus all species impacted by Tanner crab trap gear to date have been identified and quantified.

4.0 Results

4.1 Biomass Estimation

4.1.1 DFO trawl and trap survey summary.

The DFO trawl survey was undertaken between July 21 and August 3, 1999. The primary objective of the survey was to assess the abundance of Tanner crab in a selected study area off the west coast of Vancouver Island. Secondary objectives included collecting detailed biological data on Tanner crabs, comparing catch rates between trap and trawl gear, collecting detailed community structure data by depth from the deep continental slope region and collecting cross shelf physical and biological oceanographic data.

A total of 34 trawl sets were completed, of which 29 were usable for estimating biomass; the total catch by trawl of Tanner crabs was 313.48kg (Table 1). Tanner crabs were caught between 436 m and 1301 m and were present in all but four tows. The angle Tanner (*Chionoectes angulatus*) was caught in two tows. The catch was clearly partitioned by depth with males being found in all depth strata but dominating the shallowest two (400-560, 560-720 m), while females and juveniles dominated the three deeper strata (720-880, 880-1040,1040-1200 m). Tanner crabs ranging in size from 10 mm to 176 mm were retained by the trawl net (Fig. 4). A total of 6 strings of 15 conical top loading traps were set during the survey. Traps catches were much higher than trawl catches, with the 6 sets yielding 345.37 kg of Tanner crabs. The depth stratification noted in the trawl catches was apparent in the trap catches as well.
The width frequency histograms for the population as a whole (Fig. 4) or by sex (Fig.5) are nearly identical to that presented in Tester and Carey (1986) in which they identify molt increments. Using the size at instar relationship presented in Tester and Carey (1986), the first instar captured during this survey was instar IV corresponding to the mode at 10 mm. Instar V is represented by the mode at 15 mm, instar VI corresponds to the mode at 21 mm and instar VII corresponds to the peak at 26 mm. They estimated the age of instar VII crabs to be 20 months. Tester and Carey arrived at a mean increase in carapace width per molt increment of 39 % for instars III-VII. If one assumes that relationship holds true until the puberty molt the modes identified at 36 mm, 52 and 67 mm correspond to molts VIII – X (calculated modes should appear at 37 mm, 52 mm and 72 mm).

The catch partitions into three obvious size classes: <40 mm, 40 – 75 mm and >75 mm. Animals larger than 75 mm dominated stratum 1. Strata 2 and 3 were dominated by crabs < 40 mm, and stratum 4 was dominated by crabs 40 – 75 mm. Stratum 5 was not clearly dominated by any one size class but contained the highest number of soft-shell individuals. Width/weight relationships by sex were derived for Tanner crabs. These indicate that males are heavier at a given width than females throughout their lives. Maturity ogives were plotted for Tanner crabs based on the morphometric allometry of claw dimensions versus carapace width for males and 5th abdominal segment versus carapace width for females. A clear separation of mature/immature individuals was evident from which 50 % maturity was estimated to be 112 mm for males and 88 mm for females; maturity ogives are presented in Figure 6.

The catch and catch density for the 29 usable tows obtained during the trawl survey are presented in Table 1 for all sizes and both genders of crabs as well as for male Tanner crabs larger than 112 mm. Table 2 presents Mean Catch Per Unit Effort (CPUE) and densities by stratum for all sizes of crab and for males larger than 112 mm. Strata 4 had the highest mean CPUE for all sizes of crabs while stratum 2 had the highest CPUE for male Tanner crabs over 112 mm. Observed mean densities for both categories of crabs were highest in stratum 4. Trawl survey methods and results will be further detailed in a subsequent cruise report (Workman et al. in prep.).

4.1.2 Results of the distributional trap survey

The first strings of gear were deployed on December 16, 1999, in PFMA 125 off the northwest coast of Vancouver Island. The survey then progressed southward until the southern half of Vancouver Island was complete and then northward to Pisces Canyon to complete the Vancouver Island portion of the survey; this was accomplished on February 4th, 2000. Two replicates were completed on February 10th to evaluate variation in catch rates due to fishing experience. Experimental harvests commenced on January 24th, 2000, with a precautionary allocation of 40,200 kg of Tanner crab for PFMA 126 and were completed on March 30th, 2000, having achieved the harvest allocation.

Survey work started off the west coast of the Queen Charlotte Islands on March 5th, 2000. The original completion date for the trap survey was to be March 31st 2000, this was extended to April 31st, 2000 to ensure some survey coverage for the west coast of the Queen Charlotte Islands. Only one vessel was available to undertake the work, therefore, the survey protocol was modified to maximize survey coverage (by latitude) in the remaining time. This was done by omitting every second survey block. The last set of survey gear was retrieved off the west coast of the Queen Charlottes on April 27th, 2000 having completed 14 blocks between Langara Island and Rennell Sound. No directed experimental harvest was permitted as a result of this survey although limited quantities were landed to test processing facilities in Masset.

A coastwide total of 290 survey sets and 64 experimental harvest sets were completed (Figures 7-9). Of the 49 survey blocks off the west coast of Vancouver Island, 45 were surveyed. Three blocks (1-3) at the southern extreme of the survey area were omitted due to a lack of fishable habitat; specifically not all depth strata were present in the blocks. Block five was omitted because there was a cable-laying vessel working in the area. Of the 45 blocks fished, all depth strata were fished in 40. Off the west of the Queen Charlottes 14 blocks were fished, but of these all five depths were fished only 3 times. Rough bottom topography was the main reason for missing a depth stratum.

In Table 3 mean catch rates (number of crabs per trap) are summarized by stratum for both males and females. In Table 4 mean catch rates are presented for male and female Tanner crabs by PFMA for areas either completed or partially completed. Catch rates for males were highest in stratum 3, for females they were highest in stratum 5. The PFMA with the highest mean catch rate of males was PFMA 126. The highest catch rate of females was seen in PFMA 124. Catch rates achieved during the experimental harvests are presented in Table 5. Figure 10 presents fishing locations for the experimental harvests.

The Angle Tanner (*Chionoecetes angulatus*) was only encountered in 2 sets, however the Scarlet King crab (*Lithodes couisi*) became increasingly abundant as the survey progressed northward on the WCVI and was especially abundant off the WCQCI.

Width frequency histograms for male and female Tanner crabs measured during the industry trap survey and experimental harvest are presented in Figures 11 and 12. Note the distinct difference in size frequency observed between trap gear and trawl gear. Trap gear is clearly selective for larger crabs. For males, the major mode is 115 mm (Fig. 11) with a minor one at 33mm, for females the modal size is ~ 70 mm (Fig. 12) with minor modes occurring at 20 and 32 mm.

4.1.3 Biomass estimate analysis

Habitat estimates by strata and PFMA are presented in Table 6. The areas surveyed by trap off the WCVI account for 5608 km^2 of habitat or 48% of the estimated coastwide total of 11678 km^2. Biomass estimates by PFMA along with bootstrapped 95% confidence intervals are presented in Table 7 for all sizes and both genders of crabs and for male Tanner crabs larger than 112 mm. These estimates are not weighted by trap CPUE and should be interpreted as preliminary values.

4.1.4 Trap weighting factors

Weighting factors (W_{PFMA}) used to calculate biomass by PMFA for the WCVI are presented in Table 8. These values are for male crabs over 112mm only. The weighting factors for area 123 and 124 are less than 1, in areas 125 to 127 they area greater than 1. We interpret this to mean that stocks of Tanner crab are more abundant off northern Vancouver Island than off southern Vancouver Island. The biomass estimates presented in Table 7 are multiplied by the W_{PFMA} by area (Table 8) to arrive at a final estimate of biomass. Biomass estimates for areas for which the distributional trap survey has been completed are presented in Table 9.

4.2 Sources of Mortality

4.2.1 Natural mortality

The natural mortality rate for this species is unknown. It is assumed to be high for juveniles and low for terminally molted adult crabs. Form our own observations and those of Pereyra (1968) we know that Tanner crab juveniles are an important prey item for several deep water fishes including shortspine and longspine thornyheads (*Sebastolobus alascanus*, *S. altivelis*), sablefish (*Anoplopoma fimbria*), and Dover sole (*Microstomus pacificus*). Estimated total life span for Alaskan Tanner crab (*C. bairdi*) is as high as 15 years (Somerton 1981), for snow crab (*C. oplio*) recent estimates are as high as 19 years (Comeau et al. 1998). It is generally accepted that longer life spans are indicative of lower natural mortality rates, and assuming that *C. tanneri* has a similar life span to either *C. opilio* or *C. bardi* would suggest a relatively low natural mortality rate, especially for larger terminally molted crabs.

4.2.2 Continental slope trawl fishery

The west coast of Vancouver Island is currently the focus of a deep- water trawl fishery for thornyhead rockfish (*Sebastolobus spp*.). Since about the mid 1980s an intense fishery for thornyheads has developed and has been steadily expanding northward along the west coast of Vancouver Island as new, trawlable grounds are discovered and local stocks are depleted. The fishery now extends from the US border in the south to Brooks Peninsula off the WCVI (Figure 13). In Table 10 we present the annual catch by PFMA and year for Tanner crabs. The by-catch of Tanner crab has steadily increased in areas 124 to 126 over the last 4 years accounting for over 126 metric tonnes in 1999. In Table 11 we present the count of bottom tows performed by year, the number deeper than 450 m, the number with Tanner crab and the number with Tanner crab deeper than 450 m.

The purpose of this table is to show that the percentage of deep-water tows with Tanner crab has increased in each of the last 4 years. This may be a function of better species identification and recording by observers, but the data suggest a shift in fishing pattern on the part of thornyhead fishermen to targeting longspine thornyheads which are found deeper than their congeners the shortspine thornyheads resulting in increased by-catch of Tanner crab. The table also shows an overall increase in effort in deepwater fisheries over the last 4 years (% of tows deeper than 450 m). The table shows the count of all tows with Tanner crab and the count of tows with Tanners deeper than 450 m. This gives us some indication of the proportion of the reported Tanner crab incidence that might be *C. bardi. Chionoecetes tanneri* does not occur shallower than 450m whereas *C. bairdi* is seldom found deeper.

4.2.3 Sablefish Trap Fishery

In Figure 14, we present a plot of the incidental catch of Tanner crabs from DFO directed Sablefish trap surveys. We have no current means of directly estimating by-catch of Tanner crab in the sablefish trap fishery.

4.3 Ecosystem Considerations

4.3.1 Trawl

The partial species list from the 1999 Tanner crab trawl survey is presented in Table 12. This table summarizes results from 34 bottom tows. The list is partial because there are still specimens that we have yet to identify. Several new species records for Canadian waters including *Sebastes malanostomus* (Blackgill rockfish), Anaplogastridae (Family:

Fangtooths), *Alepocephalus tenebrosus* (California slickhead) were recorded during this survey. The unidentified specimens include a large Barracudina, one new species of shrimp, and several unidentified invertebrates.

A list of species caught with Tanner crab in the groundfish trawl fishery is presented in Table 13. The criteria used to isolate the records in the database were the presence of Tanner crab in a tow and depth greater than 400 m. This table summarizes the catches from 6677 tows from all areas of the coast during all seasons. Many of the minor species recorded in this table are mid-water species and were likely caught during deployment or retrieval of the gear.

4.3.2 Trap

Species caught incidental to Tanner crab by DFO in trap gear used during the 1999 Tanner crab survey are presented in Table 14. In Table 15 the catch by species and area from the distributional trap survey is presented. The feature worth noting in this table is that the incidence of *Lithodes couisii* increased as the survey moved northward. In Table 16 the total by-catch by species for the structured trap survey is presented. The most common species encountered as by-catch was sablefish (*Anoplopoma fimbria).* From sablefish tagging studies it appears that these animals survive well when released from trap gear at the surface. In Table 17, we present the total by-catch by species for the experimental harvests conducted in PFMA 126. It is clear from this table that when fishermen target Tanner crab exclusively they can effectively exclude almost all by-catch.

Species specific catch information is not available from the Sablefish trap fishery, however in Table 18 we present a summary of species recorded from DFO Sablefish trap surveys.

5.0 Discussion:

This report endeavors to consolidate a great deal of information. The methods used to collect and analyze these data have been presented along with summaries of their results. In the course of the discussion we will try to identify some of the sources of uncertainty and identify the assumptions implicit in each part of the analysis. Finally we will discuss how we might move forward using the available information to initiate an experimental fishery to test some of the assumptions of our assessment methodology and refine our understanding of the population dynamics of Tanner crab.

5.1 Biomass Estimation

5.1.1 Trawl survey data

Assumptions implicit in using trawl data to estimate the abundance of Tanner crabs are:

1. The catch coefficient was assumed to be 1. This means that all crabs within the path of the net are captured and that no crabs escape under the footrope, around

the wing tips or outrun the net. This is the value used by other investigators using trawls to assess *Chionoecetes* crabs (Hebert et al. 1999; Biron et al. 1999; Dawe et al. 1997).

2. Crab distribution remains constant over the duration of the survey. The only reported directed movement for this species occurs in the early spring when males and females congregate by depth for breeding (Pereyra, 1966; Tester and Carey, 1986; Jamieson et al. 1990), therefore we assumed the distribution during the trawl survey did not change.

3. The vessel path at the surface represents the distance towed along the bottom. This is not strictly true. We have no means at present of globally referencing the true position of the net on the bottom, however we assume the net position relative to the vessel remains constant with the vessel proceeding in a more or less straight line. Sea conditions during the survey were calm and it is assumed that current effects on the vessel would be transferred to the net. Tow duration was set to ½ hr. and the tow distance later computed from the start and end position of each haul using a great circle equation optimized for the west coast of Canada. The start and end positions were recorded when the net touched down or lifted off the bottom. The use of GPS and charting software will improve the accuracy of the distance towed by logging the vessel position throughout the tow.

4. The wingtip spread or net geometry is constant within and between tows. The final assumption is that the net opening is unaffected by depth, current or vessel speed. It was possible on this cruise to directly measure the net opening. With the FS3300 net sonar the reported opening ranged from 12.1 to 15.1 m with an average of 13.65. The FS3300 actually measures the cross-section of the net at the point at which the transducer attaches to the headrope and will underestimate the net opening. The Simrad ITI reported wingtip spreads of 13.1 to 17 m with an average of 14.97 m. Because the ITI measures the wingtip spread instead of the net cross-section we chose the mean value of 14.97 m as the effective path width of our net when computing area-swept.

In an effort to assess the quality of our trawl data we looked for other sources of trawl data with which to compare our results. There were two other sources of data available for comparison, groundfish trawl by-catch data and, CPUE data from trawl surveys of Tanner crabs conducted by other researchers. The CPUE achieved during the 1999 Tanner crab trawl survey ranged from 0.0 to 130.22 kg/hr with a mean of 13.08 and standard deviation of 22.88 kg/hr. This corresponds to a density of crabs of 208.17 kg/km^2 with a standard deviation of 403.18 kg/km^2. CPUEs in the groundfish trawl fishery for the same area as that surveyed ranged from 0 to 112.8 kg per hour with a mean of 6.13 kg/hr and a standard deviation of 7.56 kg/hr. This corresponds to an average density of 142.36 kg/km^2 with a standard deviation of 276.31 kg/km^2. In a long term study of the deep water benthic fauna in the area of the Columbia River, Pereyra (1966) observed CPUEs for Tanner crab ranging from 18.6 kg /hr to 21.8 kg/hr. There are very few other published CPUE or density estimates for *C. tanneri*. The values obtained during the trawl survey are approximately twice those observed in the groundfish trawl fishery and are close to but less than the values observed by Pereyra off Oregon in the early 1960s. The discrepancy between our current catch rates and those from Oregon in the early sixties may reflect trawl impacts on the abundance of Tanner crabs in our study area, differences in the fishing power of the nets or changes in the absolute abundance between time periods.

Fishery independent trawl surveys will provide an unbiased means of estimating the absolute abundance of all age classes of Tanner crabs and provides the only means of assessing the abundance of juveniles. This type of information is unobtainable from commercial trap CPUE data due to the selectivity and tendency towards hyperstability of the commercial trap data.

5.1.2 Industry trap survey

As noted in the results, the fishermen were able to follow the survey protocol well and had a clear appreciation of the need for a standardized survey design. There were however a few problems with the data collected during the survey. There were some inconsistencies between observers, in several instances the observer failed to record the catch of, or collect biological samples from, juvenile crabs. Most often the recorded total catch weights per string were estimates arrived at by multiplying the number of crabs caught by 1.7 lb./crab. This was due to difficulties in weighing the crab with the scales provided. There appear to be inconstancies between observers with respect to shell condition codes assigned, which is a matter of experience and should become less of a problem as observers gain experience. During harvest sets the by-catch of some species was not recorded (Snails). The most troublesome of these problems is the misreporting of juveniles in the catch. Observation of their abundance and distribution may be applicable in evaluating recruitment for this species. Better communication and additional training and equipment should rectify these problems.

The computation of trap weighting factors (W_{PFMA}) involves several assumptions. The first is that there is a linear relationship between CPUE and biomass. This is difficult to evaluate without a time series of data, however, Hebert et al. (1999), show a good relationship between trap catch rates and biomass estimates for Snow crab. Thus we will accept this assumption for the time being. The second assumption is that the catchability of Tanner crab remains constant for the duration of the survey. We suspect this is not entirely true because as the survey progressed the depth segregation by sex broke down due to the formation of breeding aggregations. Additionally, fishermen (Marcus Griffin, Paul Edwards, Pers. Comm.) have reported that the CPUE for this species increases through the fall and winter (September to March). This may be attributable to hardened molted crabs recruiting to the fishable stock and migration to a common depth for the purposes of breeding. The third assumption in computing weighting factors is that there are no fishing effects due to experience. We found no clear pattern of differences between vessels consequently we will assume all fishermen performed equally well during the survey. Given the above and the relatively short time frame over which the

WCVI survey was completed, we will treat the trap CPUE data as though it is representative of the abundance of Tanner crabs.

In our analysis, CPUE is a relative measure of abundance between areas. Two of the most experienced fishermen, Marcus Griffin and Paul Edwards have both expressed concerns over using CPUE without looking at between vessel effects due to the knowledge required to fish for Tanner crabs. They observed the following:

- Some of the vessels were not adequately equipped to fish the gear under the weather conditions encountered (seas 3-4 meters, winds to 35 knots).

- Some vessels set in the wrong direction with respect to current and wind and may have had their gear pile up on the bottom, thereby reducing estimates of CPUE.

- Crabs appear to favor certain bottom configurations/substrates and may form local concentrations. The inability to target these concentrations may affect CPUE by introducing more variability into the analysis.

While the authors note the observations, these between vessel effects were not apparent in the survey data. All participating vessels had similar mean CPUEs and variances when fishing in the same areas.

The survey work off the WCQCI was conducted almost two months after the work off the WCVI. The catch rates were lower and the depth distribution markedly different from the WCVI. This may reflect real differences in abundance and distribution however, we suspect these results indicate seasonal agglomerative behavior for the purposes of spawning. Furthermore we suspect this reduces the comparability of these results with those from the WCVI, consequently no attempt was made to calculate weighting factors for the WCQCI without further survey information.

The incidence of the Angle Tanner (*Chionoecetes angulatus*) was extremely low in this survey. The original assumption (Phillips and Lauzier 1997) that this species would comprise a portion of the Tanner landings does not appear to be accurate. There is marked segregation by depth, with Angle Tanner only rarely encountered at the deepest survey depths. Catch trends for the Scarlet King crab (*Lithodes couisi*) indicate that this species may pose a significant by-catch problem in the Tanner trap fishery in the central and northern areas of the coast. *Lithodes couisi* is currently an unlicensed species for which little is known of its life history, biology, distribution or seasonal abundance. There appears to be a high market value for this species which may be an incentive to include them in the harvest of Tanner crabs, however we have at present no basis to manage this species. Because King crabs are normally associated with harder bottom types and tanner crabs with softer bottom types, their increased abundance in northern areas may reflect a lack of preferred habitat for *Chionoecetes tanneri* in these areas. This may affect our estimates of *Chionoecetes tanneri* abundance and harvest potential.

During the survey, some fishing gear was lost due to conflicts with trawlers and commercial shipping. Commercial shipping can detach the buoys marking either end of a string of gear making the gear difficult or impossible to find. Trawlers can likewise remove the floats from a string of gear but may also drag their nets across the gear detaching traps from the groundline, destroying individual traps, or moving the entire string of gear to a different location. During the survey several traps were lost due to detachment from the groundline, several more were destroyed by trawl gear, and one entire string was unaccountably lost. Because a commercial fishery for Tanner crabs would be a deep-water fishery conducted well offshore it may be difficult to initiate unless the above noted conflicts can be resolved.

5.1.3 Biomass estimation analysis

The mean stratified methods employed herein are standard. Other methods of estimating abundance include VPA, catch age analysis, and surplus production modeling: these all require a time series of catch/biomass and biological data, which we lack. Additional methods include mark/recapture and depletion analysis. Both these approaches have the benefit of yielding results in a relatively short time frame. Two major complications in conducting tagging studies are that tagging mortality and tag shedding both would need to be assessed prior to the inception of a large-scale tagging program. Tagging studies on snow crab conducted on Canada's East Coast have been quite successful. These studies have shown that tags can be retained through at least one molt as long as the tag is anchored in the suture line. This technique may be applicable for Tanner crabs. The more likely problem for Tanner crabs is tagging mortality. Tanner crabs live at much greater depths than snow crab and are susceptible to both temperature and salinity stress. Small scale tagging and holding studies would need to be conducted to assess post-tagging survival. Depletion estimation is a useful tool for estimating the absolute abundance of a population. The first step is to remove enough of the population to induce a detectable decrease in CPUE. Then, assuming the population is closed and assuming the relationship between biomass and CPUE is known or can be determined from the data, biomass is estimated by regressing CPUE on catch. Where CPUE reaches zero and crosses the catch axis is the estimate of the total population size. Depletion studies have the advantage of being simple in design, execution and analysis and are generally accepted by fishermen.

One alternative method of using trawl catch data to estimate biomass is to use an interpolating algorithm. Biomass is estimated for snow crab in the southern Gulf of St. Lawrence and on the Eastern Scotian Shelf using a kriging algorithm (Hebert et al. 1999; Biron et al. 1999) to interpolate a spatial estimate of biomass from trawl survey data. The same approach has been applied to estimating the abundance of Red King crab in Bistol Bay (Vining and Watson, 1996). Boutillier (1999) uses a bicubic spline algorithm to interpolate an estimate of pink shrimp abundance in British Columbia. Interpolators perform best when they have a large uniform series of data points from which to interpolate, which was not available from the DFO survey. Consequently, a mean stratified estimation approach was adopted.

Separate biomass estimates were computed for the Tanner crab population as a whole inclusive of females and juveniles and for only Male tanner crab larger than 112 mm. This was done because we feel the size at 50 % maturity would serve as a meaningful minimum size limit and that any future fishery should only be directed at male crabs. The biomass of male tanner crabs accounts for approximately 38 % of the total biomass. The 95 % confidence intervals computed for the whole population was 55 % to 180 % of the point estimate. The 95 % confidence interval for the estimate of large males was 70 % to 142 % of the point estimate. The coefficients of variation (CV) of the biomass estimates for the whole population ranged from 0.29 to 0.36 and for large males from 0.17 to 0.22. Because of the relatively low variance in the data and narrow confidence intervals produced by bootstrapping it was decided to use the stratified mean estimator until such time as an alternative is available.

5.2 Sources of Fishing Mortality

At the time of the Phase 0 document (Phillips and Lauzier 1997) it was thought that the impact of other fisheries on *Chionoecetes tanneri* stocks was minimal and that the stocks were at or near virgin biomass. Recent analysis of data from the deep-water slope rockfish fishery has shown this not to be the case over most of the WCVI.

5.2.1 Commercial groundfish trawl fishery

This trawl fishery poses a major threat to the development of a new Tanner crab trap fishery since by-catch in the trawl fishery in some areas is equal to the total estimated harvestable biomass of Tanner crab. Tanner crabs are present year-round at the depths trawled and are reported from as much as 72 % (Table 10, 1999) of groundfish trawls conducted at depths greater than 450 m. The incidence of Tanner crab increases when effort in an area shifts from fishing shortspine thornyhead, to the deeper longspine thornyhead. Reported by-catch may underestimate the total mortality of Tanner crab in the trawl fishery for the following reasons:

- Catch may not be reported by all observers or may not be present in the random sample used to determine species composition.

- Larger mesh size and extended tow length may cause extrusion of dismembered and juvenile crabs through the mesh in the codend.

It is the practice of the slope trawl fishery, when entering a new area or returning to an area not fished for a period of time, to make a series of tows at the same location. Trawl fisherman have noted (Brian Mose, Pers. Comm.) that initially by-catch of Tanner crabs is high but declines rapidly with repetitive trawling while the thornyhead catches remain relatively constant. Based on personal observations during the DFO trawl survey, discard mortality for Tanner crab in the trawl fishery must be assumed to be 100 %. A directed trap fishery for Tanner crab would target large male crabs the while the deep-water trawl fishery impacts all sizes and both sexes. Size composition data collected during the DFO Tanner crab trawl survey (Figs. 4 and 5) show that only 2.8 % (by number) of the crabs caught by trawl are males over 112 mm. It is difficult to assess what the long term impacts of trawling might be on the population as a whole. One might speculate however that recruitment failure would be detected after several years of trawl fishing if the entire juvenile population is available to trawl gear. Collection of a time series of biological samples and comparisons between trawled and untrawled areas may answer this question.

5.2.2 Sablefish trap fishery

By-catch of Tanner crabs, and other crab species, is reported from all areas of the outer coast. Crabs are discarded but the degree of discard mortality associated with this fishery is uncertain although assumed to be 100% by some managers (Boutillier et al. 1998). As discussed in section 5.1.3, crabs brought up from depth (>500 m) and discarded at the surface would be subject to both temperature and salinity stress, if prolonged this alone is sufficient to induce mortality. Additional stresses associated with release at the surface include displacement due to drift, especially if they do not sink because of air trapped under the carapace and predation either on the way down or when reaching the bottom in a disoriented condition. Because the incidence of Tanner crab by-catch in the Sablefish trap fishery has not been quantified, this is an unknown source of mortality.

5.3 Ecosystem Considerations

Clearly from the species catch data trawls are a very non-selective means of harvesting animals from the deep continental slope region. The DFO trawl survey encountered over 140 species of fish and invertebrates, whereas the groundfish trawl fishery database reports over 230 species caught with Tanner crab from tows deeper than 450 m. Several of the species reportedly caught in the groundfish trawl fishery are pelagic organisms and would likely have been caught during deployment or retrieval of the net. Several of the species identified are unlikely to have been caught from the depths reported meaning the species identification may be suspect in some cases. Research Tanner crab trap sets captured 16 species while the industry trap survey reported only nine. Sablefish trap survey data reports 24 species (including Tanner crab) as being caught with sablefish. Most of the by-catch from the distributional Tanner crab trap survey was sablefish, which have a high rate of survival when released at the surface. This cannot be said of many animals released after capture by trawls. Trawling represents a major disruption to slope ecosystems due to the wide range of organisms affected and longer regeneration times due to low water temperatures and overall low productivity of the environment at those depths.

The role of Tanner crabs in the deep slope ecosystem is not well understood, however, their anatomy suggests they are equipped to dismember large pieces of food that sink to the bottom, and are capable of travelling over comparatively large distances to do so. They also undoubtedly feed on benthic and interstitial organisms and themselves provide a food source for a number of species. Of a sample of 20 shortspine thornyhead (*Sebastolobus alascanus*) examined for stomach contents during the DFO tanner crab trawl survey, 14 were full of Tanner crab juveniles exclusively, 4 were empty and 1 contained the remains of a small fish. The crabs from the stomachs were identifiable to sex and some could be measured, as their shells were intact. The size of crabs found in stomachs broke into two groups: 20-30 mm and 70 – 100mm; those from 70-100mm were soft while the 20-30 mm size were hardshell. Stomach content of other fish species were not examined, although Pereyra (1966) records the smallest size range of crabs from fish stomachs, notably Dover sole (*Microstomus pacificus*) and sablefish (*Anaplopoma fimbria*).

5.4 Experimental Harvest

One of the main questions to be addressed by this document is where do we go from here. Currently we have approximately 40 % of the distributional trap survey completed, a group of trained observers, and willing participants. The view of the WCSA and interested fishermen is that they would also like to continue with the survey given the proviso that there will be some opportunity to harvest sufficient quantities of Tanner crab to pay for the work. In an effort to address this question a simple depletion experiment was designed wherein a harvest of 100 metric tonnes of male Tanner crabs larger than 112 mm would be authorized in PFMA 125. This will allow us to test our assessment methodology and investigate population responses to harvesting. From Table 9 it can be seen that the experimental quota exceeds the estimated biomass of large male Tanner crabs for area 125 (89 Tonnes) by some 11 tonnes. Should the proponents be able to harvest this quantity of crab in a single short season it would indicate we have an underestimation bias in our assessment methodology. If the proponents are unable to harvest this quantity of crab the assessment technique would be validated and confirm that the resource is very limited. If there are detectable declines in CPUE over the course of the experimental harvest it should be possible to compute an independent estimate of biomass using a depletion estimator. By collecting detailed biological data, population responses to harvest will be studied. The proposed time frame for this experiment is three years. Results will be reviewed annually to determine whether the DFO should permit further harvests or terminate the experiment. Additional studies in other areas may be considered in the second and third years of the study.

Data collected to date indicates that Tanner crabs are widely distributed along the British Columbia coast, the area being considered for this experiment only accounts for 6.9 % of the total estimated Tanner crab habitat coastwide. Given the limited area, in which the experiment is being conducted, this approach is deemed precautionary in that it puts only a small proportion of the total population at risk of overfishing.

This approach has several advantages over others in that it should yield useful results in a relatively short timeframe, it is logistically simple for Tanner crab fishermen, fisheries managers and enforcement personnel to implement and gear conflicts should be minimized. Gear conflicts may be minimized because the areas indicated as promising Tanner crab fishing locations by the proponents are generally untrawlable and inshore from the commercial shipping lanes.

As we have no biological basis on which to set an appropriate scale for this experiment, a single PFMA was chosen for purely logistical reasons. PFMAs are recognisable to fishermen, managers and enforcement personnel and this may assist in management of the experiment. The determination of a biologically appropriate spatial scale will require further study of the stock unit composition for this species. The question of spatial scale is important because the consequence of assessing or managing a species at too large a spatial scale is serial depletion as distinct stocks are extirpated sequentially as the fishery proceeds. This was the case for Pinto abalone on the Pacific coast in which literally dozens or hundreds of distinct stocks were fished out sequentially under a coast wide quota. The consequence of choosing too small a spatial scale is increased assessment and management costs due to the need to assess and manage many stocks individually. To address this question we must continue the coastwide distributional trap survey. The survey permits the collection of detailed biological data and samples from all areas of the coast, which can then be compared to investigate stock structure.

One of the questions to be addressed by collecting detailed biological data is whether this species displays compensatory growth or recruitment when fished. This is an important question to address when determining species suitability for exploitation. If the species displays strong compensatory growth or recruitment, it may indicate the species is less susceptible to recruitment or growth over-fishing. Desirable responses would include increased growth due to decreased intraspecific competition for food or increased recruitment due to reduced competition for habitat or reduced cannibalism by adults on juveniles. A less desirable response from a fisherman's perspective but equally valuable biologically would be earlier maturation at a smaller size resulting in a biologically productive stock with a smaller average size. Undesirable outcomes would include no compensatory response to harvest or a depensatory response, or allee effect, wherein the effect of reducing the density of animals reduces their ability to reproduce or recruit. For example, red sea urchins show reduced fertilization due to reduced spawner density and reduced recruitment due to increased predation on juveniles when the spine canopy of adults is removed by harvest. Female crabs in general, including *C. bardi* and *C. opilio*, have the ability to store sperm over a period of several years and fertilize a number of egg clutches from a single mating; this may be a response to natural fluctuations in the abundance of males. Consequently a fishery targeting males is likely more sustainable than one targeting the entire population. However, egg clutches fertilized with stored sperm have a lower viability and produce fewer larvae than those fertilized with fresh sperm. The presence of barren females or females with smaller egg clutches, possibly from using stored sperm, may indicate a paucity of males and may be useful as an indicator of stock condition.

At present, only the WCVI structured trap survey is complete. Preliminary indications from the WCQCI show lower CPUE than off Vancouver Island and very little is known of the abundance of Tanner crab in the Queen Charlotte Sound area. The proposed experimental quota may seem low when compared with the reported harvest of 400 tonnes during the 1987-89 experimental fishery. However, the intention of this experiment is to refine our assessment methods and answer some basic questions about the population dynamics and biology of this species while the distributional trap survey is completed, not to initiate commercial harvest. This is because based on our current understanding of the resource it appears very small. In fact, using our current biomass estimates and conservative 10 to 20 % exploitation rates it appears that for all PFMA in which the commercial groundfish trawl fishery operates the total estimated harvest of Tanner crabs is already taken by that fleet. Consequently any development of a targeted commercial fishery is dependant on refining our estimates of abundance, determining the impact of trawling operations on Tanner crab population and assessing population responses to harvest.

6.0 Recommendations

6.1 It is recommended that the current assessment approach, with conservative experimental harvests being used to refine and calibrate methods, be continued. Alternative approaches may be developed as a time series of catch and biological data accumulates.

6.1.1 To test the assessment methods, validate the biomass estimates and evaluate population responses to harvest we recommend an experimental quota of 100 metric tonnes of male Tanner crab larger than 112 mm be harvested from PFMA 125. Until stock status is better understood all other areas of the BC coast should remain closed to directed fishing for Tanner crabs.

6.2 It is recommend that fishery-independent trawl surveys be used to assess *Chionoecetes tanne*ri crab stocks.

6.2.1 To accomplish this, three index areas will be established and surveyed by trawl on a three-year rotation. The current index area (Central Vancouver Island) will remain, and at least two others will be added. One off south-west Vancouver Island to monitor the impacts of trawling on deep-water ecosystems and Tanner crab stocks and the other to be determined at a later date.

6.2.2 Results from the DFO trawl survey indicate that *Chionoecetes tanneri* is distributed below the depths currently surveyed, consequently, the depth of the trawl survey must be extended.

6.3 It is recommended that the trap survey be completed.

6.3.1 It is recommended that a precautionary harvest as discussed above (Rec. 6.1.1) be allowed to offset costs of the continued survey.

6.3.2 It is recommended that observer coverage be continued throughout the development phase of the fishery. Solutions to problems encountered in data collection may include having observers directly accountable to DFO, allowing more time for training and including the vessel skippers in some sections of the training. Trained observers will become a valuable and necessary part of future surveys and harvest.

6.3.3 It is recommended that single heavy traps (large King crab traps) be used to survey areas that cannot be fished effectively using the survey trap strings.

6.3.3.1 It is recommended that single trap gear above be calibrated to the survey string gear to enable biomass estimates over all areas of the coast.

6.4 It is recommended that further expansion of the continental slope trawl fishery be curtailed until the social and economic losses that occur as a result of this type of exploitation are critically examined.

6.4.1 It is recommended that by-catch caps for Tanner crab be developed for the trawl fishery to allow the establishment of a selective fishery for Tanner crabs.

6.4.2 It is recommended that an alternative means of selective harvest of slope rockfish such as trapping or off-bottom trawling be investigated.

6.5 It is recommended that the by-catch of Tanner crab in the sablefish trap fishery be quantified. Without knowledge of the incidental removals by this fishery, it will be impossible to ascertain total harvest of Tanner crabs. In conjunction with estimating incidence of capture, it will be necessary also to estimate mortality with respect to discards.

6.6 It is recommended that species harvested from the continental slope be managed on an ecosystem basis rather than on arbitrary assemblage basis or a fishery by fishery basis. Consideration should be given to the impact of various gear types on the continental slope habitat.

6.7 It is recommended that Limit Reference Points (LRPs) and Target reference points be (TRPs) be developed for this species.

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Table 1: Data from the DFO Tanner crab trawl survey, July 21 to August 3, 1999. These data were used to compute the estimated biomass of Tanner crabs.

Set	Strata	Distance m	Area Swept Km^2	Total Catch Kg	Density Kg/ Km^2	Catch Males > 112 m Kg	Density Males > 112 mm Kg/ Km^2
1	1	1219.67	0.018258	0.90	49.29	0.90	49.29
2	2	3129.298	0.046846	7.40	157.97	6.22	132.69
3	3	3101.421	0.046428	1.30	28.00	0.66	14.28
4	4	3053.764	0.045715	106.35	2326.38	17.02	372.22
5	5	3112.95	0.046601	14.70	315.44	10.44	223.97
6	5	3197.402	0.047865	16.60	346.81	4.81	100.57
7	5	2929.803	0.043859	5.10	116.28	3.37	76.75
8	4	3530.409	0.05285	6.61	125.07	2.91	55.03
9	3	3113.193	0.046604	8.90	190.97	3.92	84.03
10	2	3792.992	0.056781	15.90	280.02	15.74	277.22
11	1	3628.323	0.054316	0.00	0.00	0.00	0.00
12	1	4032.469	0.060366	1.00	16.57	1.00	16.57
13	1	3845.697	0.05757	0.90	15.63	0.90	15.63
14	2	3772.706	0.056477	7.80	138.11	4.29	75.96
15	4	3756.338	0.056232	21.00	373.45	5.67	100.83
17	2	3865.678	0.057869	0.00	0.00	0.00	0.00
18	3	3717.763	0.055655	8.76	157.45	4.56	81.88
19	4	1367.279	0.020468	2.11	103.09	1.50	73.19
20	3	1987.503	0.029753	18.90	635.23	4.73	158.81
21	2	2440.802	0.036539	6.20	169.68	5.33	145.93
22	5	3662.097	0.054822	0.00	0.00	0.00	0.00
24	2	5224.092	0.078205	3.20	40.92	3.20	40.92
25	1	3785.243	0.056665	2.20	38.82	2.20	38.82
26	3	2785.412	0.041698	0.00	0.00	0.00	0.00
27	1	3488.781	0.052227	1.50	28.72	1.50	28.72
28	1	2966.437	0.044408	1.00	22.52	1.00	22.52
29	2	3383.964	0.050658	5.30	104.70	5.30	104.70
30	3	3385.679	0.050684	11.00	217.03	9.02	177.97
31	4	2707.127	0.040526	11.64	287.23	1.40	34.47

Table 2: Mean, Minimum and Maximum Catch Per Unit Effort Kg/hr (CPUE) for all sizes of crabs and for male crabs larger than 112 mm only, caught during the 1999 Tanner crab trawl survey. Mean, Minimum and Maximum Densities in Kg/Km^2 from the catch data in Table 1.

		CPUE Kg/hr		
	Strata	Mean	Min	Max
All Sizes	1	1.95	0.00	3.37
	2	9.83	0.00	22.19
	3	14.07	0.00	42.00
	4	37.84	4.69	130.22
	5	11.02	0.00	22.64
Across	strata	13.71	0.00	130.22
Males Over 112 mm	1	1.95	0.00	3.37
	2	8.57	0.00	21.96
	3	6.10	0.00	13.53
	4	7.58	1.90	20.84
	5	6.01	0.00	14.56
Across	strata	5.94	0.00	21.96
		Density Kg/Km2		
	Strata	Mean	Min	Max
All Sizes	1	24.51	0.00	449.29
	2	127.34	0.00	280.02
	3	204.78	0.00	635.23
	4	643.04	103.09	2326.38
	5	171.20	0.00	346.81
Across	strata	212.10	0.00	2326.38
Males Over 112 mm	1	24.51	0	49.29
	2	111.06	0	277.22
	3	86.16	0	177.97
	4	127.15	34.47	372.22
	5	93.58	0	223.97
Across	strata	85.65	0	372.22

Table 3: Mean number, standard deviation (STD) and maximum number of male and female Tanner crab per trap by stratum across areas from the distributional trap survey. The minima are not included as they are all zero.

Stratum	Mean Number of Males	STD of Number of Males	Max of Number of Males	Mean Number of Female	STD of Number of Female	Max of Number of Females
1	1.00	3.54	38	0.05	0.51	10
2	1.96	3.59	35	0.07	0.62	11
3	3.23	4.88	37	0.20	0.90	14
4	2.39	3.93	25	0.49	1.30	10
5	1.78	6.29	177	0.69	3.10	41

Table 4: Mean number, standard deviation (STD) and maximum number of male and female Tanner crab per trap by PFMA across Strata for the distributional trap survey. The minima are not included in the table as they are all zero.

PFMA	Mean Number of Males	STD of Number of Males	Max of Number of Males	Mean Number of Female	STD of Number of Female	Max of Number of Females
102	0.40	0.98	6	0.08	0.33	3
123	0.85	1.73	14	0.12	0.44	4
124	2.08	3.66	27	0.74	3.00	41
125	2.45	6.33	177	0.48	1.61	24
126	3.31	5.23	37	0.13	0.67	8
127	2.90	5.22	38	0.11	0.59	7
142	0.94	1.70	11	0.01	0.09	1

Table 5: Mean number, standard deviation (STD) and maximum number of male and female Tanner crab per trap by Vessel and Captain for the harvest undertaken in PFMA 126. The minima are not included in the table as they are all zero.

Vessel/ Captain	Mean Number	STD of Number of Males	Max of Number of Males	Mean Number of Female	STD of Number of Female	Max of Number of Females
1	12.28	11.60	50	0.34	1.81	26
2	14.22	13.57	71	1.18	3.28	29
3	6.84	8.54	63	0.37	0.92	5
4	15.24	10.85	51	7.42	9.80	62

Table 6: Habitat estimates for Tanner crab by Pacific Fisheries Management Area (PFMA) for the coast of BC. This only includes areas that are part of the continental slope between 400 and 1200 m. Habitat area is expressed in km^2.

	Strata (Depth range in m)					
	1	2	3	4	5	
PFMA	400-560	560-720	720-880	880-1040	1040-1200	Total by Area
101	160	121	106	192	439	1018
102	76	69	49	30	4	229
123*	194	194	160	213	216	978
124	276	327	234	319	336	1491
125	123	144	155	217	179	819
126	199	371	233	199	140	1142
127	151	178	181	305	362	1178
130*	486	476	417	417	349	2145
142	431	565	462	490	731	2679
Total by Strata	2096	2445	1997	2383	2757	11678

*Areas 123 and 130 are consolidations of one large area with smaller adjacent areas. Area 123 includes 3 km^2 of habitat from area 121. Area 130 includes 336, 14, and 1 km^2 of habitat from areas 108, 110 and 111.

Table 7: Biomass estimates in metric tonnes for Pacific Fisheries Management Areas (PFMA) of the west coast of Canada. Separate estimates have been produced for the entire population of crabs and for males over 112 mm. The SE is the standard error of the estimate the 95% confidence interval was generated using bootstrapping.

All sizes of Tanner crabs			95% Confidence Interval	
PFMA	Biomass	SE	Lower	Upper
123	241	80	129	456
124	367	120	199	689
125	227	81	114	442
126	255	76	146	468
127	330	115	172	637
101	250	77	136	450
142	634	189	361	1157
102	41	12	23	73
130	494	158	272	928
Total	2839		1552	5300

Male Tanner over 112 mm			95% Confidence Interval	
PFMA	Biomass	SE	Lower	Upper
123	89	16	64	126
124	138	25	98	194
125	78	15	55	114
126	106	18	77	148
127	114	23	76	167
101	95	21	60	141
142	249	44	174	351
102	18	3	13	24
130	189	32	137	263
Total	1075		754	1528

Table 8: Trap weighting factors calculated using trap catch rate data collected during the distributional trap survey off the WCVI. The weighting factors are calculated from the mean catch of male Tanner crabs larger than 112 mm per trap by PFMA relative to the catch rate in the reference area.

Reference Area catch rate			1.636
PFMA	Mean N/trap	STD	Scaling factor
123	0.779	1.223	0.476
124	1.509	2.596	0.922
125	1.912	2.179	1.169
126	3.291	3.618	2.012
127	2.871	3.475	1.755

Table 9: Biomass estimates for all sizes of Tanner crabs and male Tanners over 112 mm by PFMA in metric tonnes. Confidence intervals are presented for male Tanner crabs over 112 mm. The weighting factors are from Table 8. The scaled biomass estimate is in metric tonnes of male Tanner crab larger 112 mm in carapace width.

PFMA	All sizes	Males over 112 mm	95% Confidence Interval		Weighting factor	Scaled Biomass estimate
			Lower	Upper		
123	241	89	64	126	0.48	43
124	367	138	98	194	0.92	127
125	227	78	55	114	1.17	89
126	255	106	77	148	2.01	213
127	330	114	76	167	1.76	200
101	250	95	60	141	-	N/A
142	634	249	174	351	-	N/A
102	41	18	13	24	-	N/A
130	494	189	137	263	-	N/A
Total	2839	1075	754	1528		

Table 10: By-catch of Tanner crab in the Canadian groundfish trawl fishery. Catches are in kilograms summed by area and year.

	Year				PFMA
PFMA	1996	1997	1998	1999	Total
0	10.4				10
6				0.5	0
101			28.1	34.0	62
102	0.9	2.3	3.6	2.7	15
104		132.0	6.4		138
105	0.5	15.0		0.5	16
106		34.9			35
107	0.5	0.5		3.6	5
108	2.3				2
109	1.4	2.3		0.5	4
110		6.8			7
111	4.5		4.5	0.5	10
121		3.6			4
123	593.8	4357.7	5197.8	2374.6	12677
124	18497.8	16656.6	27112.1	32646.9	95782
125	6707.8	5505.8	25534.9	35326.3	74207
126	3656.5	19317.9	13446.5	55692.9	94093
127	3.6	13.6	18.1	117.0	152
130	96.2	188.7	494.0	1.8	785
142		136.1	136.1	184.2	579
Annual Total	29576	46374	71982	126386	278585

Table 11: The total number of groundfish tows, the number of tows deeper than 450 m, the number of tows containing Tanner crab and the number of tows with Tanner crab from depths greater than 450 m by year. The last two columns are the proportion or percentage of groundfish tows that occurred at depths greater than 450 m (relative to all tows) and the percentage of tows with Tanner crab from depths greater than 450 m (relative to all tows at depths greater than 450 m) by year.

Year	GF Tows Total	Tows deeper than 450 m	Tows with Tanner crab	Tows with Tanner crab deeper than 450 m	Percentage of tows deeper than 450 m	Percentage of Tows with Tanner crab deeper than 450 m
1996	25774	2879	1074	1042	0.11	0.36
1997	17378	2460	1565	1525	0.14	0.62
1998	18493	2934	1837	1800	0.16	0.61
1999	18709	2943	2201	2132	0.16	0.72

Table 12: Total catch by species by trawl gear during the 1999 Tanner crab trawl survey off the west coast of Vancouver Island. Species have been keyed to the lowest taxonomic level possible. Total catch weight is in kilograms. The species code is a three character alphanumeric used by Fisheries and Oceans Canada, Pacific region, science branch to identify each species.

Species Code	***Latin Name***	**Common name**	**Total Catch**
455	*Anoplopoma fimbria*	Sablefish	2,871.64
453	*Sebastolobus altivelis*	Longspine thornyhead	1,550.55
626	*Microstomus pacificus*	Dover sole	940.30
451	*Sebastolobus alascanus*	Shortspine thornyhead	820.24
256	*Albatrossia pectoralis*	Pectoral rattail	592.44
254	*Coryphaenoides filifer*	Filamented rattail	439.39
251	*Coryphaenoides acrolepis*	Roughscale rattail	425.98
ZAG	*Chionoecetes tanneri*	**Grooved Tanner crab**	313.48
394	*Sebastes aleutianus*	Rougheye rockfish	220.60
220	*Antimora microlepis*	Pacific flatnose	184.59
452	Sebastolobus Spp	Thornyheads	155.30
059	*Raja rhina*	Longnose skate	109.50
602	*Atheresthes stomias*	Arrowtooth flounder	104.20
3L0	Actiniaria (Order)	Anemones	101.15
243	*Lycodes diapterus*	Black eelpout	93.11
038	*Apristurus brunneus*	Brown cat shark	86.36
385	Icosteidae(Family)	Ragfishes	84.10
95E	*Berryteuthis magister*	Red squid (Schoolmaster gonate squid)	75.74
235	*Bothrocara brunneum*	Twoline eelpout	73.22
403	*Sebastes borealis*	Shortraker rockfish	65.10
TAC	*Pasiphaea pacifica*	Glass shrimp	59.15
198	*Stenobrachius leucopsarus*	Northern lampfish	49.61
225	*Merluccius productus*	Pacific hake	42.64
605	*Embassichthys bathybius*	Deepsea sole	36.17
U30	*Bathyraja trachura*	Black skate	34.90
U08	Opisthoteuthidae (Family)	Flapjack devilfish	33.72
017	*Eptatretus deani*	Black hagfish	33.03
5AB	Ophiuridae (Family)	Brittle stars	26.13
3G0	Scyphozoa (Class)	Jellyfish	24.26
642	Alepocephalidae (Family)	Slickheads	24.20
4GA	Asteroidea(Class)	Starfish	22.19
153	*Bathylagus milleri*	Stout blacksmelt	19.82
610	*Errex zachirus*	Rex sole	19.70
U01	*Solaster endeca*	Northern sunstar	19.07
643	*Talismania bifurcata*	Threadfin slickhead	18.22
849	Unidentified matter	Unidentified matter	17.45
239	*Lycodapus fierasfer*	Blackmouth slipskin	17.03
171	*Chauliodus macouni*	Pacific viperfish	16.59

Table 12: continued

Species Code	*Latin Name*	Common name	Total Catch
U05	*Allocentrotus fragilis*	Fragile urchin	9.78
10A	Gastropoda (Class)	Snails	9.54
233	*Lycodes cortezianus*	Bigfin eelpout	7.60
677	*Lycenchelys crotalina*	Snakehead eelpout	7.50
427	*Sebastes malostomus*	Blackgill rockfish	6.30
574	*Careproctus melanurus*	Blacktail snailfish	5.11
U09	*Psychrolutes phrictus*	Blob sculpin	4.70
SQH	*Eualus macrophthalmus*	Large eyed eualid	4.40
ZAE	*Chionoecetes angulatus*	**Angle Tanner**	3.50
6KA	*Briasaster latifrons*	Heart urchins	2.84
167	*Tactostoma macropus*	Longfin dragonfish	2.73
066	*Hydrolagus colliei*	Spotted ratfish	2.40
91A	Cephalopoda (Class)	Unidentified squid/octopus	2.33
400	*Sebastes aurora*	Aurora rockfish	2.00
396	*Sebastes alutus*	Pacific ocean perch	1.90
058	*Bathyraja interrupta*	Sandpaper skate	1.40
6NA	Holothuroidea (Class)	Sea cucumbers	1.24
99A	Benthoctopus Spp.		1.20
248	*Derepodichthys alepidotus*	Cuskpout	1.17
237	*Bothrocara remigerum*	Longsnout eelpout	1.00
SQE	*Eualus biunguis*	Deepsea eualid	1.00
020	*Lampetra tridentata*	Pacific lamprey	0.86
6AB	Echinacea (Super order)	Sea urchins	0.82
U04	*Sinalyctese challengeri (Scotoplanes)*	Deep sea cucumber	0.80
U02	*Thrissacanthus pencillatus*	Mud star	0.70
044	*Squalus acanthias*	Spiny dogfish	0.70
015	Unknown fish	Unknown fish	0.68
018	*Eptatretus stouti*	Pacific hagfish	0.60
173	*Sagamichthys abei*	Shining tubeshoulder	0.60
99D	*Benthoctopus robustus*		0.50
VMD	*Lithodes couesi*	Couesi king crab	0.50
92A	*Teuthoidea*	Squid	0.35
U24	*Abraliopsis felis*		0.30
SQA	Eualus Spp.	Eaulids	0.30
51A	Nudibranchia (Order)	Seaslugs	0.30
SEE	*Pandalopsis dispar*	Sidestripe shrimp	0.30
U21	*Molpadia intermedia*	Deep sea cucumber	0.30
557	*Bathyagonus nigripinnis*	Blackfin poacher	0.28
0AE	*Aphrodita*	Sea mouse	0.28
202	*Tarletonbeania crenularis*	Blue lanternfish	0.26
184	*Scopelosaurus harryi*	Scaly waryfish	0.25
177	*Anotopterus pharao*	Daggertooth	0.20
U27	*Abraliopsis felis*		0.20
264	*Poromitra crassiceps*	Crested ridgehead	0.20
546	Agonidae (Family)	Poachers	0.20

Table 12: continued

Species Code	*Latin Name*	Common name	Total Catch
U15	*Benthoctopus leioderma*		0.20
KAA	Isopoda (Order)	Isopods	0.15
087	Nemichthyidae (Family)	Snipe eels	0.12
185	Myctophidae (Family)	Lanternfishes	0.11
179	*Benthalbella dentata*	Northern pearleye	0.10
4JF	*Hippasteria spinosa*		0.10
168	Malacosteidae (Family)	Loosejaws	0.10
218	*Oneirodes bulbosus*	Bulbous dreamer	0.10
TPD	*Sergestes similis*	Pacific sergestid	0.06
151	*Nanensia candida*	Bluethroat argentine	0.04
189	*Diaphus theta*	California headlightfish	0.04
VCH	*Pagurus splendescens*		Trace
155	*Bathylagus pacificus*	Slender blacksmelt	Trace
163	*Argyropelecus sladeni*	Low crest hatchetfish	Trace
213	Oneirodidae (Family)	Dreamers	Trace
0AB	Polychaeta (Class)	Polychaete worms	Trace
VSA	*Munida quadrispina*	Squat lobster	Trace
090	*Nemichthys scolopaceus*	Slender snipe eel	Trace
089	*Avocettina infans*	Closespine snipe eel	Trace
169	*Aristostomias scintillans*	Shining loosejaw	Trace
182	*Notolepis rissoi*	Ribbon barracudina	Trace
U18	*Berryteuthus anonychus*		Trace
TFB	*Acanthephyra curtirostris*	Peaked shrimp	Trace
U20	*Histioteuthis*		Trace
IJF	Mysidacea (Order)	Mysids	Trace
SDD	*Pandalus montagui tridens*	Yellowleg shrimp	Trace
SIE	*Crangon dalli*	Ridged crangon	Trace
U12	*Psolus squamatus*	Sea cucumber	Trace
TAE	*Pasiphaea tarda*	Crimson pasiphaeid	Trace
TBA	Parapasiphae Spp.		Trace
96A	*Onychoteuthis borealijaponicus*	Nail squid (Boreal clubhook squid)	Trace
TEC	*Hymenodora frontalis*	Pacific ambereye	Trace
U13	Gnathophausia Spp.	Mycid shrimp	Trace
TGB	*Systellaspis braueri*	Quayle's spinytail	Trace
THB	*Notostomus japonicus*	Spiny ridge shrimp	Trace
TQA	*Sergia tenuiremis*	Ocean sergestid	Trace
TRB	*Bentheogennema borealis*	Northern blunt-tailed shrimp	Trace
U06	Ctenophora (Phyllum)	Comb jellies	Trace
U07	Brachiopoda (Class)	Lamp Shells	Trace
U10	*Calastacus stilirostrus*		Trace
TBB	*Parapasiphae sulcatifrons*	Grooved-back shrimp	Trace
5QA	Ophiurida (Order)	Basket stars	Trace
241	*Lycodapus mandibularis*	Pallid slipskin	Trace
U28	Whale bones	Whale bones	Trace
U26	Kelp (Mixed species)	Kelp (Mixed species)	Trace

Table 12: continued

Species Code	*Latin Name*	Common name	Total Catch
U25	*Thaliacea (Class)*	Salps	Trace
262	Melamphaidae (Family)	Ridgeheads	Trace
263	*Melamphaes lugubris*	Highsnout ridgehead	Trace
U23	*Calocarios seriatias (Calocaris ….)*		Trace
96F	Vampyroteuthidae (Family)	Vampire squids	Trace
3U0	Pennatulacea (Order)	Sea pens	Trace
U29	Anaplogastridae (Family)	Fangtooths	Trace
U19	*Eualus macrophthalmus*	Large eyed eualid	Trace
U11	*Calastacus investigatoris*		Trace
U17	*Bentheogennema burkenroadi*	Burkenroad's blunt-tailed shrimp	Trace
4AB	Crinodea(Class)	Sea lilies and feather stars	Trace
U16	*Japatella Spp*		Trace
U14	*Abraliopsis Spp.*	Cephalopod	Trace
95B	*Gonatus Spp.*		Trace
U22	*Chiroteuthis Spp.*		Trace

Table 13: Species or species groups recorded in the commercial groundfish trawl observer database as being caught with Tanner crab at depths greater than 400 m.

Code	*Latin name*	Common name
00A	*Mollusca (phylum)*	Molluscs
015		Unknown fish
016	*Myxinidae (family)*	Hagfish
017	*Eptatretus deani*	Black hagfish
018	*Eptatretus stouti*	Pacific hagfish
020	*Lampetra tridentata*	Pacific lamprey
024	*Alopias superciliosus*	Bigeye thresher
026	*Hexanchidae (family)*	Cow sharks
027	*Hexanchus griseus*	Sixgill shark
02C	*Polyplacophora (subclass)*	Chitons
034	*Cetorhinus maximus*	Basking shark
036	*Lamna ditropis*	Salmon shark
037	*Scyliorhinidae (family)*	Cat sharks
038	*Apristurus brunneus*	Brown cat shark
039	*Carcharhinidae (family)*	Requiem sharks
041	*Prionace glauca*	Blue shark
043	*Somniosus pacificus*	Pacific sleeper shark
044	*Squalus acanthias*	Spiny dogfish
050	*Torpedo californica*	Pacific electric ray
051	*Rajidae (family)*	Skates
054	*Bathyraja abyssicola*	Abyssal skate
056	*Raja binoculata*	Big skate
058	*Bathyraja interrupta*	Sandpaper skate
059	*Raja rhina*	Longnose skate
061	*Raja stellulata*	Starry skate
066	*Hydrolagus colliei*	Spotted ratfish
081	*Acipenseridae (family)*	Sturgeons
082	*Acipenser medirostris*	Green sturgeon
085	*Serrivomeridae (family)*	Sawpalates
087	*Nemichthyidae (family)*	Snipe eels
095	*Alosa sapidissima*	American shad
096	*Clupea pallasi*	Pacific herring
0A0	*Invertebrates*	
0AA	*Phylum annelida*	Segmented worms
100	*Sardinops sagax*	Pacific sardine
10A	*Gastropoda (class)*	Gastropods
112	*Oncorhynchus keta*	Chum salmon
118	*Oncorhynchus nerka*	Sockeye salmon
124	*Oncorhynchus tshawytscha*	Chinook salmon
136	*Osmeridae (family)*	Smelts
164	*Melanostomiidae (family)*	Scaleless black dragonfishes
167	*Tactostoma macropus*	Longfin dragonfish
169	*Aristostomias scintillans*	Shining loosejaw
170	*Chauliodontidae (family)*	Viperfishes
171	*Chauliodus macouni*	Pacific viperfish
174	*Alepisauridae (family)*	Lancetfishes
175	*Alepisaurus ferox*	Longnose lancetfish
176	*Anotopteridae (family)*	Daggertooths
177	*Anotopterus pharao*	Daggertooth
179	*Benthalbella dentata*	Northern pearleye
184	*Scopelosaurus harryi*	Scaly waryfish
185	*Myctophidae (family)*	Lanternfishes
195	*Notoscopelus japonicus*	Japanese lanternfish
206	*Batrachoididae (family)*	Toadfishes
213	*Oneirodidae (family)*	Dreamers
214	*Chaenophryne melanorhabdus*	Smooth dreamer
216	*Oneirodes thompsoni*	Spiny dreamer
220	*Antimora microlepis*	Pacific flatnose
222	*Gadus macrocephalus*	Pacific cod
225	*Merluccius productus*	Pacific hake

Table 13: Continued

Code	Latin name	Common name
228	*Theragra chalcogramma*	Walleye pollock
231	*Zoarcidae (family)*	Eelpouts
233	*Lycodes cortezianus*	Bigfin eelpout
235	*Bothrocara brunneum*	Twoline eelpout
237	*Bothrocara remigerum*	Longsnout eelpout
238	*Lycenchelys jordani*	Shortjaw eelpout
239	*Lycodapus fierasfer*	Blackmouth slipskin
241	*Lycodapus mandibularis*	Pallid slipskin
242	*Lycodes brevipes*	Shortfin eelpout
243	*Lycodes diapterus*	Black eelpout
244	*Lycodes palearis*	Wattled eelpout
245	*Lycodes pacificus*	Blackbelly eelpout
248	*Derepodichthys alepidotus*	Cuskpout
249	*Macrouridae (family)*	Grenadiers
251	*Coryphaenoides acrolepis*	Roughscale rattail
252	*Coryphaenoides armatus*	Russet grenadier
256	*Albatrossia pectoralis*	Pectoral rattail
258	*Scomberesocidae (family)*	Sauries
264	*Poromitra crassiceps*	Crested ridgehead
266	*Oreosomatidae (family)*	Oreos
271	*Trachipterus altivelis*	King-of-the-salmon
273	*Aulorhynchinae (subfamily)*	Tube snouts
275	*Gasterosteinae (subfamily)*	Sticklebacks
27F	*Poliniceslewisii*	Lewismoon snail
287	*Trachurus symmetricus*	Jack mackerel
289	*Bramidae (family)*	Pomfrets
28I	*Fusitriton oregonensis*	Oregontriton
291	*Caristiidae (family)*	Manefishes
2A0	*Phylum porifera*	Sponges
2AA	*Phylum tardigrada*	Waterbears
2I0	*Hexactinellida (class)*	Glass sponges
317	*Bathymasteridae (family)*	Ronquils
324	*Stichaeidae (family)*	Pricklebacks
351	*Anarrhichthys ocellatus*	Wolf eel
359	*Zaprora silenus*	Prowfish
365	*Coryphopterus nicholsi*	Blackeye goby
371	*Katsuwonus pelamis*	Skipjack tuna
374	*Scomber japonicus*	Chub mackerel
385	*Icosteidae (family)*	Ragfishes
386	*Icosteus aenigmaticus*	Ragfish
394	*Sebastes aleutianus*	Rougheye rockfish
396	*Sebastes alutus*	Pacific ocean perch
3A1	*Phylum cnidaria*	Coeclenterates
3A2	*Hydrozoa (class)*	Hydroid
3G0	*Scyphozoa (class)*	Jellyfish
3J0	*Anthozoa (class)*	
3J1	*Zoantharia (subclass)*	
3J2	*Madreporia (order)*	Stony corals
3L0	*Actiniaria (order)*	Anemone
3R0	*Alcyonacea (order)*	Soft corals
3S0	*Gorgonacea (order)*	Gorgonian corals
3U0	*Pennatulacea (order)*	Sea pens
400	*Sebastes aurora*	Aurora rockfish
401	*Sebastes babcocki*	Redbanded rockfish
403	*Sebastes borealis*	Shortraker rockfish
405	*Sebastes brevispinis*	Silvergray rockfish
410	*Sebastes crameri*	Darkblotched rockfish
412	*Sebastes diploproa*	Splitnose rockfish
414	*Sebastes elongatus*	Greenstriped rockfish
417	*Sebastes entomelas*	Widow rockfish
418	*Sebastes flavidus*	Yellowtail rockfish
421	*Sebastes helvomaculatus*	Rosethorn rockfish
429	*Sebastes mystinus*	Blue rockfish
431	*Sebastes nebulosus*	China rockfish
433	*Sebastes nigrocinctus*	Tiger rockfish

Table 13: Continued

Code	Latin name	Common name
435	*Sebastes paucispinis*	Bocaccio
437	*Sebastes pinniger*	Canary rockfish
439	*Sebastes proriger*	Redstripe rockfish
440	*Sebastes reedi*	Yellowmouth rockfish
442	*Sebastes ruberrimus*	Yelloweye rockfish
448	*Sebastes wilsoni*	Pygmy rockfish
450	*Sebastes zacentrus*	Sharpchin rockfish
451	*Sebastolobus alascanus*	Shortspine thornyhead
452	*Sebastolobinae (subfamily)*	Thornyheads
453	*Sebastolobus altivelis*	Longspine thornyhead
455	*Anoplopoma fimbria*	Sablefish
458	*Erilepis zonifer*	Skilfish
467	*Ophiodon elongatus*	Lingcod
472	*Cottidae (family)*	Sculpins
4A0	*Flatworms*	
4AA	*Phylum echinodermata*	Echinoderms
4AB	*Crinodea (class)*	Sea lilies and feather stars
4GA	*Asteriodea (subclass)*	Starfish
4JD	*Mediaster aequalis*	Vermillion star
4OC	*Dermasterias imbricata*	Leather star
4PD	*Patiria miniata*	Bat star
4SC	*Acanthaster planci*	Crown of thorns
4TB	*Solaster dawsoni*	Morning sun star
4TC	*Solaster stimpsoni*	Striped sun star
4XE	*Picopodia helianthoides*	Sunflower star
4ZA	*Pisaster ochraceus*	Purple star
51A	*Nudibranchiata (suborder)*	Seaslugs
540	*Scorpaenichthys marmoratus*	Cabezon
546	*Agonidae (family)*	Poachers
550	*Podathecus acipenserinus*	Sturgeon poacher
557	*Bathyagonus nigripinnis*	Blackfin poacher
564	*Odontopyxis trispinosa*	Pygmy poacher
568	*Cyclopteridae (family)*	Lumpfishes and snailfishes
571	*Aptocyclus ventricosus*	Smooth lumpsucker
573	*Careproctus gilberti*	Smalldisk snailfish
574	*Careproctus melanurus*	Blacktail snailfish
586	*Liparis mucosus*	Slimy snailfish
596	*Citharichthys sordidus*	Pacific sanddab
598	*Citharichthys stigmaeus*	Speckled sanddab
5AA	*Ophiuroidea (class)*	
5AB	*Ophiurae (order)*	Brittle stars
602	*Atheresthes stomias*	Arrowtooth flounder
605	*Embassichthys bathybius*	Deepsea sole
607	*Eopsetta jordani*	Petrale sole
60A	*Bivalvia (class)*	Bivalves
610	*Errex zachirus*	Rex sole
612	*Hippoglossoides elassodon*	Flathead sole
614	*Hippoglossus stenolepis*	Pacific halibut
621	*Pleuronectes bilineatus*	Rock sole
623	*Pleuronectes asper*	Yellowfin sole
625	*Eopsetta exilis*	Slender sole
626	*Microstomus pacificus*	Dover sole
628	*Pleuronectes vetulus*	English sole
631	*Platichthys stellatus*	Starry flounder
633	*Pleuronichthys coenosus*	C-O sole
635	*Pleuronichthys decurrens*	Curlfin sole
636	*Psettichthys melanostictus*	Sand sole
640	*Mola mola*	Ocean sunfish
642	*Alepocephalidae (family)*	Slickheads
67B	*Pectinidae (family)*	Scallop
6AB	*Echinacea (superorder)*	Sea urchins
6HA	*Gnathostomata (superorder)*	Sand dollars
6KA	*Atelostomata (superorder)*	Heart urchins
6NA	*Holothuroidea (class)*	Sea cucumbers
855	*Family phocidae*	Earless seals

Table 13: Continued

Code	*Latin name*	Common name
860	*Order cetacea*	Whales & porpoises
862	*Family delphinidae*	Porpoises & dolphins
866	*Lagenorhynchus obliquidens*	Pacific white-sided dolphin
8AB	*Ascidiacea (class)*	Ascidians and tunicates
91A	*Cephalopoda (family)*	
91G	*Rossia pacifica*	Squat squid
92A	*Teuthoidea (order)*	Squid
92D	*Loligo opalescens*	Opal squid
94H	*Ommastrephes bartramii*	Neon flying squid
95B	*Gonatus spp*	
95E	*Berryteuthis magister*	Red squid (aka schoolmaster gonate squid)
96A	*Onychoteuthis borealijaponicus*	Nail squid (aka boreal clubhook squid)
96C	*Moroteuthis robusta*	Giant squid
97A	*Octopoda (order)*	Octopus
998		Inanimate objects
999		Missing sample
A00	*Phylum arthropoda*	
HCA	*Cirripedia (subclass)*	Barnacles
IAA	*Malacostraca (subclass)*	Malacostracans
SAA	*Decapoda (order)*	Decapods
SAB	*Nantantia (order)*	Shrimp
SCJ	*Pandalus hypsinotus*	Humpback shrimp
SDF	*Pandalus platycerous*	Prawn
SEE	*Pandalopsis dispar*	Sidestripe shrimp
SIA	*Crangon spp*	
UAA	*Repiantia (suborder)*	
VAA	*Anomura (section)*	
VAC	*Paguridae (family)*	Hermit crabs
VLC	*Acantholithodes hispidus*	Bristly crab
VMB	*Lithodes spp*	
VMD	*Lithodes couesi*	
VMH	*Lopholithodes spp*	Box crabs
VNH	*Paralithodes cammtschatica*	Red king crab
VSA	*Munida quadrispina*	Squat lobster
XKG	*Cancer magister*	Dungeness crab
XLA	*Cancer productus*	Red rock crab
ZAA	*Oxyrhyncha (superfamily)*	Spider crabs
ZAD	*Chionoecetes spp*	Tanner crabs
ZAF	*Chionoecetes bairdi*	
ZAG	*Chionoecetes tanneri*	
ZCA	*Oregonia gracilis*	Decorator crab

Table 14: Total catch by species by trap gear during the 1999 DFO Tanner crab survey off the west coast of Vancouver Island. Total catch weight is in kilograms. The species code is a three character alphanumeric used by Fisheries and Oceans Canada, Pacific region, science branch to identify each species.

Species Code	Latin Name	Common name	Total Catch
ZAG	*Chionoecetes tanneri*	Grooved Tanner crab	345.37
455	*Anoplopoma fimbria*	Sablefish	107.00
ZAE	*Chionoecetes angulatus*	Angle Tanner Crab	11.81
VOG	*Paralomis multispina*		3.40
251	*Coryphaenoides acrolepis*	Roughscale rattail	0.80
5AB	Ophiuridae (Family)	Brittle stars	0.10
6NA	Holothuroidea (Class)	Sea cucumbers	Trace
3G0	Scyphozoa (Class)	Jellyfish	Trace
3L0	Actiniaria (Order)	Anemone	Trace
10A	Gastropoda (Class)	Gastropods	Trace
6AB	Echinacea (Super order)	Sea urchins	Trace
ZGE	*Chorilia longipes*	Redclaw crab	Trace
U01	*Solaster endeca*	Northern sunstar	Trace
U02	*Thrissacanthus pencillatus*	Mud star	Trace
U04	*Sinalyctese challengeri*	Deep sea cucumber	Trace
5QA	Ophiurida (Order)	Basket stars	Trace

Table 15: Catch by species and area during the distributional Tanner crab trap survey, values are best estimates. Weights are in kilograms.

PFMA	Species	Number	Weight
123	***Chionoectes tanneri***	**437**	**291.00**
123	*Paralomis multispina*	9	7.75
123	*Anoplopoma fimbria*	7	5.50
123	*Lithodes couesi*	4	1.25
123	*Sebastolobus alascanus*	3	0.75
123	*Sebastolobus altivelis*	3	-
124	***Chionoectes tanneri***	**2777**	**1563.00**
124	*Anoplopoma fimbria*	66	154.50
124	*Coryphaenoides acrolepis*	5	7.75
124	*Lithodes couesi*	11	6.75
124	*Paralomis multispina*	3	3.75
124	*Sebastolobus altivelis*	8	0.60
124	*Sebastolobus alascanus*	3	0.20
125	***Chionoectes tanneri***	**3207**	**2342.00**
125	*Anoplopoma fimbria*	36	113.25
125	*Lithodes couesi*	26	22.05
125	*Pisces*	6	18.50
125	*Paralithodes cammtschatica*	2	2.00
125	*Sebastolobus altivelis*	7	1.95
125	*Coryphaenoides acrolepis*	1	0.75
125	*Sebastolobus alascanus*	2	0.75
126	***Chionoectes tanneri***	**2741**	**2794.00**
126	*Anoplopoma fimbria*	62	200.75
126	*Lithodes couesi*	74	84.55
126	*Coryphaenoides acrolepis*	2	6.00
126	*Paralomis multispina*	8	5.00
126	*Sebastolobus altivelis*	5	2.00
126	*Sebastolobus alascanus*	2	0.75
127	***Chionoectes tanneri***	**2343**	**3550.00**
127	*Lithodes couesi*	249	297.25
127	*Anoplopoma fimbria*	57	281.00
127	*Coryphaenoides acrolepis*	4	9.00
127	*Paralomis multispina*	8	7.75
127	*Sebastolobus altivelis*	2	0.88
142	***Chionoectes tanneri***	**636**	**325.00**
142	*Anoplopoma fimbria*	80	594.50
142	*Lithodes couesi*	564	533.25
142	*Pisces*	130	104.00
142	*Lithodes aequispina*	2	5.00
142	*Coryphaenoides acrolepis*	1	2.00
101	***Chionoectes tanneri***	**169**	**129.00**
101	*Anoplopoma fimbria*	65	18.00
101	*Pisces*	201	4.00
101	*Sebastolobus altivelis*	1	-
101	*Lithodes couesi*	50	-
101	*Sebastolobus alascanus*	1	-

Table 16: Total by-catch by species caught during the distributional trap survey for Tanner crab December 1999 – April 2000. This total represents 290 strings of gear consisting 5094 trap hauls.

Species	Number	Weight
Anoplopoma fimbria	373	1,367.50
Lithodes couesi	978	945.10
Pisces	337	126.50
Coryphaenoides acrolepis	13	25.50
Paralomis multispina	28	24.25
Sebastolobus altivelis	26	5.43
Lithodes aequispina	2	5.00
Sebastolobus alascanus	11	2.45
Paralithodes cammtschatica	2	2.00

Table 17: Total by-catch by species caught during the experimental harvests conducted in PFMA 126 in February and March of 2000. These data are from 64 sets of gear representing approximately 3650 trap hauls.

Species	Number	Weight
Lithodes couesi	121	43.85
Anoplopoma fimbria	27	34.50
Sebastolobus alascanus	2	0.25

Table 18: Species caught with sablefish during annual DFO sablefish assessment trap surveys. Occurrence is the number of times the species was recorded from a set of gear out of a total of 377 sets of gear.

Latin name	Common name	Occurrence
Atheresthes stomias	Arrowtooth flounder	137
Sebastolobus alascanus	Shortspine thornyhead	105
Hippoglossus stenolepis	Pacific halibut	77
Chionoecetes tanneri	Grooved Tanner crab	74
Coryphaenoides acrolepis	Roughscale rattail	63
Microstomus pacificus	Dover sole	61
Sebastes aleutianus	Rougheye rockfish	51
Albatrossia pectoralis	Pectoral rattail	47
Sebastes babcocki	Redbanded rockfish	35
Lithodes aequispina	Golden king crab	32
Antimora microlepis	Pacific flatnose	29
Squalus acanthias	Spiny dogfish	26
Ophiodon elongatus	Lingcod	25
Chionoecetes spp	Tanner crabs	21
Coryphaenoides filifer	Filamented rattail	20
Macrouridae (family)	Grenadiers	18
Sebastes borealis	Shortraker rockfish	18
Lithodes couesi	Scarlet King	13
Somniosus pacificus	Pacific sleeper shark	12
Sebastes helvomaculatus	Rosethorn rockfish	10
Pycnopodia helianthoides	Sunflower starfish	9
Sebastes alutus	Pacific ocean perch	7
Fratercula corniculata	Horned puffin	6
Chionoecetes bairdi	Alaskan Tanner	5
Gadus macrocephalus	Pacific cod	5
Fusitriton oregonensis	Oregontriton	4
Embassichthys bathybius	Deepsea sole	2
Pleuronectes bilineatus	Rock sole	2
Hydrolagus colliei	Spotted ratfish	2
Octopoda (order)	Octopus	2
Lithodes spp	King crab	2
Careproctus melanurus	Blacktail snailfish	2
Merluccius productus	Pacific hake	1
Theragra chalcogramma	Walleye pollock	1
Myxinidae (family)	Hagfishes	1
Apristurus brunneus	Brown cat shark	1
Sebastinae (subfamily)	Rockfishes	1
Sebastes elongatus	Greenstriped rockfish	1
Sebastes zacentrus	Sharpchin rockfish	1
Sebastes reedi	Yellowmouth rockfish	1
Lopholithodes spp	Box crabs	1
Asteroidea (class)	Starfish	1
Errex zachirus	Rex sole	1
Pleuronectes vetulus	English sole	1
Octopus spp	Octopus	1
Sebastes melanops	Black rockfish	1

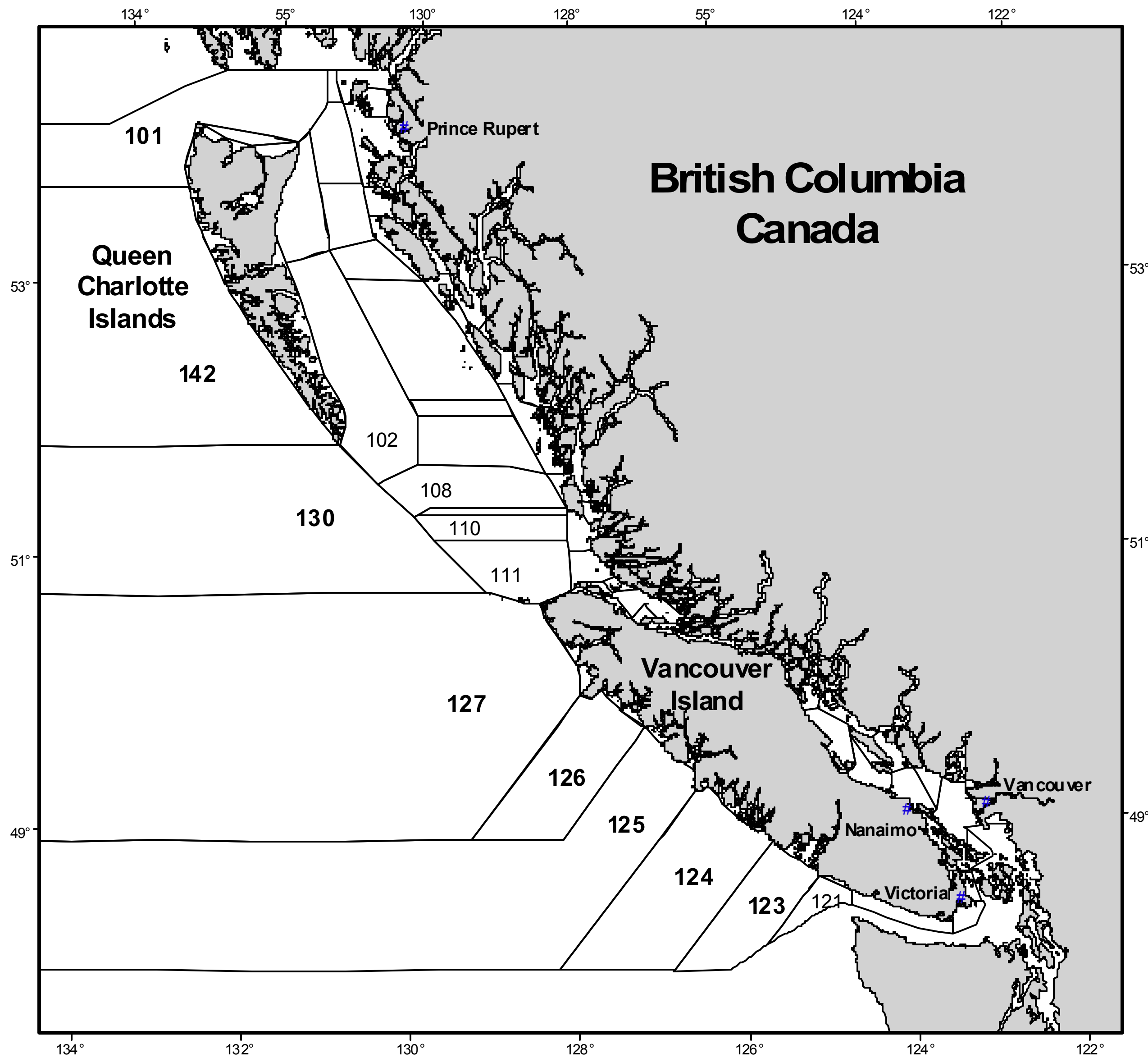


Figure 1: The west coast of Canada showing British Columbia, Vancouver Island, and the Queen Charlotte Islands. The Major Pacific Fisheries Management Areas (PFMA) with Tanner crab habitat are labelled in bold, areas contributing minor quantities of habitat are also labelled (not in bold).

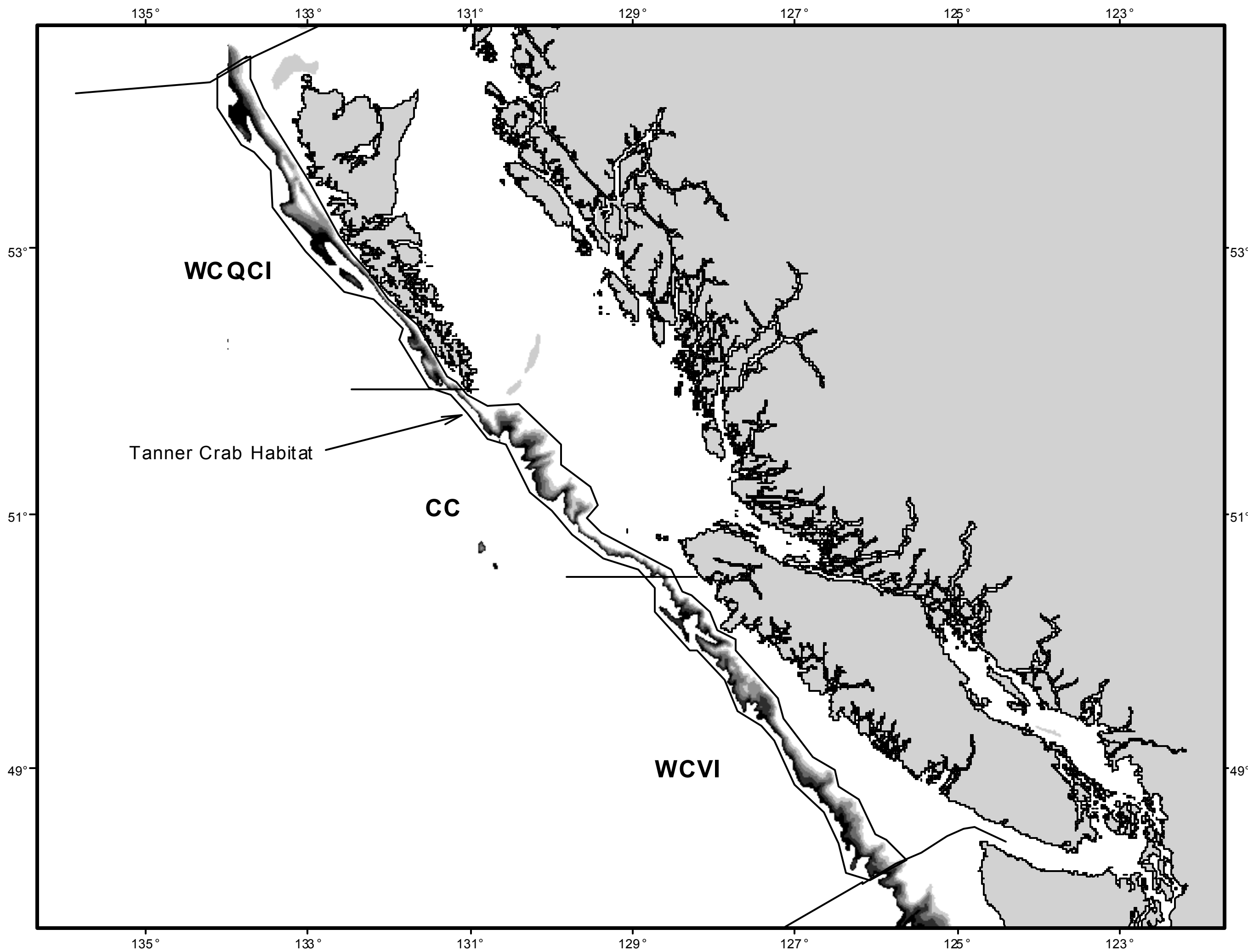


Figure 2: Map of the West Coast of Canada showing the area considered to be Tanner crab habitat on the continental slope (the area within the Tanner crab habitat polygon). Potential Tanner crab Habitat is shaded and covers the depth range from 400 to 1200 m. Also shown is the current division of the coast into three areas for survey administration and management: west coast of Vancouver Island (WCVI), central coast (CC), and west coast Queen Charlotte Islands (WCQCI).

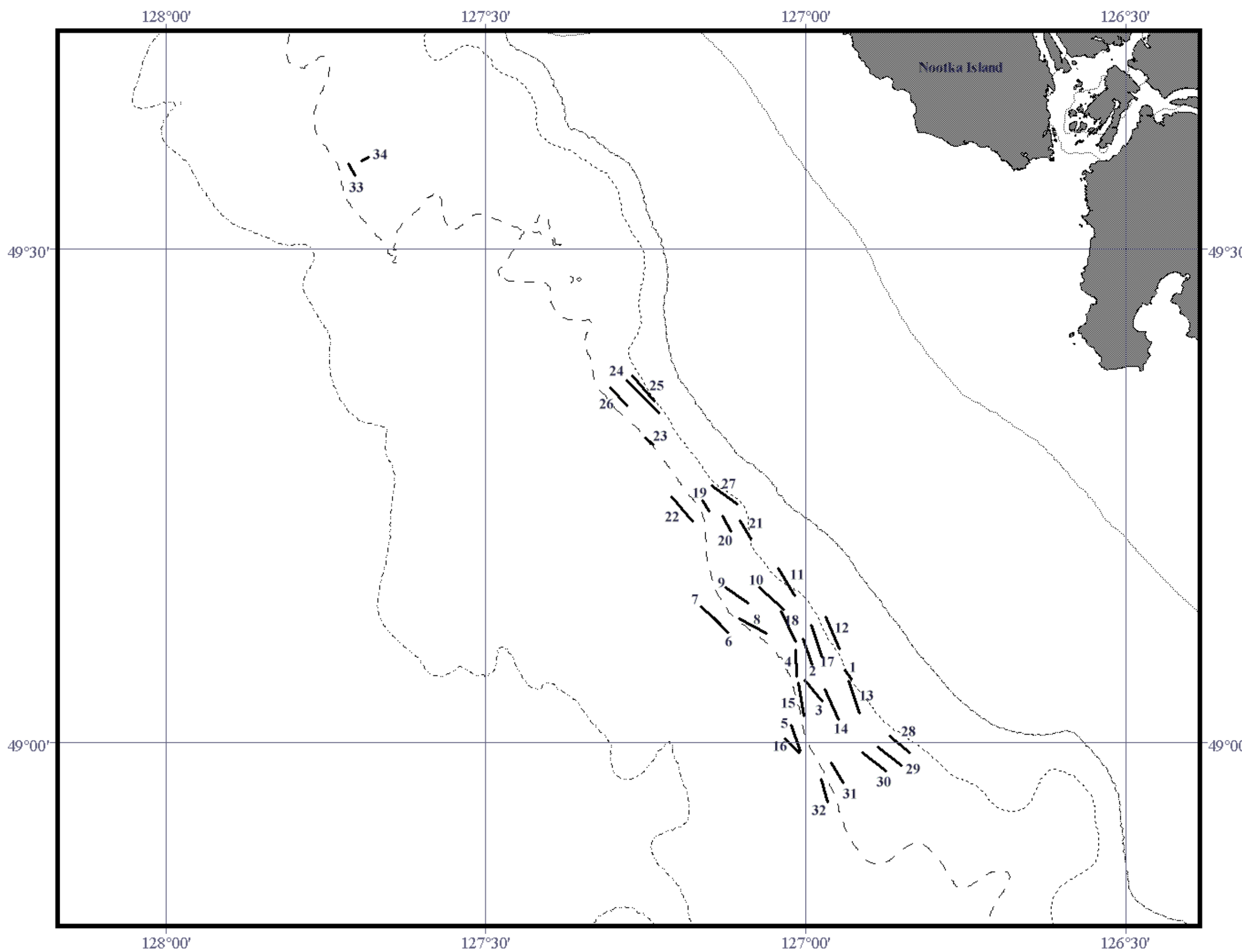


Figure 3: Trawl location from the 1999 DFO Tanner crab trawl survey, July 19 to August 3, 1999. Tows are labeled with their corresponding set number.

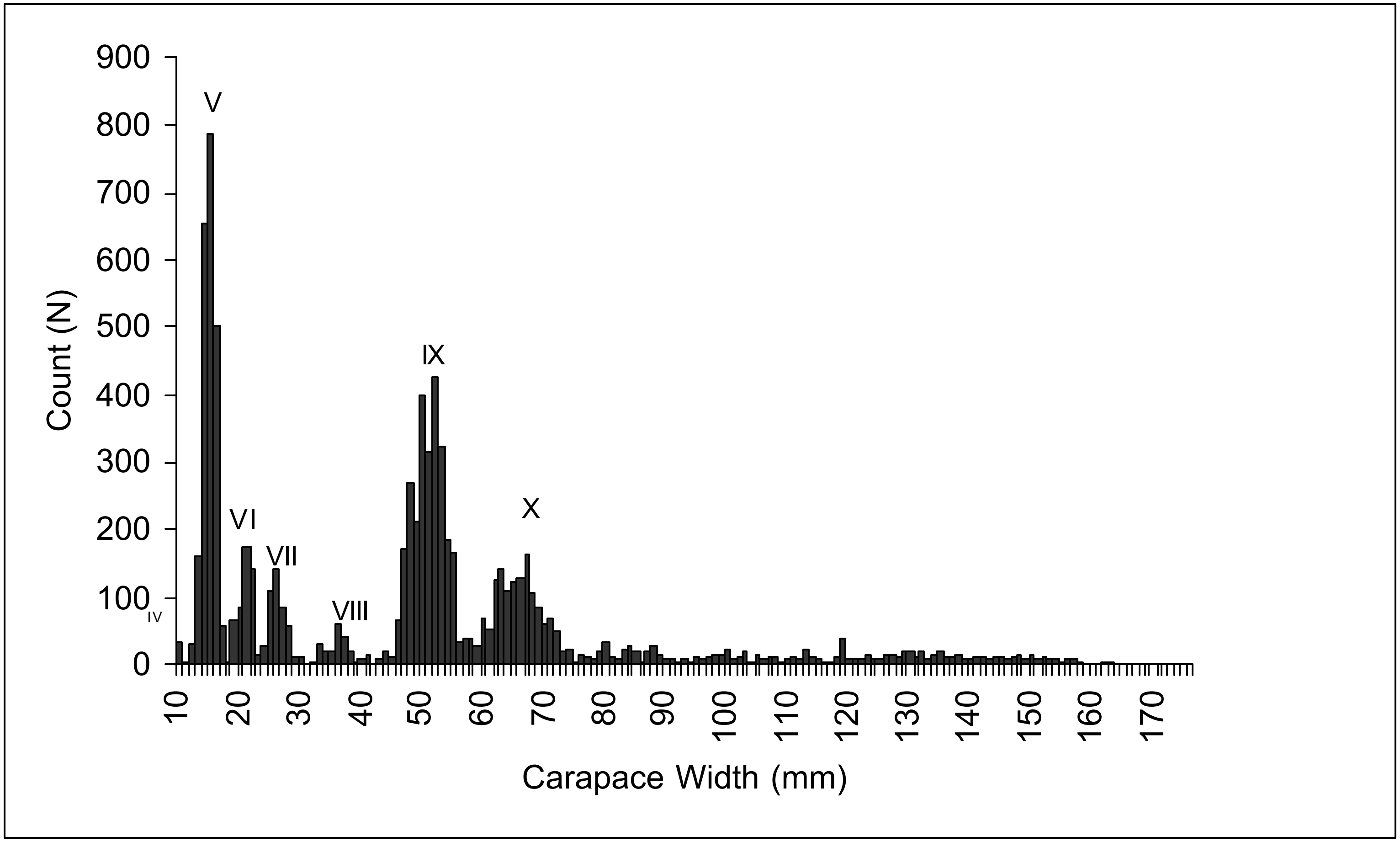
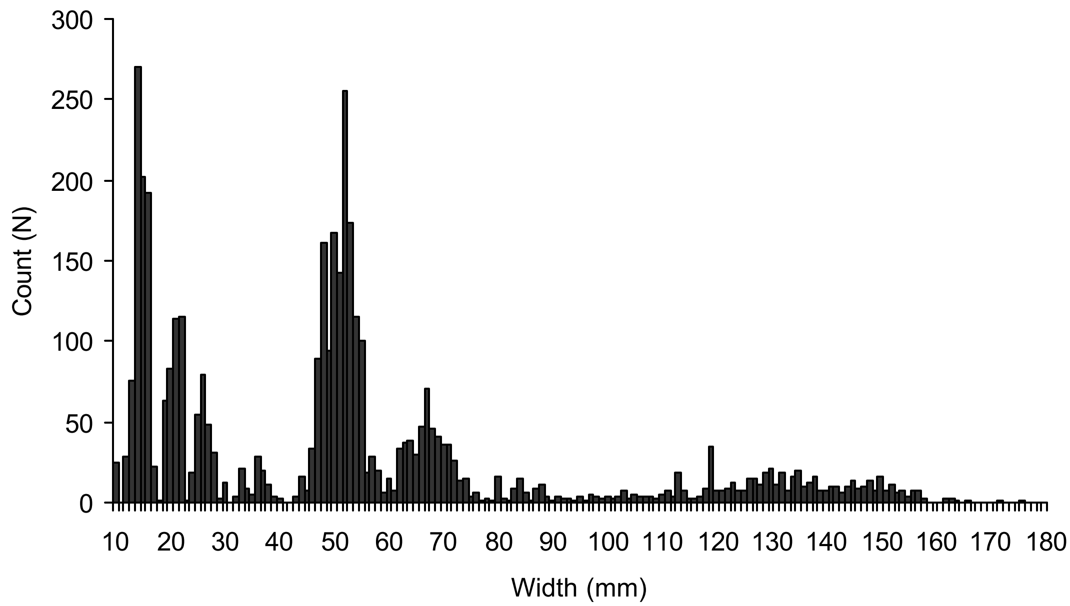


Figure 4: Width frequency histogram from the Tanner crab trawl survey undertaken off the west coast of Vancouver island July 19 - Aug3, 1999. This figure includes both sexes. Modes are labeled with their corresponding instar stage.



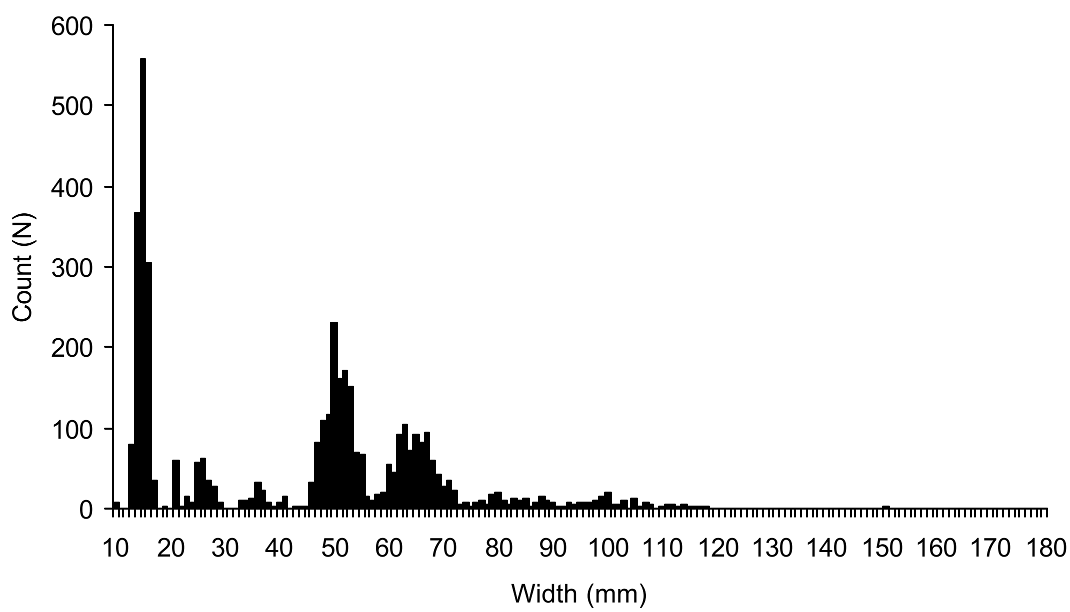


Figure 5: Width frequency histograms by sex for Tanner crab caught by trawl during the 1999 DFO Tanner crab trawl survey. The top panel is males the lower panel, females.

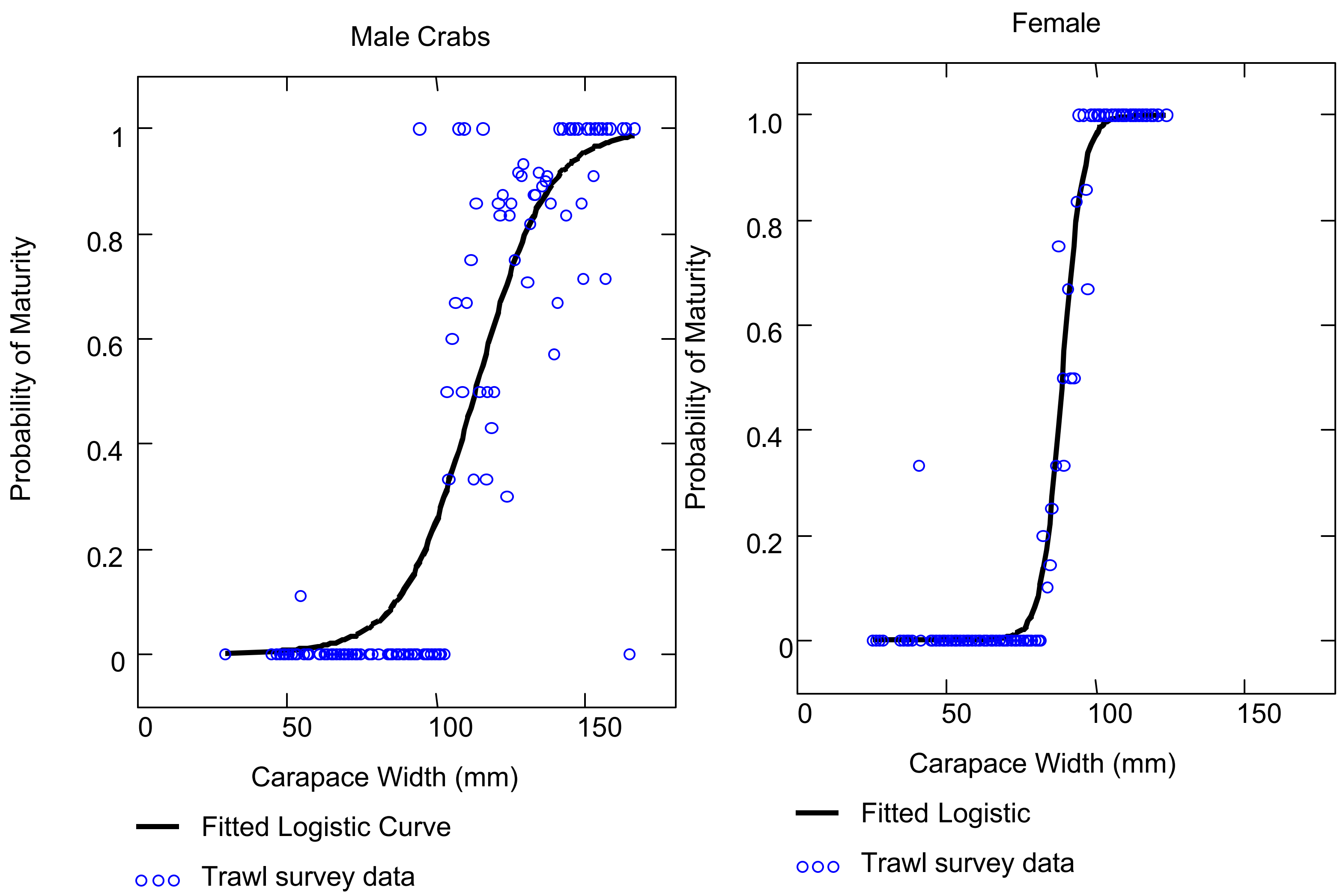


Figure 6: Maturity ogives used to determine size at 50% maturity. The proportion mature in each 1-mm size increment is plotted as a function of size (carapace width) to produce these figures. Size at 50% maturity for males is 112 mm, for females it is 88 mm.

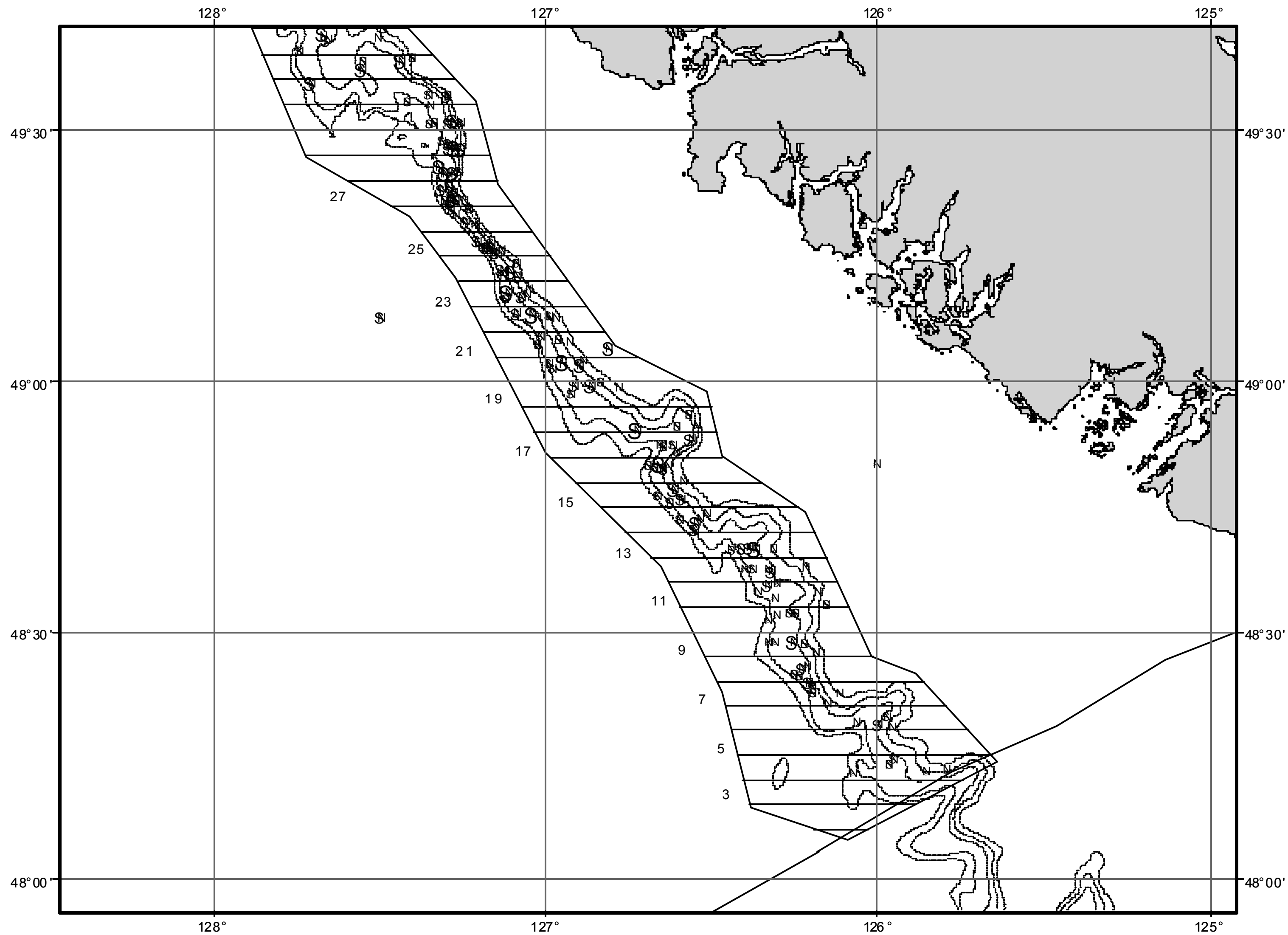


Figure 7: Locations for Tanner crab trap survey sets conducted during the distributional trap survey showing set locations (x's), survey blocks (labeled with numbers) and stratum boundaries (dashed lines: 400-520, 521-640, 640-760, 761-880, 881-1000 m). Symbols are sized to total catch per string. This plot is for the southwest coast of Vancouver Island (WCVI).

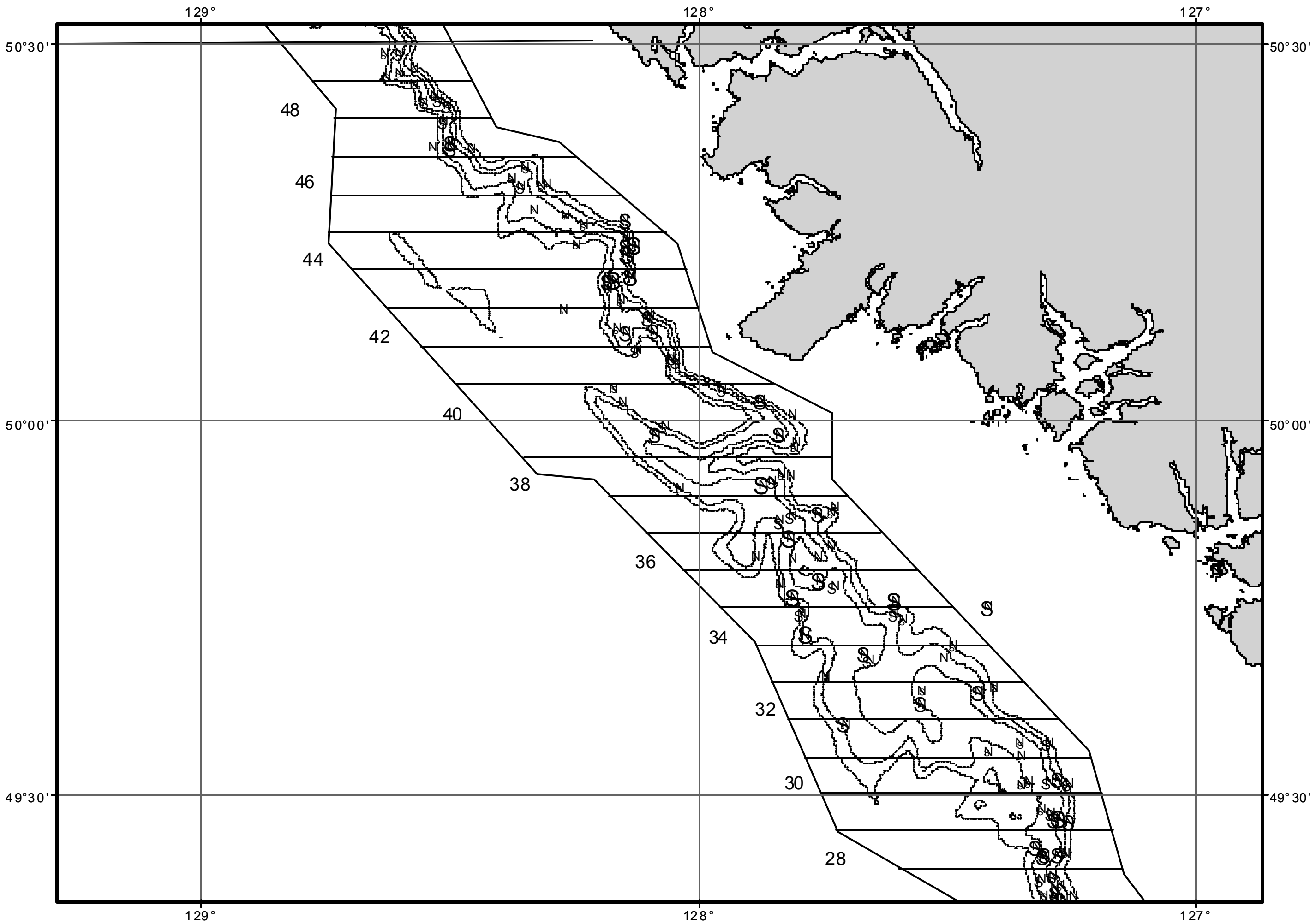


Figure 8: Locations for Tanner crab trap survey sets conducted during the distributional trap survey showing set locations (x's), survey blocks (labeled with numbers) and stratum boundaries (dashed lines: 400-520, 521-640, 640-760, 761-880, 881-1000 m). Symbols are sized to total catch per string. This plot is for the northwest coast of Vancouver Island (WCVI).

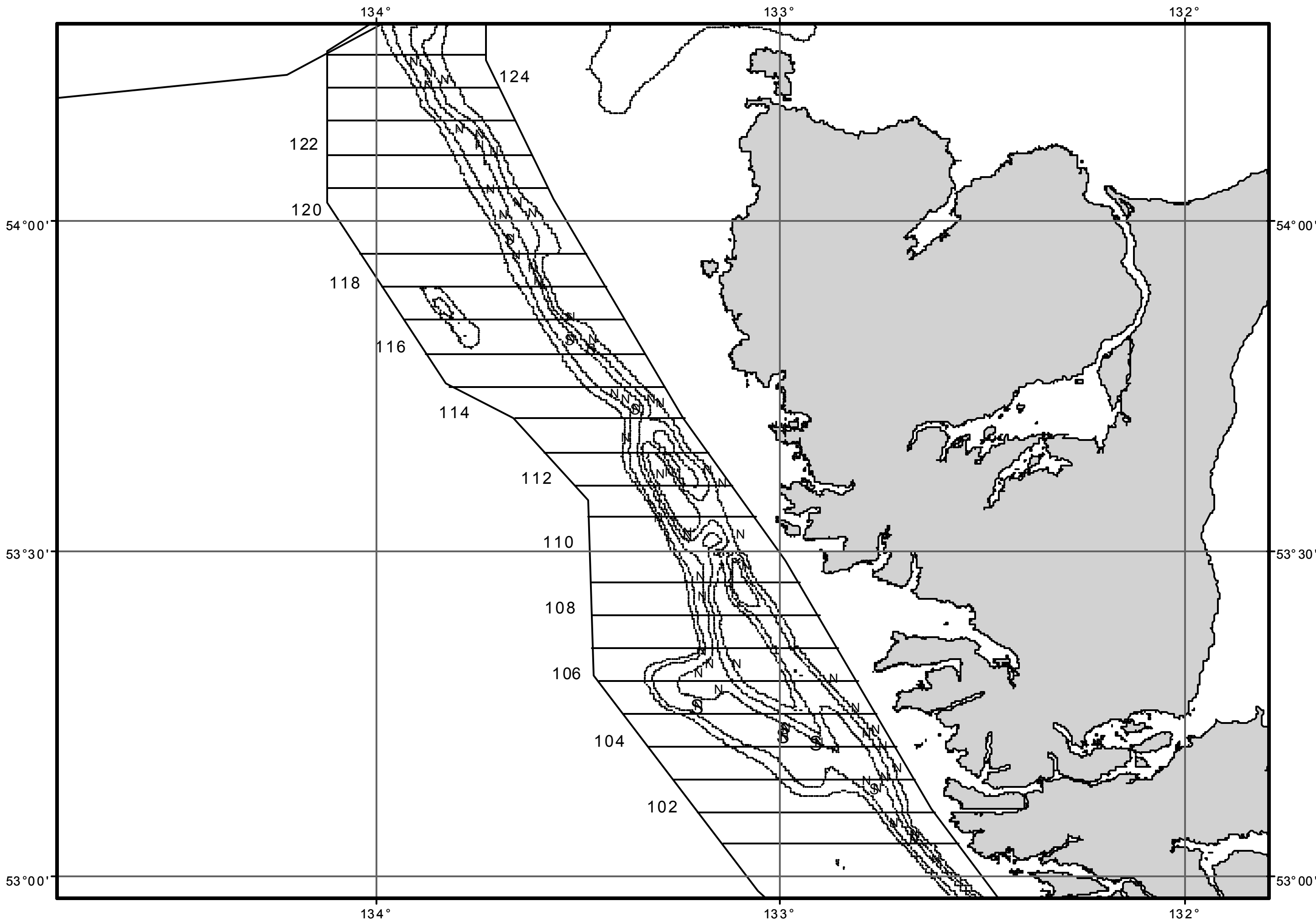


Figure 9 Locations for Tanner crab trap survey sets conducted during the distributional trap survey showing set locations (x's), survey blocks (labeled with numbers) and stratum boundaries (dashed lines: 400-520, 521-640, 640-760, 761-880, 881-1000 m). Symbols are sized to total catch per string. This plot is for the west coast of the Queen Charlotte Islands (WCQCI).

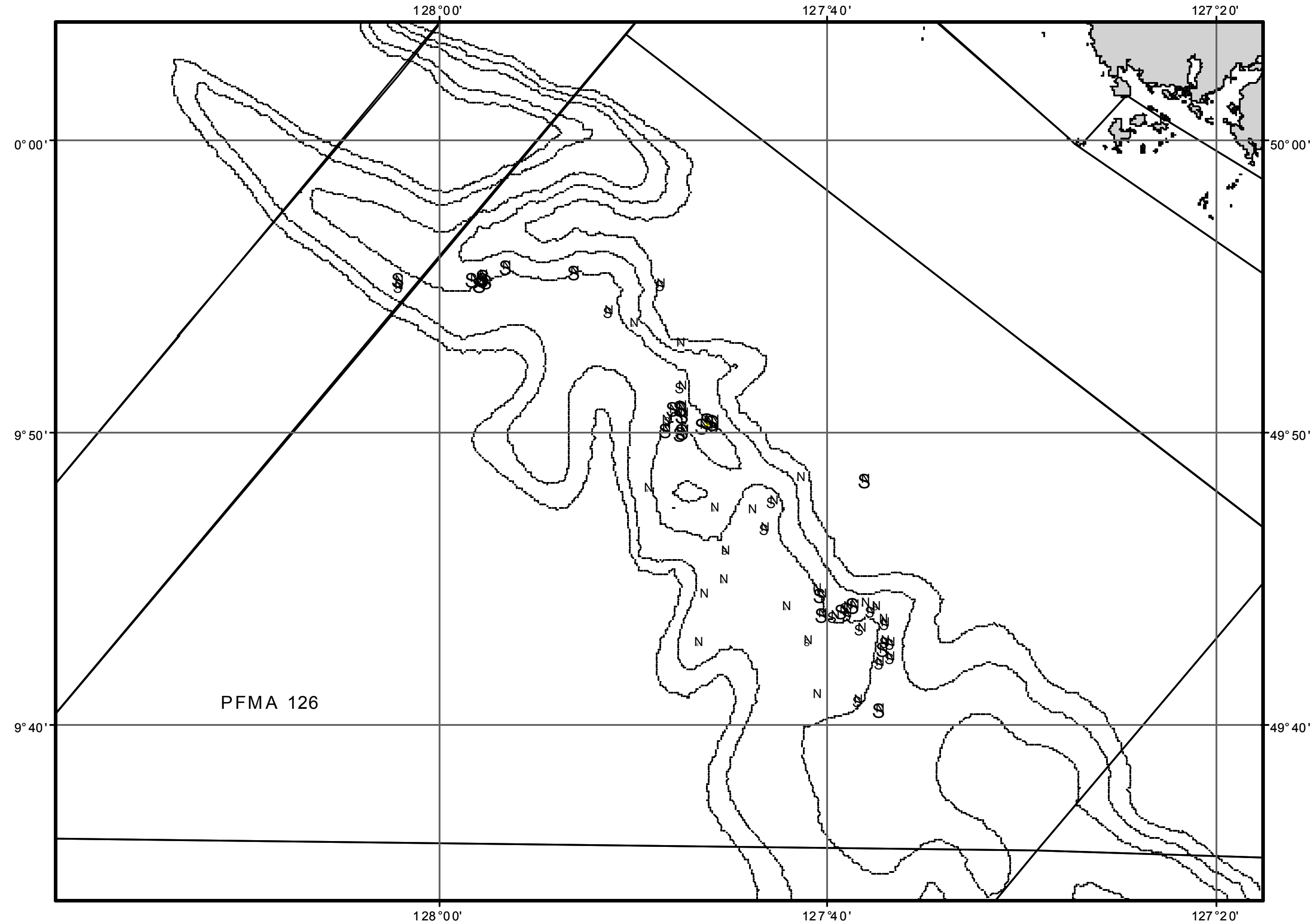


Figure 10. Set locations for Tanner crab experimental harvests conducted following the structured distributional trap survey. The figure shows set locations (x's), PFMA boundaries (solid black lines) and survey stratum boundaries (dashed lines: 400-520, 521-640, 640-760, 761-880, 881-1000 m). Symbols are sized to mean trap catch rate (N/trap) per string. This plot is for PFMA 126.

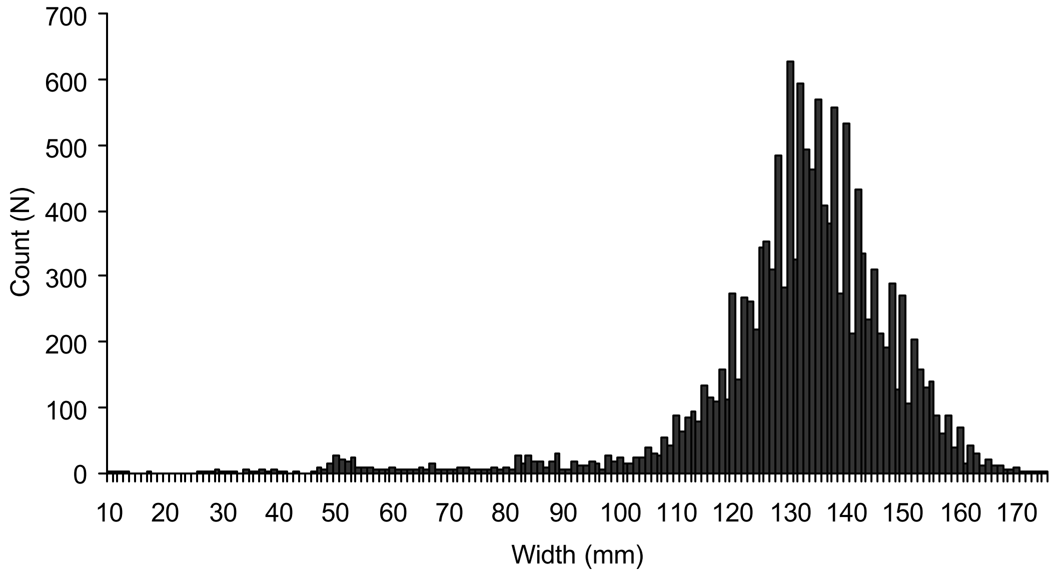


Figure 11: Width frequency histogram for male Tanner crab caught during the distributional industry trap survey and experimental harvest. N= 14021.

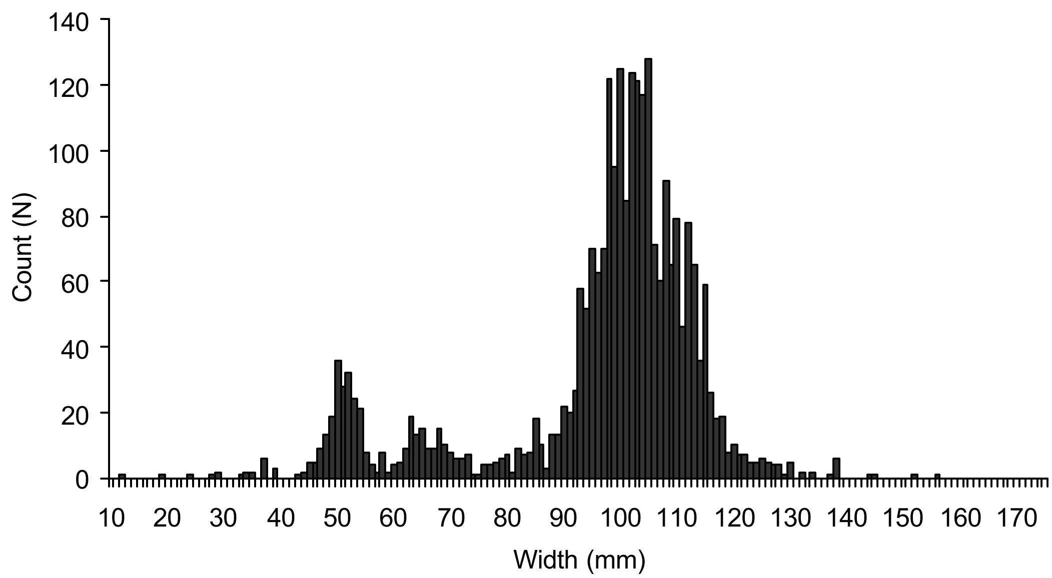


Figure 12: Width frequency histogram for female Tanner crab caught during the 1999 structured industry trap survey, N = 2579

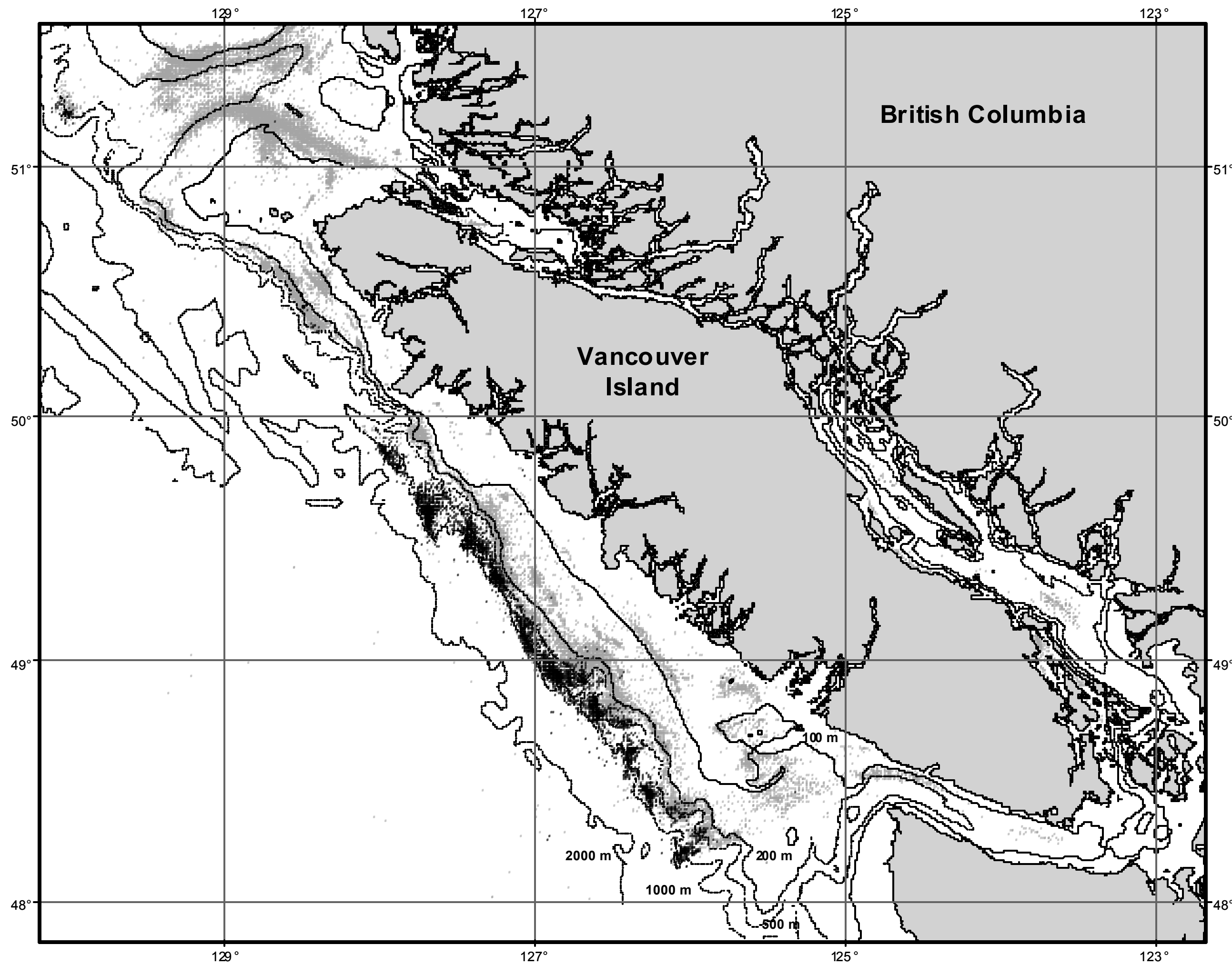


Figure 13: Plot of groundfish trawl locations, light gray symbols indicate the mid-point of a trawl set, the black symbols are trawl sets that contained Tanner crab. The 100, 200, 500, 1000 and 2000 m contours are shown and labeled.

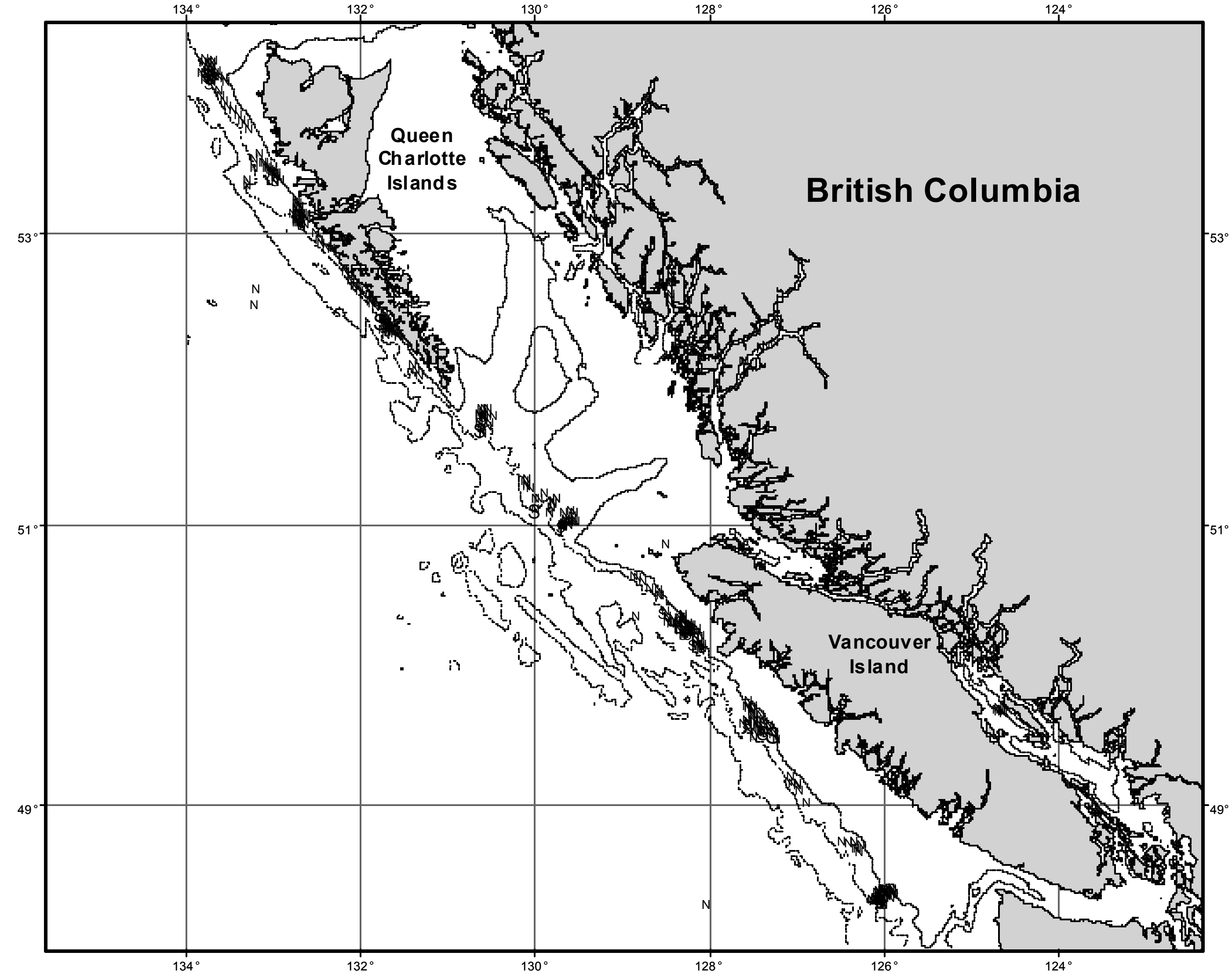


Figure 14: Plot of sablefish survey set locations (x's), and locations where Tanner crab were caught (the sized circle symbols). The symbol size is scaled to the total catch of Tanner crabs for the string. The 200, 1000 and 2000 m contours are also shown.

Appendix 1

Request for working paper submitted by the biologist responsible for Managing the Tanner crab fishery

PSARC INVERTEBRATE SUBCOMMITTEE

Request for Working Paper

Date Submitted: March 3, 2000

Individual or group requesting advice:
(Fisheries Manager/Biologist, Science, SWG, PSARC, Industry, Other stakeholder etc.)
Fiona Scurrah, Biologist NCD; Dan Clark, Biologist SCD

Proposed PSARC Presentation Date:
(outline any timing concerns for the provision of advice)
June 2000

Subject of Paper (title if developed):

A review of the DFO and Industry surveys on abundance and distribution of Tanner crab off the coast of British Columbia and assessment of the fishery potential and a review of management options for a commercial Tanner crab fishery.

Lead Author(s):

Greg Workman, Jim Boutillier, Antan Phillips, Fiona Scurrah

Fisheries Management Author/Reviewer:

Fiona Scurrah, Dan Clark

Rational for request:
(What is the issue, what will it address, importance, etc.)
Phase 1 coast-wide trap survey completed for the West Coast of Vancouver Island March 31, 2000, West Coast of the Queen Charlotte Islands partially completed April 31, 2000; DFO trawl survey completed August 3, 1999. A review is required before further development can proceed.

Question(s) to be addressed in the Working Paper:
(To be developed by initiator)

What are the results of the DFO trawl survey and Industry trap survey of Tanner crab. What is the current estimate of abundance and stock condition for Tanner crabs. What is the potential annual harvest of Tanner crabs and what is the current annual level of incidental mortalities. What are the current options for a commercial fishery and what potential allocation conflicts might arise from such a fishery.

Objective of Working Paper:
(To be developed by FM & StAD for internal papers)
Review Phase 1 and make recommendations a Phase 2.