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A progress report on the development of a new fishery for inshore Tanner Crabs *(Chionoecetes bairdi* Rathbun, 1924) in Rivers Inlet, British Columbia

Rapport d'étape sur l'établissement d'une nouvelle pêche du crabe des neiges du Pacifique (*Chionoecetes bairdi* Rathbun, 1924) dans le bras de mer Rivers, en Colombie-Britannique

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ABSTRACT

Fisheries and Oceans Canada (DFO) and the Wuikinuxv Nation have undertaken a cooperative Phase 1 assessment of inshore Tanner crab, *Chionoecetes bairdi,* in support of developing a fishery for Tanner crabs in Rivers Inlet, B.C. This follows the Phase 0 information review on *C. bairdi* by Krause *et al.* (2001). This paper presents new information regarding distribution, abundance, and biological characteristics of *C. bairdi* in Rivers Inlet.

The results from exploratory trap and trawl surveys and a mark-recapture program carried out between January 2004 through March 2005 by DFO and the Wuikinuxv Nation are presented. Trappings captured more male than female *C. bairdi* (5.27:1). Trawling proved unsuccessful at capturing Tanner crabs. *C. bairdi* were found distributed throughout Rivers Inlet (except Fitz Hugh Sound) but were not overly abundant. Some areas supported more Tanner crabs than others; crabs were more abundant in Draney Inlet and Darby Channel. *C. bairdi* were found at depths ranging from 36-340 m with greatest abundance of males at 50 to 150 m and females 100 to 200 m.

Male *C. bairdi* captured in Rivers Inlet ranged in size from 4 to 137 mm carapace width (CW). The mean size of 50% maturity for males is 94 mm CW and 81 mm CW for females. A 20% growth rate was estimated for mature males. Based on this information a minimum size limit of 113 mm CW was determined for males taking into account one moult increment past size of maturity to allow a season of breeding. The presence of a terminal moult after maturity remains inconclusive.

Our data show a small proportion of mature males moult throughout the year with a moult event possibly taking place in the spring or summer. Breeding in Rivers Inlet occurs in the fall with an egg-release period in the spring. Natural mortality (*M*) for male Tanner crabs was estimated at 0.69 and 1.12. Tagging showed that Tanner crab movements ranged between 0 and 4,592 m over a period of 4 to 422 days. Tanner crabs did not move between major areas within Rivers Inlet.

A multiple census mark-recapture technique was used to estimate the population size of male Tanner crabs in Rivers Inlet. A total of 1,315 crabs (1,055 males and 260 females) were tagged and released during six research surveys in Rivers Inlet of which 20 were recovered by surveys and 6 by the public. The population estimate for male Tanner crabs greater than 55 mm CW in Rivers Inlet is 37,907 (28,483 to 56,650). The total number and biomass of legal size males ($\geq$ 113 mm CW) was estimated to be 7,178 to 9,553 (lower 95% CI and mean) or approximately 4,163 to 5,541 kg, respectively.

The relatively small size of *C. bairdi* found in Rivers Inlet compared to those in Alaska and the lack of significant abundance of legal males raises doubt whether a future fishery for Tanner crabs in Rivers Inlet would be economically viable.

RÉSUMÉ

Pêches et Océans Canada (MPO) et la Wuikinuxv Nation ont entrepris la première étape d'une évaluation coopérative du crabe des neiges du Pacifique de la zone côtière, *Chionoecetes bairdi,* en vue de l'établissement possible d'une pêche de ce crabe dans le bras de mer Rivers (C.-B.). L'initiative fait suite à l'examen, à l'étape préliminaire, de la documentation sur *C. bairdi*, réalisée par Krause et coll. (2001). Le présent document apporte de nouvelles données sur la répartition, l'abondance et les caractéristiques biologiques de *C. bairdi* dans le bras de mer Rivers.

Les résultats des relevés exploratoires au casier et au chalut, ainsi que d'un programme de marquage et recapture effectués entre janvier 2004 et mars 2005 par le MPO et la Wuikinuxv Nation y sont présentés. La pêche aux casiers a permis de capturer plus de mâles que de femelles *C. bairdi* (5.27:1). Le chalutage s'est révélé inefficace pour la capture des crabes des neiges du Pacifique. On a observé *C. bairdi* tout le long du bras de mer Rivers (sauf dans le détroit de Fitz Hugh), quoiqu'on ne puisse pour autant parler de surabondance. Les crabes étaient davantage concentrés dans certains endroits que dans d'autres; ils étaient notamment plus abondants dans le bras Draney et dans le chenal Darby. On a trouvé *C. bairdi* à des profondeurs allant de 36 à 340 m, les mâles étant le plus abondant entre 50 et 150 m et les femelles, entre 100 et 200 m.

La taille des mâles *C. bairdi* capturés dans le bras de mer Rivers variait entre 4 et 137 mm de largeur de carapace (LC). La taille moyenne à 50 % de maturité était de 94 mm LC pour les mâles et de 81 mm LC pour les femelles. On estime le taux de croissance des mâles adultes à 20 %. À partir de cette information, on a établi la limite de taille minimale des mâles à 113 mm LC, en prévoyant une augmentation de la taille à la maturité équivalente à la valeur d'une mue, afin de laisser aux crabes une saison de reproduction. L'existence d'une dernière mue après la maturité demeure une présomption réfutable.

Nos données montrent qu'une faible proportion de mâles matures muent à n'importe quel moment de l'année, la mue pouvant même se produire au printemps ou en été. La reproduction dans le bras de mer Rivers a lieu à l'automne et la ponte, au printemps. L'estimation du taux de mortalité naturelle (*M*) des crabes des neiges du Pacifique mâles se situe entre 0,69 et 1,12. Les activités de marquage ont révélé que les déplacements du crabe des neiges du Pacifique variaient entre 0 et 4 592 m, sur une période de 4 à 422 jours. Les crabes ne se sont pas déplacés entre les principaux secteurs du bras de mer Rivers.

Une technique de marquage et recapture utilisée au cours de plusieurs relevés a servi à estimer la population de crabes des neiges du Pacifique mâles dans le bras de mer Rivers. Au total, 1 315 crabes (1 055 mâles et 260 femelles) ont été marqués et remis à l'eau au cours de six relevés de recherche dans le bras de mer Rivers. Vingt d'entre eux ont été récupérés au cours des relevés et six, par le public. L'estimation de la population de crabes des neiges du Pacifique mâles de plus de 55 mm LC dans le bras de mer Rivers est de 37 907 (entre 28 483 et 56 650). Le nombre et la biomasse totaux de mâles de taille légalement exploitable (≥ 113 mm LC) ont été évalués à 7 178 à 9 553 poissons (IC de 95 % inférieur et moyenne) et à environ 4 163 à 5 541 kg, respectivement.

La taille relativement petite des crabes *C. bairdi* du bras de mer Rivers, par rapport à ceux de l'Alaska et le peu d'abondance de mâles de taille légale soulèvent des doutes quand à la viabilité économique d'une pêche future des crabes des neiges du Pacifique dans le bras de mer Rivers.

INTRODUCTION

Crab fisheries have long been important in British Columbia (B.C.) with aboriginal harvests pre-dating European contact and commercial harvests reported as early as 1885 (Butler 1984, 1986; Winther and Phillips 2002). The most important crab species harvested commercially, recreationally, and by First Nations in B.C. is the Dungeness crab (*Cancer magister*). In 2003, Dungeness crabs ranked first among all Pacific Region wild shellfish fisheries in total landings (7,000 tonnes) and in landed value ($37.8 million CDN) (MAFF 2003). Dungeness crabs represented 31.7% of the total landed value ($119.3 million CDN) of all B.C. shellfish species. Other crab species fished under the "R" license are the red rock crab (*Cancer productus*), red king crab (*Paralithodes camtschatica*), and the golden king crab (*Lithodes aequispina*).

Tanner and snow crabs (*Chionoecetes* sp.) are important commercially exploited species in Alaska, Japan, and the Atlantic region of Canada. Prior to 1993, permits were issued by Fisheries and Oceans Canada (DFO) to fish inshore Tanner crabs (*Chionoecetes bairdi*) in B.C. In 1993, DFO suspended the issuance of permits for Tanner crabs through a moratorium on new shellfish licenses, although landings of *C. bairdi* continued until 2000 (Krause *et al.* 2001; Winther and Phillips 2002). A review of commercial sales slip data for B.C. revealed 65 landings of *C. bairdi* from 1988 to 2000 totaling 14.85 tonnes (Krause *et al*. 2001). Tanner crabs were exclusively fished from the North Coast, Pacific Management Fishery Areas (PFMA) 1 to 6, usually in the red king crab fishery. Responses from a questionnaire to "R" license fishers showed incidental catches of Tanner crabs occurred in most areas of the coast.

Interest in developing a fishery for *C. bairdi* occurred when Tanner crabs were caught incidentally in other crab fisheries. In the early 1980's, DFO conducted several surveys for *C. bairdi* throughout the Central and North Coast of B.C. and found no significant commercially exploitable populations (Butler 1986). More recently, interest in developing a fishery for *C. bairdi* has surfaced as local communities and First Nations explore new fishery resources to increase economic opportunities (Krause *et al.* 2001).

Investigations for any new or developing invertebrate fishery in Canada follow a phased approach. The Pacific Scientific Advice Review Committee (PSARC) has endorsed a three-phased framework for provision of scientific advice for the management of new fisheries (Perry *et al*. 1999). This framework guides development of new fisheries using precautionary risk averse principles based on sound scientific research and advice.

The Phase 0 information review for *C. bairdi* was completed by Krause *et al*. (2001). The paper recommended fishery development based on local reproductive biology; use of standardized gear for obtaining information on distribution, biological characteristics, stock structure, and life history strategy; tagging studies to investigate population size, stock structure, and seasonal migrations; and a biological sampling program.

As part of this phased approach, DFO and the Wuikinuxv Nation have undertaken a cooperative Phase 1 assessment of *C. bairdi* (from herein called Tanner crab) in the traditional territory of the Wuikinuxv Nation, located in the Central Coast region of B.C. (Figure 1). The purpose of this paper is to present Tanner crab biological and catch information from trap and trawl surveys of the Rivers Inlet system, including Fitz Hugh Sound, and from a mark/recapture program. This information will allow managers and stakeholders to assess the viability of a new commercial fishery for Tanner crab in Rivers Inlet, B.C.

Specific objectives of this paper include:

- assessing Tanner crab distribution and relative abundance;
- presenting biological information on Tanner crabs such as size distribution, growth, sex ratios, moult timing, reproduction, disease, size of maturity, natural mortality, and movement;
- determining Tanner crab population size in the Rivers Inlet system; and
- determining species interactions in the Rivers Inlet system and Fitz Hugh Sound.

Tanner Crab Biology

Inshore Tanner crabs belong to the family Majidae. Majid or spider crabs are true crabs, having four sets of walking legs and two claws unlike Lithodid crabs (Family Lithodidae), which have three sets of walking legs and two claws. Four species of *Chionoecetes* crabs are found in the eastern Pacific Ocean: *C. bairdi,* or inshore Tanner crab; *C. opilio*, or snow crab; *C. tanneri*, or grooved Tanner crab; and *C. angulatus*, or angle Tanner crab (Jadamec *et al*. 1999). Three of these species (*C. bairdi*, *C. tanneri* and *C. angulatus*) are found in B.C. waters (Hart 1982).

Inshore Tanner crabs are distributed in the North Pacific Ocean from Oregon to the Bering Sea. In B.C., *C. bairdi* are found throughout coastal inlets and fjords at depths of 10-475 m, although some have been recorded in offshore areas of the coast. The grooved Tanner crab (*C. tanneri*) and angle Tanner crab (*C. angulatus)* are distributed in the North Pacific Ocean along the continental slope from Mexico to the Gulf of Alaska at depths of 400-1,944 m and 900-3,000 m, respectively (Hart 1982).

C. bairdi is distinguished by its orange-brown colour dorsally, pink-cream colour ventrally and relatively flat branchial lobes. The deepwater species (*C. tanneri* and *C. angulatus*) are red or orange in colour and have enlarged branchial lobes (Hart 1982; Jadamec *et al*. 1999).

Crabs grow incrementally by moulting or shedding the old shell and expanding into a soft new shell, which then hardens. The stages of growth between moults are referred to as instars. Female Tanner crabs pass through 12 instars and terminally moult to maturity in the 13th instar at approximately 5 years of age (Jadamec *et al*. 1999). Males mature in approximately 6 years after as many as 18 moults; whether males undergo a terminal moult is still unknown. Shell hardness is a subjective categorical scale used to estimate the amount of time since the last moult. A gestalt of information, including resistance to pressure, wear or abrasion of carapace spines, dactyl tips and claws, colour, presence and size of epibiont fauna, and relative morbidity are used to assign crabs to shell hardness categories (Fong *et al.* 2004, 2005).

The sexes are distinguished by a broadened abdomen in females (to carry eggs after extrusion) and enlarged chelae in mature males. Measurements of the fifth abdominal somite and the claws are used to determine morphological maturity of female and male crabs, respectively. Grasping behaviour during mating, in which males grasp and hold females by their walking legs, leave distinctive mating marks on the female. Colour is used to estimate the stage of development of eggs; newly extruded eggs are orange and gradually darken to brown as prezoeae develop and eyespots appear. Adult male, *C. bairdi* range in size from 90-140 mm carapace width (CW) while adult females range in size from 65-110 mm CW.

METHODS

Data Sources

The Wuikinuxv Nation Fisheries Program (WNFP) conducted two systematic trap surveys of the Rivers Inlet system from the F/V WESTERN BOUNTY, a 16.7 m trawler/trapper, between January 20 – February 20, 2004 and September 2-14, 2004.

DFO Marine Ecosystems and Aquaculture Division (MEAD) conducted two trawl and trap surveys from the CCGS R/V NEOCALIGUS, a 25 m trawler/trapper from March 10-16 and December 2-9, 2004. DFO conducted a survey aboard the NEOCALIGUS from March 17-24, 2005. DFO also conducted a short trap survey of Darby Channel and Upper Rivers Inlet from the CCGS R/V VECTOR on June 4 and 5, 2004.

Reviews of shrimp trawl and prawn fisheries logbooks showed limited commercial effort in the Rivers Inlet area. A larger commercial shrimp trawl fishery takes place in Fitz Hugh Sound. A review of commercial Dungeness crab fishery logbooks revealed generally minimal commercial effort and none since 2002.

A review of the Option B groundfish trawl observer data (1996-2003) showed no records of Tanner crab bycatch, although observer coverage was minimal.

Study Area

The study area includes Rivers Inlet (center approximately 51°38, 127°32) and Fitz Hugh Sound (center approximately 51°42, 127°57) located in the Central Coast region of B.C (Figure 1). The study area is approximately 642 km^2 and maximum depth is 395 m. This area was chosen at the request of the proponents.

The study area was divided into 10 subareas: Upper and Lower Moses Inlet (Figures 2 and 3), Hardy Inlet (Figure 4), Upper Rivers Inlet (Figure 5), Middle Rivers Inlet (Figure 6), Lower Rivers Inlet (Figure 7), Draney Inlet (Figure 8), Darby Channel (Figure 9) and Fitz Hugh Sound (Figures 10 and 11).

Survey Design

Trap Survey

The WNFP trap survey utilized Tanner traps with closed escape ports. Tanner traps were nesting 1.35 m square pyramidal top-loading traps with 7.0 cm mesh. Tanner traps were baited with 1.0 kg of herring in 1.0 L perforated bait jars and baits were used only once. Soak times were approximately 24 hours.

Tanner traps were deployed either on individual buoylines (single sets) or on groundlines buoyed at both ends. Five Tanner traps were deployed singly across estuaries or in narrow channels at depths of approximately 50 and 100 m with 50-300 m spacing depending on the available area. Groundlines were deployed at specified depths throughout the study area with five Tanner crab traps attached at 80 m spacing along the groundline.

DFO trap surveys utilized three trap types: Tanner, Dungeness, and prawn traps. Dungeness and prawn traps were used because Tanner crabs are caught incidentally in these fisheries. Prawn traps, because of their smaller mesh, were fished to capture small crabs. Tanner traps were 1.22 m base, square pyramidal metal frame nesting traps with 7.0 cm nylon mesh. Dungeness traps were circular stainless steel traps with single wire 6-8 cm stainless steel mesh and two triggered tunnels. Prawn traps were stainless steel circular, stackable traps with 1.9-2.9 cm nylon web. Tanner traps were baited with two 0.5 L perforated bait jars each containing 0.5 kg of herring while Dungeness traps were baited with 0.5 kg of herring in 0.5 L perforated bait jars. Prawn traps were baited with one can of cat food grade tuna. Escape ports were closed on all traps, except on prawn traps which were not equipped with escape ports. Baits were used only once and soak times were approximately 24 hours.

Each groundline was deployed with 10 traps consisting of 4 Tanner, 3 Dungeness, and 3 prawn traps attached alternately along the groundline beginning and ending with a Tanner trap. Spacing between traps was approximately 40 m.

For the WNFP and DFO surveys, random sites or locations were not chosen due to the limited knowledge of Tanner crab distribution in the study area. Sampling locations were based on habitat type, depth, vessel capability, local First Nations traditional knowledge, and replication of sets from previous surveys to recapture tagged crabs. All areas were stratified by depths at 50 or 100 m intervals up to the maximum depth in each inlet or channel. Each inlet and channel was subdivided into three or more areas with sampling usually occurring at either end of the inlet and in the middle.

Additional considerations for NEOCALIGUS set locations included sampling for juveniles. Depths shallower than 50 m were not sampled by the NEOCALIGUS due to vessel size and lack of local knowledge.

During the NEOCALIGUS March 2005 survey we chose not to tag captured Tanner crabs except for those in Darby Channel and Upper Rivers Inlet since it was our last scheduled survey in Rivers Inlet. Both areas were sampled twice during the survey, however only those Tanner crabs captured at the beginning were tagged and released. Tanner crabs captured during subsequent sampling of Darby Channel and Upper Rivers Inlet were not tagged. Tanner crabs captured in all other areas were released, but not tagged.

Catch rates from all trap surveys were calculated by dividing the total number of Tanner crabs captured by the total number of Tanner traps fished. Dungeness and prawn trap catches were very low and, therefore, not used in CPUE calculations. Catch rates were also calculated for larger crabs (≥ 113 mm CW) by the same method. This size was selected as an expected size limit determined from size of maturity data. Catch rates were summarized by depth stratum (Table 1) and by subarea (Figures 1-11).

Trawl Survey

The purpose of trawling with the shrimp net was to determine densities of *C. bairdi.* The smaller, more versatile beam trawl was used to capture juvenile Tanner crabs. Trawling was conducted from the NEOCALIGUS during the March and December 2004 surveys only. The March survey utilized a shrimp trawl, while the December survey utilized a shrimp trawl and a small beam trawl.

The shrimp trawl was a 13.4 m net fished with 1.7 m^2 Thyboron trawl doors (Fong *et al*. 2004, 2005). The net was rigged with 20.3 cm bobbins in the bosom, the head rope was 12.5 m and the foot rope was 13.1 m. The wings and body of the net were constructed of 5.0 cm polypropylene web. The codend was built of 5.0 cm web and equipped with a 1.3 cm mesh codend liner. Sweeps and bridles were 27.4 m in length. The vertical opening of the net was approximately 3.1 m.

The beam trawl was a 3 m modified Armstrong beam trawl rigged with two 7.62 cm cork head rope floats. The wings and body of the net were constructed with 1.27 cm knotless nylon web and the codend was lined with 0.64 cm nylon web.

Considerations for trawl locations included sampling for juveniles and inventory of benthic communities. Actual suitable trawl locations were determined by the Fishing Master, through use of marine charts and a depth sounder, to avoid logs and net damage. If a set location was determined unfishable an adjacent location of similar depth was selected.

Biological Sampling

Biological sampling methods are described in Fong *et al*. (2004, 2005), Workman *et al*. (2000, 2001) and Jadamec *et al*. (1999). We also followed methods developed by DFO Marine Ecosystems and Aquaculture Division (MEAD), Pacific Biological Station (PBS) for sampling Dungeness crabs. Description of biological characteristics and field codes are in Fong *et al*. (2004, 2005).

All crabs caught were sampled for biological and morphometric information which included: species, sex, shell condition, injuries, missing limbs, carapace width (CW) inside the spines, and carapace length between rostrum notch (CNL) and the mid-dorsal edge of the carapace. Individual weights of Tanner crabs were only taken by DFO and measured to the nearest 5 g. Additionally, for males, the height (CH) and length (CL) of the right claw were measured to the nearest 1 mm with steel vernier calipers. If the right claw were missing the left claw was not measured. For females, abdominal width (AW) was measured and the presence of eggs and their respective colour noted.

Maturity

Male Tanner crabs

Male Tanner crabs undergo a maturity molt during which the allometric relationship between CW and CH increases disproportionately. Crabs are believed to be sexually mature after this moult (Stevens *et al.* 1993).

To determine size at morphometric maturity for Rivers Inlet male Tanner crabs, we used modeling results (discriminant score) and in situ observations (CH/CW ratios) derived from research conducted on male *C. bairdi* around Kodiak Island, Alaska by Stevens *et al*. (1993).

1) Discriminant Score

Stevens *et al*. (1993) calculated the discriminant score using:

$S = 49.01950 - 20.89673(\ln CW) + 16.36468(\ln CH)$.

Where S = discriminant score, CW = carapace width exclusive of spines, and CH = chela height.

They found that juveniles have discriminant score values less than -0.6 and morphometrically mature males have values greater than -0.6. For the purposes of this analysis they only considered that male Tanner crabs must also be greater than 75 mm CW to be considered mature.

2) CH/CW ratios

Stevens *et al.* (1993) (see also Paul and Paul 1996a) determined from in situ observations that most morphometrically mature grasping male *C. bairdi* had CH/CW ratios >0.17 and CH >17 mm. Males Tanner crabs were also greater than 75 mm CW.

For male Tanner crabs the best estimate of the median size of maturity is the size of 50% maturity (Somerton 1980). To estimate the size of 50% sexual maturity (SM_{50}) for the above two techniques, the x-axis was transformed back to a linear scale and divided into millimeter size intervals. For each interval the proportion of the data classified as mature was determined. A logistic function was fit to these proportions. The resulting equation was used to find the size at which 50% of the individuals were mature.

a) Mean size adult males and midpoint

There is some debate in the literature whether male Majid crabs undergo a terminal moult at maturity (see Donaldson *et al.* 1981; Conan and Comeau 1986; Dawe *et al.* 1991; Stevens *et al.* 1993; Paul and Paul 1995). If there is a terminal moult in *C. bairdi* males at maturity, then the mean size of mature (grasping) crabs would be an appropriate measure of male size at sexual maturity (Stevens *et al*. 1993). We determined the mean size of adult male crabs based on the maturity values determined by the above two methodologies.

Without being able to resolve the issue whether a terminal moult exists, then it would be precautionary to assume the mean size of maturity for male crabs lies somewhere between SM_{50} and the mean size of mature males (Stevens *et al*. 1993).

Female Tanner crabs

Female *C. bairdi* do not moult after reaching maturity. Determination of maturity in female Tanner crabs is based on a comparison of the width of the 5th abdominal segment to CW. For females the best estimate of size of maturity is either the median size of adults or, since size distributions of adult females are nearly symmetrical, the mean size of adults (Somerton 1980; Somerton 1981a; Stevens *et al.* 1993). In this study we used the mean size of adult females that were carrying eggs or spent to ensure we were including only mature females.

Natural Mortality

The instantaneous annual rate of natural mortality (M) was calculated in the following ways:

1) Hoenig's (1983) equation calculates M using the maximum age of Tanner crabs:

$$\ln(M) = 1.44 - 0.982 \ln(t_{max})$$

Where t_{max} = maximum age.

2) Zhang's *et al.* (2002) equation is a modification of Gulland's (1983) estimation procedure for Z:

$$M = -\frac{365}{n} \times \ln\left(\frac{CPUE_{survey2}}{CPUE_{survey1}}\right)$$

Where n = number of days between trap survey 2 and trap survey 1.

Changes in trap CPUE data were analyzed between surveys that took place at two points in time. The average time between surveys was 203 days (range 84 to 365 days). Trap CPUE data collected by DFO research vessels (NEOCALIGUS and VECTOR) were analyzed separately from data collected by the WNFP to ensure that fishing gear and practices were standardized as much as possible.

Changes in trap CPUE were calculated in two ways: a) CPUE estimates from surveys at two points in time in particular inlets were used, the assumption being crabs move around in inlets, but would remain in a particular inlet and, b) only those trap sets repeated at the same location between two sampling intervals were used, the assumption being crabs are quite sedentary.

The calculated values of M would also include moulting crabs because we could not detect a particular time between two surveys when a definite moult took place. Natural mortality was calculated for male Tanner crabs only.

Instantaneous total mortality rate (Z):

$$Z = F + M$$

Where F = fishing mortality. We assumed F = 0 because there was little or no commercial fishing in Rivers Inlet. It is unlikely that any incidental catch of Tanner crabs would be retained. Therefore Z = M.

Actual total mortality rate (A):

$A = 1 - e^{-z}$

Survival rate (S):

$S = e^{-z}$

Tagging and Recovery

Research Surveys

Prior to commencing the tagging study in Rivers Inlet, we collected 20 Tanner crabs (both males and females) near the southern Gulf Islands in the Straight of Georgia and held them in a tank at PBS. The purpose was to test our tagging methodology to determine if immediate (< 7days) mortality or tag loss occurred.

In Rivers Inlet, live uninjured Tanner crabs captured during trap sampling were tagged using individually numbered, highly visible (blue) 1.6 cm Floy® T-bar tags (Model FD-94, Floy Tag & Mfg., Inc.). Dead, injured or moribund crabs were not tagged. Methods for tagging Tanner crab during this survey follow those described in McBride (1982) and Taylor (1982). T-bar tags were inserted in the right posterior suture line under the posterior margin of the carapace. The needle of the tagging gun (Model Mark III Regular Pistol Grip, Floy Tag & Mfg., Inc.) was inserted at an upward angle just above the 4th walking segment and just below the carapace through the suture line. Crabs were tagged and released following biological sampling. Tagged crabs recovered in surveys were sampled for biological information, the tag number recorded, and then re-released.

Other Fisheries

A reward program was implemented to encourage fishers to return specific geographic information and fishing method when tagged crabs were captured during fishing. The program targeted local First Nations and recreational fishers and ended March 31, 2006. Reward posters were placed at the Post Office at Dawson's Landing, at the Wuikinuxv band office, at DFO Fisheries Offices in Port Hardy and Bella Coola, and distributed to all the recreational fishing lodges throughout the Rivers Inlet area.

Tanner Crab Abundance

Mark/Recapture Model

A multiple census mark-recapture technique was used (Norris 1972). In general, Tanner crabs were captured, tagged, and released on several occasions with the number of tagged and unmarked crabs recorded for each sample. Over time the number of tagged crabs in the population generally increased.

Population estimates for male Tanner crabs in Rivers Inlet were calculated using Schumacher and Eschmeyer’s Estimate (Ricker 1975) with the following assumptions:

1) The population is closed;
2) Mortality (fishing and natural) is the same for tagged and unmarked crabs;
3) All crabs, whether tagged or unmarked, have the same probability of being caught;
4) Crabs do not lose their tags over the study period;
5) All tags are reported when tags are recaptured;
6) Tagged crabs are randomly distributed throughout the population;
7) Recruitment equals natural mortality.

The reciprocal of 1/N is the population estimate N.

$$\frac{1}{N} = \frac{\sum(T_t R_t)}{\sum(C_t T_t^2)} \tag{1}$$

Where T_t = total tagged crabs at large at the start of the tth sampling interval, C_t = total number crabs caught at time t, and R_t = number of tagged crabs in the sample C_t.

Some of the crabs tagged and released would have died due to natural mortality. To estimate this impact on T_t:

$$T_t = \sum(p_{t-1}\, e^{-Mt}) \tag{2}$$

Where p_{t-1} = number of crabs tagged and released at the t-1 sampling interval, M = natural mortality rate, t = length of time crabs released (no. days/365).

To calculate the variance of 1/N:

$$s^2 = \frac{\sum(R_t^2 / C_t) - (\sum R_t T_t)^2 / \sum(C_t T_t^2)}{m-1} \tag{3}$$

Where s^2 = the mean of the squares of deviations from the line of R_t / C_t against T_t, m = number of catches examined.

Confidence limits were determined for 1/N which is more symmetrically distributed (DeLury 1958).

The variance of 1/N is:

$$\frac{s^2}{\sum C_t T_t^2} \tag{4}$$

For computing limits of confidence for 1/N from (4), t-values are used corresponding to m-1 degrees of freedom. Confidence limits for N are found by inverting those obtained for 1/N.

RESULTS

Trap Survey

The WNFP conducted two trap surveys from the F/V WESTERN BOUNTY between January 20 – February 20, 2004 and September 2-14, 2004.

During the January/February survey, the WNFP deployed a total of 568 traps of which 417 were Tanner traps on 84 groundline sets, 5 sets of Dungeness traps totaling 47 traps and 22 sets of single Tanner traps totaling 104 traps (Table 2). Forty-eight of the 106 sets captured Tanner crabs while none of the Dungeness trap sets captured Tanner crabs. Depths sampled ranged from 7-370 m. Tanner crabs were captured in depths from 36-340 m.

The WNFP deployed 73 trap sets totaling 361 Tanner traps during the September survey (Table 2). Forty of the 73 sets captured Tanner crabs. Depths sampled ranged from 24-391 m. Tanner crabs were captured in depths from 55-311 m.

DFO conducted three trap surveys from the NEOCALIGUS between March 10-16, 2004, December 2-9, 2004 and March 17-24, 2005. There was also a short survey conducted from the VECTOR on June 4-5, 2004.

Two hundred and thirty-two traps on 22 sets were deployed during the NEOCALIGUS March 2004 survey (Table 3). Eighteen of the 22 groundline sets captured Tanner crabs. Depths sampled ranged from 55-330 m. Tanner crabs were captured in depths ranging from 65-320 m.

The NEOCALIGUS deployed 291 traps on 30 groundline sets during the December 2004 survey (Table 3). Twenty-three of the 30 groundline sets captured Tanner crabs. Depths sampled ranged from 67-207 m. Tanner crabs were captured in depths ranging from 67-207 m.

During the NEOCALIGUS March 2005 survey, 416 trap sets on 42 groundlines were deployed (Table 3). Thirty-four of the 42 groundline sets captured Tanner crabs. Depths sampled ranged from 65-210 m. Tanner crabs were captured in depths ranging from 65-210 m.

The VECTOR June 2005 survey deployed 80 traps on 8 groundlines (Table 3). Only Darby Channel and Upper Rivers Inlet were sampled. Tanner crabs were captured in all sets. Depths sampled ranged from 61-137 m.

<u>Tanner Crab Catch Rates</u>

By Depth

Mean Tanner crab catch rates ranged from 0 to 4.14 ± 4.36 SD in stratum 3 (100-149 m) for males and 0 to 0.63 ± 1.41 SD in stratum 4 (150-199 m) for females in all surveys (Tables 4-9). Mean catch rates of legal male Tanner crabs (≥ 113 mm CW) for all surveys were highest in strata 2 and 3 (50-150 m) except from the WFNP January/February survey where stratum 4 had the highest average catch rate 1.28

± 2.15 SD (Table 7). Mean catch rates for females differed slightly; the highest catch rates occurred in strata 3 and 4 (100-200 m). Overall, very few Tanner crabs were caught in strata 1 and 6.

By Area

Mean catch rates for males varied considerably between areas ranging from 0 to 6.73 ± 4.55 SD (Tables 10-15). Mean catch rates for females ranged from 0 to 0.65 ± 0.99 SD. No Tanner crabs were caught by trawl and trap gear in Fitz Hugh Sound and the mean catch rates of males and females were near zero in lower Rivers Inlet. Overall, mean catch rates for males were consistently highest in Draney Inlet and Darby Channel. For large male Tanner crabs (≥ 113 mm CW) the mean catch rate was 2.09 ± 3.02 SD.

The catch rates for females were variable between areas except in Fitz Hugh Sound where no crabs were caught.

Species Associations

Bycatch of species was recorded as an aggregate for each string of gear. The most numerous species encountered during the WNFP trap surveys were Dungeness crabs (*Cancer magister*) followed by spot prawns (*Pandalus platyceros*), squat lobsters (*Munida quadrispina*) and heart urchins (*Brisaster latifrons*) (Tables 16 and 17). Tanner crabs were usually the second most encountered species behind Dungeness crabs which were mostly captured when sampling occurred in shallower waters (<50 m) near estuaries. Other crab species encountered included brown box crabs (*Lopholithodes foraminatus*), decorator crabs (*Oregonia gracilis*), graceful crabs (*Cancer gracilis*), hermit crabs (*Paguridae*) and red claw crabs (*Chorilia longipes*). The few fish species encountered included darkfin sculpins (*Malacocottus zonurus*) and quillback rockfish (*Sebastes maliger*).

The most numerous species caught during DFO trap surveys were squat lobsters, spot prawns, and Dungeness crabs (Tables 18-20). Squat lobsters and spot prawns were almost entirely captured with prawn traps. Other species of crabs captured were brown box crabs, red claw crabs, toad crabs (*Hyas lyratus*) and hermit crabs. Fish bycatch was low and consisted of quillback rockfish, yelloweye rockfish (*Sebastes ruberrimus*), and darkfin sculpins.

Trawl Survey

Thirty-one tows were made from the NEOCALIGUS between March 10-16, 2004 of which 30 were successfully completed (Table 21). Tanner crabs were captured in 13 of 31 tows. Depths sampled ranged from 77-337 m. Tanner crabs were captured in depths ranging from 79-328 m. Forty Tanner crabs were captured by trawling.

Eight tows were made by the NEOCALIGUS from December 2nd to 9th , 2004 of which 6 were successfully completed. Tanner crabs were captured in 4 of 8 tows. Depths sampled ranged from 68-334 m and Tanner crabs were caught in depths from 145-334 m. Thirty-nine Tanner crabs were captured by trawling.

Eight beam trawl tows were made by the NEOCALIGUS from December 4th to 8th , 2004. Tanner crabs were captured in 4 of 8 tows. Depths sampled ranged from 43-102 m and Tanner crabs were caught in depths 43-68 m. Twenty-eight juvenile Tanner crabs were captured by beam trawling; they ranged in size from 4 to 89 mm CW.

Biomass Estimation

Trawling using the 13.4 m shrimp net proved ineffective at catching Tanner crabs. In many instances, trawling failed to capture Tanner crabs while traps deployed at the same sites were successful at capturing crabs. We decided not to compute density estimates from trawling due to the low numbers of Tanner crabs caught which would likely result in an underestimation of Tanner crab biomass.

Density estimates of Tanner crabs from beam trawling were not possible because the distance towed could not be accurately determined and this was not the purpose of using this gear type. This type of trawling was used primarily in shallower areas because the net was more maneuverable and the smaller mesh size allowed sampling of a wide range of crab sizes.

Species Associations

The most common fish caught by trawling included spotted ratfish (*Hydrolagus colliei*), Pacific hake (*Merluccius productus*), walleye pollock (*Theragra chalcogramma*), slender sole (*Lyopsetta exilis*), spiny dogfish (*Squalus acanthias*), flathead sole (*Hippoglossoides elassodon*), and the blackbelly eelpout (*Lycodes pacificus*) (Tables 22 and 23). Other crab species captured by trawling included squat lobsters, Dungeness crabs, brown box crabs, red claw crabs, and hermit crabs (Tables 22 and 23).

The beam trawl generally caught fewer species than the shrimp trawl net because of its small size. The most common fish species (>2% of the catch) were walleye pollock, slender sole, flathead sole, and blackbelly eelpouts. Crab species included squat lobsters and Dungeness crabs (Table 24).

Tanner Crab Biological Information

Size

Size of *C. bairdi* caught in Rivers Inlet ranged from 4 mm, probably the first instar (Jadamec *et al*. 1999), to 137 mm. Female Tanner crabs ranged in size from 4 to 106 mm (Figure 12). Male Tanner crabs ranged in size from 4 to 137 mm CW (Figure 13). The mean sizes of trap captured female and male Tanner crabs were 79.5 and 102.0 mm CW, respectively. It is important to note that crabs in the size range between 20 and 60 mm CW were not caught by the fishing gear. The mean weight of male Tanner crabs between 113 and 137 mm CW is 580 ± 95 g. This weight will become important later when we discuss the viability of a fishery for Tanner crabs.

Tanner crab carapace length (CNL) was measured to determine the relationship with CW. CNL was linearly related to CW for the size range of trap captured females (n = 28) and males (n = 407). The relationships are expressed by the following equations (Figure 14):

Females: CNL = 1.10 CW + 2.642
Males: CNL = 1.14 CW - 0.0087

The relationship between CNL and CW show that Tanner crabs are wider than they are longer by approximately 13 mm for females and 14 mm for males. The importance of this relationship will be discussed later when we evaluate an appropriate escape ring size.

Growth

The smallest size mode captured in Rivers Inlet was 6 mm, after which modes occurred at approximately 9, 13 and 18 mm. It seems that juvenile Tanner crabs grow on average approximately 44% at each moult up to 18 mm CW. We were unsuccessful at capturing Tanner crabs between 20 and 60 mm so we cannot estimate the growth rate of pre-adults. The next modes captured diverge by sex at 55 mm for females and 67 mm for males. Males continued to grow at a rate of approximately 22% producing modes at 82 and 100 mm, and 20% at a possible moult to 120 mm CW (Figure 13). It could be argued that the broad size range (72-137 mm) of males could represent one mode indicative of a terminal moult.

Females undergo a final moult at a mean size of 80 mm CW. Although there appears to be two modes because of the wide range (65 – 105 mm) (Figure 12), we believe this covers one mode because it is known that female Tanner crabs undergo a terminal moult when mature (Somerton 1981a; Stevens *et al*. 1993).

Two (one female, one male) of the 26 tagged Tanner crabs recovered had moulted and grown (Table 25). The female grew 17.8% in size (68 to 80 mm CW) and its telson size had grown 54.8% over a period of 319 days from January 22, 2004 to December 6, 2004. The female was not carrying eggs and appeared to be immature (as evidence from the abdominal width) when initially tagged and released; however, she was carrying eggs when recovered. The male Tanner crab grew 28.7% (94 to 121 mm CW) in just over a year from March 16, 2004 to March 21, 2005. CL and CH had grown 47% and 50%, respectively. The male Tanner crab had increased in weight by 217% (285 g to 620 g).

Sex Ratio

A total of 1,456 male and 276 female Tanner crabs were captured by trap gear in Rivers Inlet. Male Tanner crabs outnumbered females captured by all trap gear by a ratio of 5.27:1. This suggests that female Tanner do not readily enter trap gear possibly due to competition from males.

A total of 30 male and 49 female Tanner crabs were captured by trawling in Rivers Inlet. Females outnumbered males by a ratio of 1.3:1. This is probably a closer approximation of the naturally occurring sex ratio because trawl gear captures crabs without distinction to sex or size, and there are no aggressive effects associated with attraction to bait.

<u>Shell Condition and Moulting</u>

Shell condition is a subjective evaluation based on the number of well defined criteria (Fong *et al.* 2004, 2005; Jademec *et al.* 1999). The new-shell component of mature male Tanner crabs appears to decrease from 63% in the January WNFP survey to 51% during the DFO June survey and then increase to 76% in the WNFP survey (Figure 15). This may suggest moulting in males occurs during the summer months from July to September.

The proportion of soft-shell male Tanner crabs was consistently about 3-5% of the total catch of mature males in DFO surveys (Figure 16). There were no soft-shell or newly moulted male crabs identified during the WNFP surveys leading us to believe there was a tendency to underestimate the number of soft-shell crabs. These were probably coded as new hard shell rather than new soft-shell. The results from the DFO surveys indicate that a small portion of mature male Tanner crabs moult throughout the year.

One tagged male probably moulted in the summer to a larger size (Table 25). It had a new shell in March 2004 and probably would not have moulted until the shell became worn, possibly at least three months later meaning it probably moulted sometime between June and August. It was an old-shell crab in March 2005 suggesting at least six months of shell wear.

The number of soft-shell female crabs was not consistent from survey to survey. During the DFO March 2004 survey, 11% of the females were soft-shell suggesting that moulting might take place during early spring. However, this was not confirmed by the March 2005 data in which there were no newly moulted crabs (Figure 16). One explanation is newly moulted female Tanner crabs might not be interested in feeding, but rather remain hidden since they are more vulnerable to injuries and predation.

One tagged female moulted to a larger size possibly in the summer (Table 25). It had a new shell in January and may have moulted between May and July to end up with an older shell in December.

<u>Reproduction</u>

From the number of recently spawned-out or spent females, the egg release period for female Tanner crabs in Rivers Inlet appears to be in early spring (Figure 17). Gravid females were captured in every survey; proportions ranged from 25% of the total catch of mature females in March 2005 to 100% in January/February, June, and September 2004. Eggs were typically orange in September and December surveys (Figure 18). More red/brown eggs were observed in January. By March most of the eggs were brown providing further evidence that eggs are released in the early spring.

The proportion of primiparous females (carrying first clutch of eggs) was 34%, multiparous females (berried, older shell) was 61% when data from the six surveys were combined. The proportion of mature females with eggs or spent was 95% indicating that many of the females were being bred.

<u>Disease</u>

One Tanner crab was suspected of having black mat fungus during the DFO March 2005 survey, but examination by the Shellfish Health Program at the Pacific Biological Station determined that it did not have black mat fungus. The histological examination revealed damaged and eroded areas of melanized exoskeleton with associated chitonolytic bacteria and extensive haemocyte infiltration in the underlying connective and muscle tissues (G. Meyers *pers. comm.* 2005).

Maturity

Male Tanner Crabs

A positive relationship exits between CH and CW for male Tanner crabs (Figure 19). However, there is no clear distinction between morphometrically immature and mature individuals as have been reported for Majid crabs. There is much variability in CH for crabs 75 to 95 mm CW. Figure 19 reflects only standardized data collection protocols whereby only those crabs measured by DFO biologists are displayed. CL versus CW was also plotted (not shown) and showed a similar pattern with no definitive breaks in the data points.

Calculated sizes of maturity for male Tanner crabs range from 81 to 108 mm CW depending on the methodology used and whether a terminal moult is assumed to take place (Table 26, Figures 20 and 21).

From the sizes of maturity it was possible to determine size limits using either the size of maturity values or applying a 20% growth rate to the size of maturity value. Size limits range from 81 to 121 mm (Table 26). The proportion of male Tanner crabs available for harvest with these size limits ranges from a high of 93.9% to a low of 10.4%.

Female Tanner crabs

The abrupt increase in AW compared to CW is clearly evident for female Tanner crabs when they moult to maturity (Figure 22). The mean CW of all egg-bearing and spent females (new and older shelled) was 81 ± 6.1 mm (n = 247). The mean size of maturity for female Tanner crabs is 81 mm CW.

Natural Mortality

Depending on whether Tanner crabs live 10 to 17 years in Rivers Inlet, Hoenig's (1983) equation calculates the instantaneous annual rate of natural mortality M from these potential lifespans to range from 0.44 to 0.26. This corresponds to an actual mortality rate ranging between 0.23 and 0.36 and a survival rate ranging between 0.64 and 0.77.

The natural mortality rate based on mean CPUE estimates from trap sets repeated in different subareas or inlets ranged from -0.81 to 4.34. The mean value of M was 0.69. This corresponds to an actual mortality rate of 0.5 and a survival rate of 0.5 based on the assumption that $Z = M$ due to no commercial fishing in the inlet.

The natural mortality rate based on mean CPUE estimates collected from 96 paired trap sets throughout Rivers Inlet ranged from -2.78 to 6.47 (Table 27). The mean value of M was 1.12. This corresponds to an actual mortality rate of 0.67 and a survival rate of 0.33 based on the assumption that Z = *M*.

Predation

Predation is inferred by the species of crab and fish caught by trap and trawl gear. Juvenile *C. bairdi* would be cannibalized by larger Tanner crabs and possibly eaten by Dungeness crabs.

Common fish that probably are predators of Tanner crabs (see also Hart 1973) include the spotted ratfish, sole (slender and flathead), spiny dogfish, blackbelly eelpouts, Pacific halibut (*Hippoglossus stenolepsis*), rockfish (quillback, yelloweye), giant wrymouth (*Cryptacanthodes giganteus*), longnose skate (*Raja rhina*), and darkfin sculpins.

Tagging and Recovery

The results from the tagging mortality experiment indicated the tagging technique did not cause immediate mortality. Of the 10 Tanner crabs tagged and held in tanks, all survived for a minimum of 7 days. No tag loss was observed. However, Stevens (2002) found that tagged Tanner crabs suffered significantly higher mortality than non-tagged crabs during the first 3 months in a controlled study.

Research Surveys

A total of 1,315 Tanner crabs (1,055 males and 260 females) were tagged and released during six research surveys in Rivers Inlet. Tanner crabs were tagged throughout the Rivers Inlet system except in Fitz Hugh Sound where no Tanner crabs were captured. The majority of crabs tagged and released were from Draney Inlet, Darby Channel, and Upper Rivers Inlet. The longest time a crab was liberated between tagging and recapture was 422 days; the shortest time was 4 days (Table 28). During all surveys, 26 Tanner crabs were recovered by trap gear, none by trawling. Of the twenty-six recoveries, 22 were males and 4 were females; two (one female and one male) had moulted and grown (Table 25).

Other Fisheries

Six tagged Tanner crabs were returned by the public. The Tanner crabs were captured in Darby Channel and Upper Rivers Inlet. Three crabs were female and 3 were males, none of which had moulted. There were no Tanner crabs reported from any members of the Wuikinuxv Nation although there was a separate reward program for members of the community.

Movement

Tanner crab movements ranged from 39 to 4,592 m and averaged 1,341 ± 1,371 m (mean ± SD) (Table 28). We excluded crabs recaptured after being liberated less than a week. All recovered Tanner crabs had remained in the same subarea or inlet where they were tagged. Movement appeared to be random; there was little correlation (R^2 = 0.067) between distance moved and the time elapsed between initial tagging and recovery.

Tanner Crab Abundance

Relative Abundance

Catch rates from trap surveys were consistently highest during all surveys in Darby Channel, Draney Inlet and Upper Rivers Inlet (Tables 10-15). There were no Tanner crabs captured in Fitz Hugh Sound by either trap or trawl gear.

Catch rates for male Tanner crabs were highest in depths 50 to 150 m (Tables 4-9). Catch rates for females were generally higher in depths 100 to 200 m.

Mark/Recapture

Male Tanner crabs

In total 1,445 male Tanner crabs were caught during the six surveys (Table 29). Of these 905 crabs were tagged, released and available in the Rivers Inlet system for recapture during the study period. This does not include the 150 crabs tagged and released in March 2005. Only 13 tagged crabs were recaptured which is 1.4% of the total number of tagged crabs available. One tagged male crab was caught by a fisher in May/June 2004 and reported to the DFO. Consequently one crab was removed from the number of tagged crabs available in the population in June and subsequent sampling periods.

The population estimate only includes crabs big enough to be tagged. The smallest male Tanner crab tagged was 57 mm CW.

Assuming a natural mortality rate $M = 0.69$, the population estimate for male Tanner crabs greater than 56 mm CW in Rivers Inlet is 37,907 crabs (28,483 to 56,650).

DISCUSSION

Tanner Crab Distribution

Geographic and Bathymetric Distribution

Tanner crabs were found throughout all areas of Rivers Inlet except in Fitz Hugh Sound. Trap surveys indicate Draney Inlet and Darby Channel had the greatest abundance. Tanner crabs were generally caught on soft mud bottoms in low slope, sheltered inlets and fjords near creek or river mouths. This may explain why there are few Tanner crabs in the larger, more open areas such as Fitz Hugh Sound and lower and middle Rivers Inlet.

Depth distribution for *C. bairdi* in Rivers Inlet from trap and trawl survey data ranges between 36 to 340 m. Hart (1982) reported crabs between 6 to 474 m. Our information from beam trawling found juveniles near shores at depths between 43 to 68 m. Krause *et al.* (2001) stated that juveniles tend to predominate in the shallows up to 3 m, but vessel size limited our ability to sample depths less than 35 m with the beam trawl.

Tanner Crab Movements

Geographic and Bathymetric Movements

No Tanner crabs were found in Fitz Hugh Sound and very few were found in the lower portion of Rivers Inlet indicating that Tanner crabs might not migrate out of Rivers Inlet into open waters. Krause *et al.* (2001) states that Tanner crabs have seasonal migrations patterned around major life history events including hatching, spawning, and moulting. Our tag return information suggests Tanner crabs do not actively move throughout the inlet. This suggests there might be little mixing of adult populations of Tanner crabs and there is one distinct population in Rivers Inlet made up of several smaller sub-populations.

Tanner crabs probably remain in the same area after settlement of larvae although it is well known that *C. bairdi* and other cogeners (for example *C. opilio*) form high-density mating aggregations in Alaska (Stevens *et al*. 1994). We did not see any evidence of seasonal or sexual migration, although it is possible that Tanner crabs reside in one area, migrate to another area for breeding, and then return. Further tag returns might provide more insight on Tanner crab movement patterns.

Stevens *et al*. (1993) suggested there is a migration of Alaskan Tanner crabs toward deeper water with age. Megalops-stage larvae settle in shallow inshore regions. After reaching maturity and undergoing first mating, the majority of males and females probably migrate to water depths greater than 100 m. The results from our catch rate data suggest adult sexes might be segregated by depth. Adult females were found in deeper water than adult males, but some overlap occurs at depths between 100 and 150 m.

Tanner Crab Biological Information

Size

The trap survey data probably provide a true reflection of size of mature adult Tanner crabs for both sexes. The peak abundance of male Tanner crabs is around 100 mm CW. The size range of Tanner crabs 20 to 60 mm CW were missing from our size frequency distribution indicating that traps are not useful for capturing pre-adults, possibly due to selectivity characteristics of trap gear. There might be aggressive competition by larger Tanner crabs for bait.

Comparatively, male Tanner crabs in Alaska are much larger, capable of reaching a size of 200 mm CW (Donaldson *et al.* 1981). The minimum size limit for male *C. bairdi* in Alaska is 140 mm CW.

The largest male caught in Rivers Inlet was 137 mm CW which is smaller than the legal size limit in the Bering Sea. Bigger crabs probably do not exist in Rivers Inlet. Thus Tanner crabs living in the central coast of British Columbia are smaller than those living in colder northern waters around Alaska, although there could be much regional variability in size and growth rates. Somerton (1981b) showed there is regional variability in the size of sexual maturity in both sexes in *C. bairdi* in the eastern Bering Sea.

Growth

Gillespie *et al*. (2004) characterized growth of *C. tanneri* as being quite rapid during early life stages, likely an adaptation in response to predation by numerous flatfish, sculpins, and other fish and is probably the same for *C. bairdi*. Estimates of growth per moult, in percent CW, range from 15 to 32% and decreases with size (Jadamec *et al.* 1999). Our estimates of growth from the size frequency of male Tanner crabs indicate a 45% growth rate for juveniles, 22% for pre-adults, and 20% for a possible moult past morphological maturity. Later stage growth rates could be higher, however, as the tagged crab grew 29% to 121 mm CW (Table 25).

Moulting

Data collected from trap surveys and tagging suggest that a spring or summer moult might occur in the Rivers Inlet population. The proportion of new-shell mature male crabs decreased through the winter and spring surveys, then increased during the September survey. A fishery for *C. bairdi* in Rivers Inlet should avoid soft-shell periods as they are more vulnerable to handling mortality.

Alaskan *C. bairdi* may moult earlier in the year than those in Rivers Inlet. *C. bairdi* held in tanks moulted between January and April which is the breeding period of these species (Paul *et al.* 1995; Paul and Paul 1995). Pubescent females generally mate and moult early in the year (January to May) and over a longer time period than adult females (April to May) (Stevens *et al.* 1993).

Sex Ratio

The trap surveys captured primarily male Tanner crabs suggesting that females do not readily enter traps. If traps had been equipped with escape rings, the catch of females would even be less. Therefore, a trap fishery for Tanner crabs would likely result in minimal bycatch of females. Of concern would be the uncertainty regarding survival of undersized male Tanner crabs that have not yet recruited to the fishery, but would be routinely caught and discarded.

Maturity

Logarithmic plots of chela size versus CW show separation between regression lines for morphometrically immature and mature male Majid crabs such as the inshore Tanner crab (*Chionoecetes bairdi*; Somerton 1980, 1981b; Stevens *et al*. 1993), snow crab (*C. opilio*; Conan and Comeau 1986; Dawe *et al*. 1991; Sainte-Marie *et al.* 1995), and offshore Tanner crab (*C. tanneri*; Workman *et al.* 2000, 2001). However, this relationship was not readily observable in our study even after data were standardized by research vessels to ensure that measurement errors possibly made by inexperienced field personnel were not clouding the results. Paul and Paul (1995) admit that alteration of the male CH with maturity is not an obvious change, like that seen with the female abdominal flap. We measured male CH to the nearest 1 mm (not to the nearest 0.1 mm as suggested by Stevens *et al.*), which may not have been precise enough to detect subtle changes in size. We did however observe abrupt changes in claw height in the field. One tagged male moulted and its CH increased 50% suggesting it moulted from being immature to mature sometime during the year. This crab moulted from an initial size of 94 mm CW. Catching more male crabs 20 to 65 mm CW would have helped us partition the immature and mature crabs better. We might have missed collecting juvenile crabs by not sampling in depths shallower than 35 m where these crabs are more abundant (Stevens *et al.* 1993)

Whether there is a terminal moult at maturity for male Majid crabs has been hotly debated. Conan and Comeau (1986) concluded that *C. opilio* males underwent a terminal moult at maturity like females and this is characteristic of the genus. However, Dawe *et al*. (1991) provided evidence against the idea of a terminal moult in *C. opilio*. The presence of multiple modes among mature *C. bairdi* could result either from males maturing (and undergoing a terminal moult) over at least three instars, as suggested by Comeau *et al*. (1989) or from males continuing to moult and growing after maturity (Donaldson *et al*. 1981). Paul and Paul (1995) showed that functionally mature male *C. bairdi* can molt. They suggested that if there is a terminal moult it probably occurs after they reach the legal size (140 mm CW) in Alaska.

The data collected from this study do not help resolve this issue. No male Tanner crabs greater than 137 mm CW were collected suggesting that there could either be a terminal moult at maturity or one additional moult after they reach maturity. Crabs found over 130 mm CW could have moulted from 105 mm CW to that size (assuming a 25% growth rate). The other possibility is that growth rates might be generally lower and crabs might moult twice from size of maturity to reach the maximum size seen in the Rivers Inlet system. There is evidence of long intermolt periods for large male crabs and these periods might be longer for crabs living in colder waters. Paul and Paul (1995) said males big enough to copulate with multiparous females took more than two years to moult.

In the absence of a clear incremental increase in claw size when male Tanner crabs moulted to maturity, we determined size of maturity using methods developed from Alaskan *C. bairdi* males. If the assumption is that there is no terminal moult at maturity, then the size of 50% maturity was used. It can be interpreted as the size at which a randomly chosen individual has a 50% chance of being mature. It can also be interpreted as the median size of sexual maturity (Somerton 1980). If one assumes there is a terminal moult at maturity, then the mean size of mature crabs is an appropriate size of maturity estimate (Conan and Comeau 1986). Stevens *et al*. (1993) suggested a midpoint between the size of 50% maturity and the mean size of mature crabs as a compromise between the two methods.

The discriminant score (*S*) type of analysis calculated a SM_{50} = 81 mm CW which we believe is too small for the Tanner crab population in Rivers Inlet. The size frequency distribution of male crabs shows that 94% of the population captured would be considered mature and this is not realistic considering the number of small clawed crabs observed in the field larger than this size and the lack of crabs smaller than this size.

We believe the size of maturity estimates calculated from the CH/CW ratios are more appropriate for the size frequency of males captured in Rivers Inlet. This method determines which crabs are morphometrically mature and are able to grasp multiparous females (Stevens *et al.* 1993). But Paul and Paul (1995) observed males that had not reached their maximum claw size, but were functionally mature and copulated with primiparous females. This suggests that there are likely smaller male crabs deemed immature by this ratio method that are capable of successfully breeding. Adams and Paul (1983) said male *C. bairdi* as small as 65 mm CW carry functional spermatophores and can successfully fertilize female crabs in captivity. It should be noted Paul and Paul (1995) argued that using the ratio of CH to

CW was not a valid method to assign morphometric maturity; rather the log of CH versus CW should be used. However, they did not have any data to support their claims.

If one assumes there is no terminal moult at maturity in male Tanner crabs, then SM_{50} = 94 mm CW would be an appropriate value to use in the interim until more conclusive data are collected. If one assumes there is a terminal moult to maturity then SM_{50} = 108 mm CW would be the value to use. The midpoint value between these two estimates is 101 mm CW.

The mean size of maturity of male *C. bairdi* in Kodiak, Alaska is 113 mm CW, from three different studies (Brown and Powell 1972; Donaldson *et al.* 1981; Stevens *et al.* 1993). Size in the eastern Bering Sea was determined to be 109 and 117 mm (Somerton 1981b). Because Alaskan Tanner crabs are bigger than those found in Rivers Inlet, it is reasonable that the size of 50% maturity for Tanner crabs in Alaska would be larger than that estimated for smaller crabs in Rivers Inlet.

Females Tanner crabs undergo a true puberty moult (Hartnoll 1978) during which their abdomens increase in size disproportionately more than other body features. Somerton (1981a) said female *C. bairdi* do not moult after maturity, so the best definition of female sexual maturity is the median size of adults because SM_{50} is affected by variation in year class strength and adult mortality. The mean size of adult female *C. bairdi* in the Bering Sea ranged from 80 mm (west) to 93 mm (east) from two different areas (Somerton 1981b). Proportionally females were 76% the size of males at maturity. This lends support to our belief that the estimated size of 50% maturity (94 mm CW) for males is the more appropriate measurement. This means females maturing at 81 mm are 86% the size of males, slightly larger than that reported for more northern Tanner crabs.

Establishing a Size Limit

Justification for establishing minimum size limits is to protect breeding stocks by setting the minimum size limit greater than the size of maturity, but size limits must also recognize the minimum acceptable size for marketing (Donaldson and Donaldson 1992). Size of maturity is important information needed to manage the harvest of a crab species (prevent recruitment overfishing) because from it we can determine a size limit.

Boutillier *et al.* (1998) and Workman *et al.* (2002) suggest one arbitrary level for a size limit is the 50% size of maturity. Based on this, a size of maturity of 112 mm CW was determined for *C. tanneri* and a minimum size-limit of 112 mm CW was established for the experimental fishery in B.C. However, the minimum marketable size for *C. tanneri* in B.C. is about 120 mm CW (C. Berry *pers comm.* 2003).

If we use SM_{50} = 94 mm as a size limit for male Rivers Inlet Tanner crabs, then 73% of the male crabs would be available for harvest. This is a very high proportion of the male crabs.

The legal size at which male *C. bairdi* can be harvested in Alaska is 140 mm CW. The premise is that males should be allowed at least one year for mating after reaching maturity (Somerton 1981b; Stevens *et al.* 1993). The size limit was derived by adding 25 mm to the 110 mm SM_{50} (from Brown and Powell 1972) to account for the expected annual growth of 110 mm males (a 21% growth rate) and 5 mm to account for the maximum difference between the commercial measurement (width including spines) and the scientific measurement (width excluding spines).

If the Alaskan management rationale is applied to Rivers Inlet crabs (the assumption being there is no terminal moult), then the size limit would be 113 mm (based on SM_{50} = 94 mm and a 20% growth rate). This would allow 25.2% of the male crabs to be available for harvest or 7,178 to 9,553 (lower 95% CI and mean) crabs in the inlet. If the assumption is a terminal moult for male crabs, then the size limit would be the size of maturity 108 mm. This would allow 34.5% of the male crabs to be available for harvest or 9,827 to 13,078 crabs. The midpoint estimates that provide a compromise between these two methods, calculates size limits at 101 mm CW (without a year of growth) and 121 mm CW (with a year of growth). This would result in 52.7% and 10.4% of the male crabs being available for harvest, respectively.

Given there is no conclusive evidence that a terminal moult at maturity exists in male Tanner crabs, we advocate a size of 50% maturity of 94 mm CW and a legal size of 113 mm CW. This follows management protocols established for size limits in the Alaskan fishery. The 113 mm CW size limit would allow a conservative harvest of 25.2% of the total male population. The size limit would also protect female crabs from harvest as their maximum size was 106 mm CW.

To evaluate an appropriate escape ring size, we need to understand Tanner crab behaviour. Like most Majid crabs, Tanner crabs walk sideways and *C. opilio* have been observed to walk sideways through escape rings (Winger and Walsh 2005). Based on the CNL of female Tanner crab at 106 mm CW, 110 mm CW for males, and a size limit of 113 mm CW, an escape ring should have at least a minimum inside diameter of 100 mm (5 inches) and be located within the bottom one third of the trap but above the floor to prevent them from getting clogged. A 100 mm escape ring would allow a 95 mm CNL (105 mm CW) female and 100 mm CNL (110 mm CW) male Tanner crab to escape while retaining the minimum legal size male Tanner crab. Escape rings are an important management tool for reducing incidental bycatch and handling mortality of non-target crabs. Handling times and exposure to air are known to significantly increase mortality rates of discards (Carls and O'Claire 1995; Warrenchuk and Shirley 2002).

<u>Shell Condition</u>

As discussed earlier, the presence or absence of a terminal moult in mature male *C. bairdi* is unknown. Data gathered from all surveys show that new-shell adult male Tanner crabs were more abundant than old-shell adult males (n = 847 vs. n = 669) and there appears to be more new-shell males around the size range of 75-90 mm CW versus old-shell males (Figure 13).

Gillespie *et al.* (2004) state if a terminal moult is assumed for *C. tanneri* and there are greater proportions of new-shell crabs, it suggests that males do not live for more than 1 to 2 years after a terminal moult. If they did live longer you would expect to see a larger proportion of old-shell males and less new-shell males. If it is assumed that the data are unimodal, then you would see a broad size range of crabs making up a single cohort all moulting into maturity in a given year. If it is assumed that crabs will likely live for two years, but only rarely live for three years after the terminal moult, then you would expect to see the greatest proportion of terminal moults in new-shell condition, with the old-shell and senescent portions of the population reduced by one or two years of natural mortality.

Alternatively, if a different life history model with skip moults and small moults increments are assumed, you would expect to see nearly the same distribution of size and shell conditions, perhaps skewed to the left. New-shell crabs would be present throughout the distribution as crabs moulted successively to larger sizes, with smaller proportions of old-shell crabs present as each cohort is reduced by natural mortality. Then you might expect that most crabs moult or die after two years until they approach maximum size and that senescent crabs might only be seen near the maximum size.

Gillespie *et al*. (2004) then discuss the implications for assessments depending on whether a terminal moult exists in *C. tanneri*. If there is a terminal moult in *C. tanneri*, then males will remain reproductively active for only two or rarely three years and the maximum age is likely to be 6-7 years. If mature males skip moult and have greatly reduced moult increments, it is possible that maximum life span could be higher with nearly a decade of reproductive output. In the first case, harvest strategies could be more aggressive as natural mortality rates are high and the reproductive pool would replace itself quickly. If the latter is true, harvest strategies must be more conservative to maintain a pool of reproductively active males in the population.

Further tag return information in subsequent years would better confirm whether male *C. bairdi* have a terminal moult at maturity or if they skip moult. The longest duration a tagged mature male Tanner crab was at large before being recovered was approximately 14 months. Tag returns of male Tanner crabs exceeding two years would help confirm and/or disprove the terminal moult hypothesis.

<u>Reproduction</u>

Fishery managers would want to ensure long-term viability of the crab population through protection of reproductive potential. This means ensuring that a very high proportion of female crabs bear full egg clutches each year (Stevens *et al*. 1993). This study, on perhaps a virgin population of Tanner crabs, provides a baseline measurement as to the number of mature females capable of being bred (95%). This aspect of female reproductive potential can be measured and monitored over time throughout a fishery and provide a benchmark as to the impact of removing large numbers of mature males from a population. It is important to note that female Tanner crabs have the ability to store sperm and fertilize multiple clutches from a single breeding event (Paul 1982).

<u>Disease</u>

Meyers *et al*. (1990) highlighted the important role bitter crab disease (BCD) has on *C. bairdi* populations in Alaska. BCD is caused by a *Hematodinium*-like dinoflagellate organism that infects the hemolymph and host tissue and usually results in death of the host (Meyers *et al.* 1990; Eaton *et al.* 1991). Macroscopic symptoms of crabs infected by the dinoflagelatte protozoan are pink carapace or segmented leg joints, chalky-textured meat, and milky hemolymph (Jadamec *et al.* 1999). Meyers *et al*. (1990) reported BCD incidence was quite wide-spread in southeast Alaska and in one area prevalence was found to be 95%. Gillespie *et al.* (2004) suggest that BCD infection may be an important determinant of year-class strength of *C. tanneri* and subsequent recruitment to the fishable population.

Another known lethal disease of *C. bairdi* is black mat fungus caused by *Trichomaros invadens*, which is macroscopically recognized by the black-tar like appearance on the shell of the crab (Hoskin 1983; Jadamec *et al.* 1999).

Disease did not appear to be prevalent through macroscopic observations of Tanner crabs during trap and trawl surveys of Rivers Inlet. It is important to note that trap sampled catches are less likely to capture diseased crabs because they would probably be less active at feeding or have altered behaviour and not readily enter trap gear. Taylor *et al.* (2002) discussed problems and biases associated with selectivity of diseased crabs with trap gear. Overall, not much is known on diseases of *C. bairdi* in B.C. and this aspect of their biology needs to be examined.

Natural Mortality

Natural mortality is assumed to be high for juveniles and low for terminally moulted adult crabs (Workman *et al.* 2000). Longer life spans usually mean lower natural mortality rates, especially for larger terminally moulted crabs. *C. bairdi* in the northern Gulf of Alaska may live 12 years (Donaldson *et al.* 1981), or 14 to 17 years (Somerton 1981; Nevessi *et al*. 1996) and snow crab 19 years (Comeau *et al*. 1991). It is possible that crabs in colder waters live longer than crabs in B.C. waters. Based on the maximum lifespan of Tanner crabs, the population in Rivers Inlet could have M values ranging between 0.44 and 0.32 if they live to be 10 to 14 years old. This is close to the natural mortality rate ($M = 0.3$) estimated for adult Tanner crabs (NPFMC 1998). It is not clear, however, how this estimate was derived. Zheng and Kruse (1999) use $M = 0.4$ for Tanner crabs.

We calculated estimates of M for male Tanner crabs to be 0.69 and 1.12. Tag return data showed that Tanner crabs remained in the same inlet where they were tagged. If Tanner crabs move throughout particular inlets, but do not leave those inlets, then our value of M (0.69) might be a better estimate as it was based on trap CPUE data collected from repeated sampling within the same subareas. Zhang *et al*. (2002) estimated M for non-moulting Dungeness crabs in an unharvested, but highly populated area (Vancouver Harbour), to be 0.71 [over 7 years (1994-2000)]. This is similar to the value we calculated for a relatively undisturbed population of Tanner crab.

Our estimates of M include moulting crabs because we were unable to definitively identify a specific timing of the moult. Moulting crabs are more vulnerable and their mortality rates would be higher than non-moulting crabs. Soft-shell crabs would be more prone to predation from other crabs, fish, octopi, and sea stars. Breeding is also a risky time for male Tanner crabs. Paul and Paul (1996b) showed that male Tanner crabs in tanks have the ability to kill each other in competition for mates.

There would also be some fishing mortality included in our estimate of natural mortality, although it is probably low. There are no fisheries targeting Tanner crabs in Rivers Inlet, including First Nations and recreational fishing. Commercial fishing logbook records show limited shrimp and groundfish trawling, prawn fishing, but no commercial fishing for Dungeness crabs. It is also likely that incidental catches of Tanner crab by any commercial fisheries would be discarded back into the water because Tanner crabs are not yet a desired species. Consequently, the population of Tanner crabs in Rivers Inlet may be a relative unfished or virgin population. Only six tags were returned by the public and none by First Nations even with a reward program in place suggesting that few crabs were caught by commercial or recreational fishers. Of the crabs that were recovered, they were caught as incidental bycatch in prawn and Dungeness crab traps.

The true natural mortality rate of Rivers Inlet Tanner crabs might lie somewhere between 0.4 and 1.12. Estimates of *M* could be improved if sampling can be done during a period when crabs are not breeding or moulting. Improved estimates of natural mortality would be useful to fisheries managers if trap CPUE is used as an index of abundance to manage the fishery.

Predation

Dominant predators of *Chionoecetes* spp. (apart from cannibalism) include skates (Rajidae), eelpouts (Zoarcidae), Pacific cod (*Gadus macrocephalus*) (Yang 2004), sculpins (*Myoxocephalus* spp., *Hemilepidotus* spp., *Dasycottus setiger*), Pacific halibut, rex sole (*Glyptocephalus zachirus*) (Jewett 1982) and octopi (Ellson *et al.* 1950). The Rivers Inlet system has many of these animals listed above: skates, eelpouts, sculpins, halibut, flatfish, and octopi, all of which would eat Tanner crabs. Small juvenile crabs and soft shelled individuals would be most vulnerable to these types of predators.

Tanner Crab Abundance

Relative Abundance

The highest abundance of Tanner crabs occurred in Draney Inlet and Darby Channel and, to a lesser extent, in upper Rivers Inlet. Any future fishery would likely target these areas. It is unlikely fishing would occur in the other areas such as Hardy or Moses Inlets because catch rates from trap surveys indicate very low abundance of male Tanner crabs. There would be no fishing in lower Rivers Inlet and Fitz Hugh Sound.

Population Estimate

Very few Tanner crabs were captured by trawl gear which prevented accurate calculations to be made of crab biomass and density using this technique. The reasons why the trawl gear was unsuccessful at capturing Tanner crabs are unknown, especially since the gear was known to have fished properly. At many sites where trawl catches of Tanner crabs were zero, trap gear set in the same areas caught many Tanner crabs. It is known that adult Tanner crabs partially bury in mud-sand substrates. Females are nocturnally active and remain buried in sediments during daylight hours. Somerton and Otto (1999) state that males are caught more efficiently by trawl nets than females because they are larger and higher off the bottom, less sedentary, and less prone to bury themselves. However, the extent of burying is unknown (Krause *et al*. 2001) and this behavior may be a factor in the catchability of Tanner crabs by trawling. Mud in the trawl net and on traps indicates the substrate in many areas in Rivers Inlet where Tanner crabs were caught was soft and muddy. In addition, preferred Tanner crab habitat might be patchy and the trawl net was not able to regularly find concentrations of crabs.

Since very few female Tanner crabs were collected by both trawl and trap gear, the population estimate was determined for male Tanner crabs only. Catches of females were likely not representative of their true abundance in the population.

Population estimates for each subarea were not possible because of the low number of tag returns. It was assumed each subarea, and Rivers Inlet as a whole, were closed systems. Recaptured crabs support this assumption because the longest distance a tagged crab moved was approximately 4.5 kilometers, with many moving 1.3 kilometers or less. We assumed tagged crabs randomly distributed themselves in the subarea from which they were caught, although not throughout the entire Rivers Inlet system, during the three months between surveys.

Few tag returns suggest the following: the population being studied is quite large, tagged crabs died prematurely, tagged crabs lost their tags, only a small proportion of the population was tagged and there was limited effort to recapture tagged individuals, or there was a catchability issue with tagged animals. Tag reporting rate was not an issue — it was assumed to be 100% because there was little fishing in the area by all sectors (commercial, recreational, and First Nations). Furthermore, there was a well advertised reward program (local and non-local) to encourage fishers to return tags.

The population of Tanner crabs in Rivers Inlet is probably small, as CPUE estimates indicate they were present throughout the inlet, but not overly abundant. Some areas supported more crabs than others — Tanner crabs were most prevalent in Draney Inlet and Darby Channel. Our estimated population size of all male Tanner crabs (>56 mm CW) for Rivers Inlet is 37,907 (28,483, 56,650), of which 7,178 to 9,553 (lower 95% CI and mean) are legal males (≥ 113 mm CW).

Mortality (fishing and natural) was assumed to be the same for tagged and unmarked crabs. Care was taken to insert the anchor tags at an upward angle to avoid puncturing internal organs and killing crabs. There was no commercial fishing for Tanner crabs during the course of the study so fishing mortality was probably low.

It was assumed that crabs did not lose their tags during the study period. We followed similar methods successfully done on *C. bairdi* and *C. opilio* (McBride 1982). Tags inserted through the right posterior suture line assure a high retention rate when the old shell is discarded during a moult. This has also been shown to work with Dungeness crabs (Smith and Jamieson 1989; Alexander *et al*. 2003). After each tag was inserted it, we tugged on it to ensure that it was securely anchored. Crabs without tags were checked for evidence of lost tags.

We tagged 1,315 Tanner crabs from a total catch of 1,765 crabs caught during six research surveys. This low number of crabs caught suggests the population of Tanner crabs is not very high. In total 26 tagged crabs were recaptured. The number of recaptures was very low compared to other tagging studies with Dungeness crabs (Smith and Jamieson 1989; Alexander *et al.* 2003) because there was no commercial fishing in Rivers Inlet to assist in the recovery of tagged crabs. Only one fisher responded to the reward program set up to encourage people to return tags to the DFO. During the course of the study, he caught three Tanner crabs, one being male.

Alaska Tanner Crab Fishery

Tanner crabs are managed in three separate stocks: eastern Bering Sea, eastern Aleutian Islands, and western Aleutian Islands. The Alaskan fisheries are managed by a size/sex/season approach with an additional precaution of establishing target harvest rates. The minimum size limit (140 mm CW) for males allows them to survive at least one mating season (Zheng and Kruse 1999). Male *C. bairdi* sexually mature at 110-115 mm CW and growth during the next moult would increase their size to 135-140 mm CW (Donaldson and Donaldson 1992). Female crabs cannot be harvested. Season openings are set to minimize handling of softshell crabs and maximize meat yield. The surplus quantities of mature male abundance are determined annually by fishery independent trawl surveys (Cavin *et al*. 2004). Preseason guideline harvest levels for male Tanner crabs is based on a mature male harvest rate that ranges from 10-20% for the Kodiak and the Eastern Bering Sea areas, but not more than 30% and 50% of legal male crabs respectively (Hebert *et al.* 2005). Zheng and Kruse (1999) suggested that harvest rates for legal male Tanner crabs should not exceed 50% in Bristol Bay, Alaska and would often be lower depending on reproductive biomass levels. These authors, as well as Somerton (1981), state that yield of legal males is maximized at harvest rates >60%, although harvest rates at these levels could result in insufficient males for mating and lead to recruitment overfishing. Commercial fisheries remain open until the annual guideline harvest level is reached or other biological considerations occur to warrant closure of the fishery.

Other management tools include vessels must be licensed and registered to fish a particular area. Observer coverage is required. There are trap limits based on vessel size. Daily harvest logbooks are mandatory. Rings or mesh are required to optimize the escapement of undersize and female Tanner crabs. A minimum of four 5.0" (110 mm) rings or one third of the web on one panel of 7 ¼" (160 mm) stretched mesh is required on pots. The ADFG recommends placing rings within one mesh of the bottom (Sagalkin 2004). Research dealing with snow crab traps and snow crab behaviour has shown *C. opilio* spent most of their time moving about the floor of the trap (Winger and Walsh 2005). All crab pots must have a degradable escape mechanism (NPFMC 1998).

The Alaskan Tanner crab fishery has experienced large fluctuations in stocks and rapid declines in abundance which has resulted in area closures (NPFMC 1998). It seems that Tanner crab recruitment is highly variable. Recruitment cycles may be long and span 10 to 18 years (Zheng and Kruse 1999).

In 2004 there was no fishery for Tanner crabs in the Bering Sea and the South Peninsula. In the areas Kodiak and the Southeast areas, the total harvest of Tanner crabs was 254 t and 376 t, respectively (ADFG 2005).

Ecosystem Considerations

Incidental catch of females and undersize male Tanner crabs by trap gear is minimal and would even be less with the presence of escape rings. The incidental catch of Dungeness crabs was high, although much of it occurred when sampling shallower waters near estuaries. A fishery for *C. bairdi* in Rivers Inlet would likely avoid Dungeness crabs because the two species live at different depths with Tanner crabs occurring in deeper waters. The bycatch of fish species and other invertebrates was low.

Assessment Considerations

Abundance estimates, either relative or absolute, of *C. bairdi* would likely rely on trap surveys or, possibly, tagging studies. Density estimates from area-swept trawl were not possible given the low success in catching *C. bairdi* with our trawl net. This might not be due to the net's design, but rather to the ability of Tanner crabs to avoid capture by burying themselves in the mud. Patchy concentrations of crabs might also be implicated. A video camera survey in July 2005 attempted to look for Tanner crab *in situ,* but was limited to depths less than 60 m which is outside the Tanner crab's distribution (G. Krause unpubl. data). More precise population estimates, as well as exploitation rates, for the areas targeted by fishers could be determined by local and short term mark-recapture programs.

Using CPUE, as an index of abundance, from trap gear is fraught with problems including hyperstability, unstandardized fishing effort, change in catchability, and gear saturation (Hilborn and Walters 1992). However, if trap gear is used as an assessment tool, then standardization of gear and effort is necessary to understand the relationship between soak times and catch rates. Fishery independent CPUE as an index of abundance is an option where pre-fishery surveys (prior to any commercial harvest) would be necessary to establish initial CPUE levels (harvest rate) and in-season catch sampling for sex and size by at-sea observers to monitor declines in CPUE levels. Commercial CPUE would be weighted against fishery independent CPUE. Some of the critical assumptions with this are: sampling adequately covers the area, populations are closed or immigration and emigration are equal, sampling takes place during non-moulting periods, natural mortality of legal-size crabs is offset by undersize male crabs moulting to legal size, and all crabs above legal size have the same probability of capture.

A summary of other abundance estimation tools available are change-in-ratio methods or index removal methods and are described in Fong and Gillespie (2005).

Lacking or Uncertain Biological Information

There is still considerable uncertainty associated with growth, moulting periods, mating seasons, and natural mortality of *C. bairdi* in Rivers Inlet. The data from trap surveys and tag returns suggest there might be a summer moult period; however, additional tag returns in subsequent years would provide more information on moult timing and growth. More information is needed to determine the natural mortality rate of Tanner crabs, particularly if they are to be managed at a rate based on natural mortality. Additionally, diseases of *C. bairdi* in B.C. are not well known and need further investigation through continued sampling of crabs.

There is some uncertainty with our size of maturity estimates. Because our results are not definitive, examination of gonad condition would allow for the determination of size-at-functional maturity and more measurements relating claw morphology to CW are needed in order to properly model the relationship between the two features.

Additional tag returns would provide information concerning whether males of this species undergoes a terminal moult at maturity. More sampling of large old shell males should include looking for evidence of moulting.

Carapace measurements provided throughout this document refer to CW between the spines (notch-to-notch, NN); however, if a commercial fishery is to take place, it is likely fishers would prefer to use carapace widths inclusive of spines (point-to-point, PP) to speed up processing. This information was not collected during our study. Therefore, it will be important to establish a relationship between NN and PP carapace width measurements.

Future Options

One of the main questions to be addressed in this document is where do we proceed from here. Future development will depend almost entirely on the economic viability of pursuing a fishery for *C. bairdi*. Several factors will need to be considered when determining economic viability.

First to consider is the market demand for a new, generally small-sized crab. Market demand would have to exist for crabs between 113 mm and 130 mm CW (very few crabs were greater than 130 mm CW). By comparison, the minimum marketable size for the deep water Tanner crab, *C. tanneri*, in B.C. from experimental fishing is 120 mm CW. The experimental fishery for *C. tanneri* has not occurred for the past two years for several reasons including low profitability and market demand for the product. Furthermore *C. bairdi* would be in competition with a large, established Alaska Tanner crab and snow crab fishery. Unless a niche market is developed for B.C. inshore Tanner crabs, it is highly improbable a small-sized crab fishery could compete with Alaska. The minimum size limit for male *C. bairdi* in Alaska is 140 mm CW and the fishery is worth at least $3.5 million USD with landings totaling at least 640 tonnes. Based on the size information for *C. bairdi* in Rivers Inlet, it will be up to the proponents to determine if a market exists.

Secondly, if the species is determined to be economically viable, there needs to be sufficient supply of marketable size crabs. Based on our population estimate and catch rate data, there does not appear to be significant quantities of large male *C. bairdi* (≥ 113 mm CW) in Rivers Inlet, although other areas of the coast, particularly the North Coast inlets (Portland Canal), may have greater densities of *C. bairdi*. The population estimate for male Tanner crabs ≥ 113 CW in Rivers Inlet was 7,178 to 9,553 crabs. Using a mean weight of 0.58 kg for male Tanner crabs ≥ 113 mm CW the total available biomass would be between 4,163 and 5,541 kg.

It is important to note that much of the fishing would likely occur in two or three areas of Rivers Inlet: Draney Inlet, Darby Channel, and possibly Upper Rivers Inlet. A fishery for *C. bairdi* in Rivers Inlet would likely support only one vessel given the low abundance of large male Tanner crabs and limited area, especially in Darby Channel.

If the proponents wish to continue with fishery development considering the above information, the next stage is 'fishing for information' and implementation of agreed upon management strategies (Perry *et al.* 1999). The resource would be harvested under experimental management regimes to ascertain the productivity of the stock in question and determine whether the species or stock can sustain a commercially viable fishery. Proponents will need to consider the financial responsibilities for conducting an experimental fishery. They include: assessment costs (biological data collection, data processing etc.); catch monitoring and reporting (observers and dockside validation); costs associated with the management of the fishery; and gear investments (repairs or replacement of traps). Proponents should not expect to recover all costs associated with the experimental fishery from the sale of product.

Krause *et al.* (2001) recommended any commercial activities targeting *C. bairdi* should:

1) Use standardized trap gear;
2) Be monitored by observers and dockside validation to ensure effective catch monitoring and biological data;
3) Be managed on a small spatial scale until stock unit size and composition can be determined;
4) Make every effort to minimize discard mortality through use of passive sorting mechanisms such as escape rings.

With the above we also suggest the following conditions:

1) Fishing is restricted to the Rivers Inlet system. Not enough information is available to make generalized statements of local stock composition of *C. bairdi* in other areas outside of Rivers Inlet;
2) Retention of mature male Tanner crabs only with a minimum size limit of 113 mm CW. Harvest limits would be set at removing 100% of legal size crabs. This is still conservative because 25.2% of the total male Tanner crab population in Rivers Inlet would be targeted and the minimum size limit ensures one season of breeding for male Tanner crabs. We acknowledge that the harvest rate proposed is less conservative than the Alaskan fishery which proposes a harvest rate of 10-20% of the mature male population;
3) Fishing during biologically sensitive periods should be avoided. However, during the experimental fishing phase, fishing should take place throughout the year to determine the biologically sensitive periods such as moult and breeding times;
4) Fishing using standardized trap gear with escape ring mechanisms with an inside diameter of 100 mm located within the bottom one third of the trap and above the floor to prevent clogging of escape rings;
5) Landings are reported in both numbers and weights;
6) Detailed logbooks should be mandatory to monitor fishing activity/effort including location and depth;
7) Biological information is collected to address size of maturity (gonad condition) and whether a terminal moult at maturity exists in males (presence of a new shell under the carapace). Tagged crabs still loose from this study should be recovered to provide information on movements, growth, moult timing and the terminal moult; and
8) Bycatch and discard information should be collected to measure impacts of fishing activities.

The impacts on the Tanner crabs stocks in Rivers Inlet from an experimental fishery would be monitored by measuring several fishery related parameters such as male size distribution, changes in relative abundance (CPUE), the proportion of mature females carrying eggs, injury rates, changes in discard ratios, and changes in bycatch levels or species composition. Measurements of these parameters would be compared to estimates made from this study on the unfished population.

CONCLUSIONS AND RECOMMENDATIONS

In light of the information presented in this paper and if there is a desire to proceed further with the development of a fishery for *C. bairdi* in Rivers Inlet, B.C., we recommend that:

1. Any future experimental fishing should:

    a. Be restricted to the Rivers Inlet system. Not enough information is available to make generalized statements of local stock composition of Tanner crabs in other areas outside of Rivers Inlet;
    b. Target only mature male Tanner crabs of a minimum size limit of 113 mm CW. Harvest limits are set at removing 100% of legal size crabs. This is still conservative because the minimum size limit ensures one season of breeding for male Tanner crabs and accounts for 25.2% of the total male Tanner crab population in Rivers Inlet;
    c. Occur throughout the year to determine biologically sensitive periods such as moult and breeding times;
    d. Use standardized trap gear with escape ring mechanisms with an inside diameter of 100 mm located within the bottom third of the trap and above the floor to prevent clogging;
    e. Be monitored by observers and dockside validation to ensure effective catch monitoring and collection of biological data and bycatch information. Landings should be reported in both numbers and weights;
    f. Use detailed logbooks to monitor fishing activity including location and depth.

2. There are uncertainties with some life history aspects and biological characteristics of *C. bairdi*. Further biological information should be collected on size of maturity, terminal moult, growth, movement, moult timing and disease for *C. bairdi* in Rivers Inlet and other areas of the coast.

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Table 1. Depth strata used to categorize Tanner crab survey data in Rivers Inlet, B.C., January 2004-March 2005.

Stratum	Depths (m)
1	0-49
2	50-99
3	100-149
4	150-199
5	200-249
6	≥ 250

Table 2. Dates, areas, number of sets and number of traps fished during WNFP trap surveys for *C. bairdi* in Rivers Inlet, B.C., 2004. WB = WESTERN BOUNTY

Survey	Sets	Number of traps	Start	Finish
WB	111	568	January 20, 2004	February 20, 2004
WB	73	361	September, 2, 2004	September 14, 2004

Table 3. Dates, areas, number of sets and number of Tanner traps fished during DFO trap surveys for *C. bairdi* in Rivers Inlet, B.C., March 2004-March 2005. NC = NEOCALIGUS

Survey	Sets	Number of traps	Start	Finish
NC	22	232	March 10, 2004	March 16, 2004
VECTOR	8	80	June 4, 2004	June 5, 2004
NC	30	291	December 2, 2004	December 9, 2004
NC	42	416	March 17, 2004	March 24, 2005

Table 4. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum for all trap types from the NEOCALIGUS trap survey in Rivers Inlet, B.C., March 10-16, 2004.

		Males		Females	
Stratum	**# Traps**	**Mean**	**SD**	**Mean**	**SD**
1	-	-	-	-	-
2	22	3.23	4.71	0.00	0.00
3	21	4.14	4.36	0.19	0.51
4	10	1.80	2.20	0.20	0.63
5	-	-	-	-	-
6	3	0.00	0.00	0.00	0.00

Table 5. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum for all trap types from the NEOCALIGUS trap survey in Rivers Inlet, B.C., December 2-9, 2004.

		Males		Females	
Stratum	**# Traps**	**Mean**	**SD**	**Mean**	**SD**
1	-	-	-	-	-
2	34	1.56	2.19	0.24	0.78
3	57	0.88	1.51	0.26	0.70
4	14	0.79	1.12	0.57	1.02
5	8	0.00	0.00	0.25	0.71
6	-	-	-	-	-

Table 6. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum for all trap types from the NEOCALIGUS trap survey in Rivers Inlet, March 17-24, 2005.

		Males		Females	
Stratum	**# Traps**	**Mean**	**SD**	**Mean**	**SD**
1	-	-	-	-	-
2	53	3.98	4.40	0.02	0.14
3	72	2.36	3.64	0.21	0.63
4	26	1.50	1.90	0.04	0.20
5	8	0.00	0.00	0.00	0.00
6	-	-	-	-	-

Table 7. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum from the WESTERN BOUNTY trap survey in Rivers Inlet, B.C., January 20 - February 20, 2004.

		Males		Females	
Stratum	# Traps	Mean	SD	Mean	SD
1	30	0.07	0.25	0.00	0.00
2	90	0.52	1.20	0.11	0.53
3	112	1.02	1.81	0.29	0.83
4	80	1.28	2.15	0.11	0.39
5	84	0.29	0.75	0.08	0.32
6	125	0.06	0.26	0.03	0.22

Table 8. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum from the WESTERN BOUNTY trap survey in Rivers Inlet, B.C., September 2-14, 2004.

		Males		Females	
Stratum	# Traps	Mean	SD	Mean	SD
1	20	0.00	0.00	0.00	0.00
2	74	0.16	0.47	0.03	0.16
3	84	0.58	1.37	0.18	0.49
4	59	0.58	1.53	0.63	1.41
5	49	0.16	0.37	0.35	0.75
6	75	0.00	0.00	0.03	0.16

Table 9. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and depth stratum from the Vector trap survey in Rivers Inlet, B.C., June 4-5, 2004.

		Males		Females	
Stratum	# Traps	Mean	SD	Mean	SD
1	0	-	-	-	-
2	9	2.22	1.99	0.11	0.33
3	10	2.50	1.90	0.40	0.70
4	0	-	-	-	-
5	0	-	-	-	-
6	0	-	-	-	-

Table 10. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and area from the NEOCALIGUS trap survey in Rivers Inlet, B.C., March 10-16, 2004.

		All Males		All Females		Males ≥ 113 mm CW	
Area	**# Traps**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Upper Moses	5	2.20	3.03	0.40	0.89	0.00	0.00
Lower Moses	10	0.30	0.67	0.00	0.00	0.00	0.00
Hardy Inlet	-	-	-	-	-	-	-
Upper Rivers	11	3.82	3.40	0.09	0.30	0.18	0.40
Middle Rivers	6	1.67	3.61	0.00	0.00	0.00	0.00
Lower Rivers	-	-	-	-	-	-	-
Upper Fitz Hugh	-	-	-	-	-	-	-
Lower Fitz Hugh	-	-	-	-	-	-	-
Draney Inlet	9	3.14	4.18	0.11	0.41	1.00	1.58
Darby Channel	15	4.27	5.24	0.00	0.00	1.87	1.96

Table 11. Mean catch rate (crabs/trap) and standard deviation (SD), of *C. bairdi*, by sex and area from the NEOCALIGUS trap survey in Rivers Inlet, B.C., December 2-9, 2004.

		All Males		All Females		Males ≥ 113 mm CW	
Area	**# Traps**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Upper Moses	14	0.14	0.53	0.21	0.58	0.00	0.00
Lower Moses	4	0.00	0.00	0.00	0.00	0.00	0.00
Hardy Inlet	-	-	-	-	-	-	-
Upper Rivers	20	0.80	1.01	0.65	0.99	0.20	0.52
Middle Rivers	19	0.58	1.22	0.26	0.73	0.00	0.00
Lower Rivers	4	0.00	0.00	0.00	0.00	0.00	0.00
Upper Fitz Hugh	-	-	-	-	-	-	-
Lower Fitz Hugh	-	-	-	-	-	-	-
Draney Inlet	18	2.83	2.23	0.44	1.15	0.44	0.70
Darby Channel	34	1.00	1.79	0.12	0.41	0.59	1.08

Table 12. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and area from the NEOCALIGUS trap survey in Rivers Inlet, B.C., March 17-24, 2005.

		All Males		All Females		Males ≥ 113 mm CW	
Area	**# Traps**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Upper Moses	-	-	-	-	-	-	-
Lower Moses	-	-	-	-	-	-	-
Hardy Inlet	15	0.87	1.60	0.00	0.00	0.13	0.35
Upper Rivers	45	1.49	1.67	0.07	0.25	0.18	0.39
Middle Rivers	8	0.63	1.06	0.00	0.00	0.00	0.00
Lower Rivers	23	0.04	0.21	0.00	0.00	0.00	0.00
Upper Fitz Hugh	-	-	-	-	-	-	-
Lower Fitz Hugh	-	-	-	-	-	-	-
Draney Inlet	22	6.73	4.55	0.64	1.00	1.73	1.58
Darby Channel	46	4.07	4.39	0.00	0.00	2.09	3.02

Table 13. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and area from the WESTERN BOUNTY trap survey in Rivers Inlet, January 20 – February 20, 2004.

		All Males		All Females		Males ≥ 113 mm CW	
Area	**# Traps**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Upper Moses	47	0.72	1.35	0.36	0.82	0.02	0.15
Lower Moses	38	1.03	1.64	0.11	0.31	0.05	0.23
Hardy Inlet	58	0.36	1.28	0.03	0.18	0.00	0.00
Upper Rivers	71	1.01	1.71	0.45	1.04	0.11	0.40
Middle Rivers	90	0.19	0.69	0.00	0.00	0.00	0.00
Lower Rivers	60	0.15	0.48	0.05	0.22	0.00	0.00
Upper Fitz Hugh	40	0.00	0.00	0.00	0.00	0.00	0.00
Lower Fitz Hugh	65	0.00	0.00	0.00	0.00	0.00	0.00
Draney Inlet	32	2.63	2.73	0.16	0.37	0.84	1.35
Darby Channel	10	1.50	1.27	0.00	0.00	0.70	0.82

Table 14. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and area from the WESTERN BOUNTY trap survey in Rivers Inlet, B.C., September 2-14, 2004.

Area	# Traps	All Males		All Females		Males ≥ 113 mm CW	
		Mean	SD	Mean	SD	Mean	SD
Upper Moses	40	0.33	0.94	0.40	1.24	0.00	0.00
Lower Moses	24	0.08	0.28	0.04	0.20	0.00	0.00
Hardy Inlet	40	0.58	1.66	0.25	0.59	0.08	0.35
Upper Rivers	49	0.18	0.49	0.45	1.14	0.02	0.14
Middle Rivers	45	0.47	1.53	0.18	0.53	0.04	0.30
Lower Rivers	39	0.03	0.16	0.05	0.32	0.00	0.00
Upper Fitz Hugh	20	0.00	0.00	0.00	0.00	0.00	0.00
Lower Fitz Hugh	40	0.00	0.00	0.00	0.00	0.00	0.00
Draney Inlet	39	0.69	1.17	0.33	0.74	0.05	0.22
Darby Channel	25	0.28	0.46	0.04	0.20	0.16	0.37

Table 15. Mean catch rate (crabs/trap) and standard deviation (SD) of *C. bairdi*, by sex and area from the CCGS VECTOR trap survey in Rivers Inlet, B.C., June 4-5, 2004.

Area	# Traps	All Males		All Females		Males ≥ 113 mm CW	
		Mean	SD	Mean	SD	Mean	SD
Upper Moses	0	-	-	-	-	-	-
Lower Moses	0	-	-	-	-	-	-
Hardy Inlet	0	-	-	-	-	-	-
Upper Rivers	12	2.42	1.78	2.29	2.21	0.33	0.49
Middle Rivers	0	-	-	-	-	-	-
Lower Rivers	0	-	-	-	-	-	-
Upper Fitz Hugh	0	-	-	-	-	-	-
Lower Fitz Hugh	0	-	-	-	-	-	-
Draney Inlet	0	-	-	-	-	-	-
Darby Channel	7	2.29	2.21	0.14	0.38	0.86	0.69

Table 16. Weight (kg) and number (n) of total trap catch by species, Tanner crab trap survey Rivers Inlet, B.C., F/V WESTERN BOUNTY, January 20 – February 20, 2004.

Species	Number (n)	Weight (kg)
Crab		
Cancer magister	831	
Chionoecetes bairdi	385	
Munida quadrispina	35	1.30
Paguridae	31	1.70
Lopholithodes foraminatus	8	
Oregonia gracilis	5	0.40
Cancer gracilis	1	
Other Crustaceans		
Pandalus platyceros	311	7.28
Pandalopsis dispar	2	0.04
Molluscs		
Enteroctopus dofleini	4	7.00
Gastropoda	47	3.00
Chlamys hastata	1	0.02
Echinoderms		
Pycnopodia helianthoides	9	8.00
Stylasterias forreri	21	4.30
Brisaster latifrons	55	2.97
Mediaster aequalis	17	0.81
Luidia foliolata	1	0.10
Holothuroidea	5	0.43
Ctenodiscus crispatus	3	0.13
Florometra serratissima	4	0.10
Other Invertebrates		
Porifera	2	3.00
Actiniaria	2	0.10
Fish		
Sebastes maliger	11	5.50
Sebastes ruberrimus	2	3.00
Anoplopoma fimbria	2	2.50
Sebastes babcocki	1	2.00
Sebastes crameri	2	1.60
Hemitripterus bolini	1	1.50
Merluccius productus	1	1.50
Sebastes caurinus	2	1.25
Malacocottus zonurus	17	1.21
Sebastes aleutianus	2	1.20
Rhacochilus vacca	6	0.60
Enophrys bison	1	0.50
Theragra chalcogramma	2	0.35
Hemilepidotus hemilepidotus	1	0.30
Gadus macrocephalus	1	0.25
Leptocottus armatus	2	0.25
Cottidae	1	0.10
Lyopsetta exilis	1	0.10
Parophrys vetulus	1	0.10
Icelinus filamentosus	1	0.05
		62.84

Table 17. Weight (kg)* and number (n) of total trap catch by species, Tanner crab trap survey Rivers Inlet, B.C., F/V WESTERN BOUNTY, September 2-14, 2004.

Species	Number (n)	Weight (kg)*
Crabs		
Chionoecetes bairdi	177	
Cancer magister	124	
Munida quadrispina	55	1.13
Lopholithodes foraminatus	2	
Paguridae	1	0.03
Chorilia longipes	2	0.02
Oregonia gracilis	1	0.02
Other Crustaceans		
Pandalus platyceros	102	2.67
Pandalus hypsinotus	4	0.08
Pandalopsis dispar	4	0.07
Molluscs		
Enteroctopus dofleini	7	19.50
Echinoderms		
Pycnopodia helianthoides	3	3.00
Stylasterias forreri	5	2.28
Brisaster latifrons	34	0.68
Parastichopus californicus	1	0.30
Holothuroidea	5	0.17
Mediaster aequalis	3	0.10
Crossaster papposus	1	trace
Other Invertebrates		
Porifera	7	trace
Fish		
Sebastes maliger	12	27.50
Hippoglossus stenolepis	2	11.00
Sebastes borealis	5	9.50
Sebastes crameri	5	7.08
Sebastes aleutianus	3	6.00
Anoplopoma fimbria	2	4.00
Ophiodon elongatus	1	4.00
Cryptacanthodes giganteus	1	2.00
Malacocottus zonurus	10	1.25
Hydrolagus colliei	2	1.20
Sebastes babcocki	1	1.00

*Estimates only.

Table 18. Weight (kg) and number (n) of total trap catch by species, Tanner crab trap survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, March 10-16, 2004.

Species	Number (n)	Weight (kg)
Crab		
Cancer magister	462	
Chionoecetes bairdi	311	105.59
Munida quadrispina		6.48
Lopholithodes foraminatus	4	1.53
Chorilia longipes		0.05
Other Crustaceans		
Pandalus platyceros		30.33
Pandalus hypsinotus		1.07
Pandalus borealis		0.05
Pandalus montagui tridens		0.01
Pandalus jordani		0.01
Pandalus danae		0.01
Molluscs		
Enteroctopus dofleini	1	16.40
Gastropoda		0.13
Echinoderms		
Stylasterias forreri		0.70
Luidia foliolata		0.29
Holothuroidea		0.23
Brisaster latifrons		0.06
Ctenodiscus crispatus		0.05
Pseudarchaster alascensis		0.03
Fish		
Sebastes maliger	1	1.24
Myoxocephalus polyacanthocephalus		1.07
Sebastes crameri	1	1.04
Theragra chalcogramma		0.27
Malacocottus zonurus		0.17
Hippoglossoides elassodon		0.06
Nautichthys oculofasciatus		0.01
Total		166.88

Table 19. Weight (kg) and number (n) of total trap catch by species, Tanner crab trap survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, December 2-9, 2004.

Species	Number (n)	Weight (kg)	Percent of Total
Crabs			
Cancer magister	319	132.34	51.02
Chionoecetes bairdi	209	61.01	23.52
Munida quadrispina	1590	25.24	9.73
Lopholithodes foraminatus	7	1.53	0.59
Chorilia longipes	9	0.27	0.10
Hyas lyratus	4	0.26	0.10
Paguridae	1	0.09	0.03
Other Crustaceans			
Pandalus platyceros	823	26.29	10.14
Pandalus hypsinotus	23	0.56	0.22
Pandalus jordani	27	0.21	0.08
Eualus spp	2	0.20	0.08
Pandalus borealis	7	0.16	0.06
Pandalus montagui tridens	7	0.14	0.05
Pandalopsis dispar	3	0.12	0.05
Molluscs			
Octopus rubescens	1	1.50	0.58
Gastropoda	39	0.54	0.21
Fusitriton oregonensis	1	0.09	0.03
Echinoderms			
Stylasterias forreri	7	2.06	0.79
Pycnopodia helianthoides	1	0.77	0.30
Ctenodiscus crispatus	8	0.32	0.12
Molpadia intermedia	1	0.14	0.05
Mediaster aequalis	1	0.10	0.04
Brisaster latifrons	2	0.07	0.03
Euryalae	1	0.03	0.01
Other Invertebrates			
Brachiopoda	1	0.10	0.04
Fish			
Squalus acanthias	2	2.73	1.05
Sebastes maliger	2	1.16	0.45
Sebastes ruberrimus	1	1.06	0.41
Sebastes zacentrus	1	0.17	0.07
Malacocottus zonurus	1	0.10	0.04
Lyopsetta exilis	1	0.03	0.01
Total		259.39	100.0

Table 20. Weight (kg) and number (n) of total trap catch by species, Tanner crab trap survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, March 17-24, 2005.

Species	Number (n)	Weight (kg)	Percent of Total
Crabs			
Chionoecetes bairdi	547	213.92	44.50
Cancer magister	374	160.13	33.31
Munida quadrispina	1694	25.82	5.37
Paguridae	12	0.40	0.08
Lopholithodes foraminatus	1	0.37	0.08
Chorilia longipes	1	trace	
Other Crustaceans			
Pandalus platyceros	1785	62.51	13.00
Pandalus hypsinotus	106	2.70	0.56
Pandalus borealis	87	0.53	0.11
Pandalus jordani	36	0.20	0.04
Pandalopsis dispar	18	0.13	0.03
Eualus suckleyi	6	0.03	0.01
Pandalus montagui tridens	1	trace	
Molluscs			
Enteroctopus dofleini	1	1.50	0.31
Gastropoda	109	0.43	0.09
Echinoderms			
Pycnopodia helianthoides	1	1.60	0.33
Ctenodiscus crispatus	6	0.15	0.03
Stylasterias forreri	6	0.91	0.19
Mediaster aequalis	1	0.02	0.004
Allocentrotus fragilis	2	0.02	0.004
Brisaster latifrons	2	0.02	0.004
Pseudarchaster alascensis	1	trace	
Other Invertebrates			
Actiniaria	1	0.10	0.02
Porifera		0.02	0.004
Fish			
Cryptacanthodes giganteus	3	4.25	0.88
Gadus macrocephalus	2	2.11	0.44
Hemitripterus bolini	1	1.69	0.35
Sebastes maliger	1	0.50	0.10
Hydrolagus colliei	1	0.38	0.08
Malacocottus zonurus	3	0.10	0.02
Lyopsetta exilis	1	0.06	0.01
Sebastes crameri	1	0.04	0.01
Total		480.67	100.0

Table 21. Dates, areas, and number of tows fished during DFO trawl surveys in Rivers Inlet, B.C., 2004. NC = NEOCALIGUS

Survey	Number of Tows		Start	Finish
	Shrimp Trawl	Beam Trawl		
NC	30	-	March 10, 2004	March 16, 2004
NC	8	8	December 2, 2004	December 9, 2004

Table 22. Weight (kg) and number (n) of total trawl catch by species, Tanner crab trawl survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, March 10-16, 2004.

Species	Number (n)	Weight (kg)	Percent of Total
Crab			
Munida quadrispina		8.29	0.69
Chionoecetes bairdi	40	5.21	0.43
Cancer magister	10	3.13	0.26
Lopholithodes foraminatus	1	1.44	
Chorilia longipes		0.08	
Paguridae		0.06	
Other Crustaceans			
Pandalopsis dispar		67.96	5.67
Pandalus jordani		18.00	1.50
Pandalus platyceros		11.26	0.94
Pandalus borealis		7.05	0.59
Eualus spp.		4.98	0.42
Crangon communis		1.49	0.12
Pandalus hypsinotus		1.43	0.12
Pasiphaea pacifica		0.85	0.07
Isopoda		0.07	0.01
Pandalus montagui tridens		0.02	0.001
Molluscs			
Berryteuthis magister		6.07	0.51
Rossia pacifica		0.11	0.01
Gastropoda		0.02	0.001
Bivalvia		0.01	0.001
Fusitriton oregonensis		0.01	0.001
Loligo opalescens		0.01	0.001
Entodesma navicula		0.01	0.001
Thyasiridae		0.01	0.001
Echinoderms			
Brisaster latifrons		16.83	1.40
Molpadia intermedia		4.39	0.37
Benthoctopus leioderma	1	3.68	0.31
Luidia foliolata		1.55	0.13
Ctenodiscus crispatus		1.33	0.11
Holothuroidea		1.31	0.11
Parastichopus californicus		1.05	0.09
Allocentrotus fragilis		0.42	0.04
Pseudarchaster alascensis		0.33	0.03
Gephyreaster swifti			
Phrynophiurida		0.02	0.001
Echinasteridae		0.01	0.001
Pectinidae		0.01	0.001
Other Invertebrates			
Primnoa spp.		19.25	1.61
Porifera		4.11	0.34
Actiniaria		3.61	0.30
Sipuncuida		0.37	0.03
Brachiopoda		0.04	0.001
Fish			
Hydrolagus colliei		343.42	29.15
Merluccius productus		235.94	19.68

Table 22. (Cont'd)

Species	Number (n)	Weight (kg)	Percent of Total
Fish			
Theragra chalcogramma		167.30	13.96
Lyopsetta exilis		68.72	5.73
Squalus acanthias		35.03	2.92
Raja rhina		18.29	1.53
Hippoglossoides elassodon		17.66	1.47
Lycodes pacificus		15.17	1.27
Parophrys vetulus		14.26	1.19
Anoplopoma fimbria		13.92	1.16
Cymatogaster aggregata		8.56	0.71
Microstomus pacificus		7.42	0.62
Gadus macrocephalus		7.31	0.61
Glyptocephalus zachirus		6.36	0.53
Lycodes diapterus		5.20	0.43
Atheresthes stomias		4.40	0.37
Sebastes zacentrus		3.81	0.32
Hemitripterus bolini		3.40	0.28
Sebastes proriger		3.07	0.26
Sebastes maliger		2.97	0.25
Thaleichthys pacificus		2.08	0.17
Lumpenella longirostris		1.95	0.16
Agonopsis vulsa		1.43	0.12
Dasycottus setiger		1.32	0.11
Platichthys stellatus		1.11	0.09
Agonidae		0.95	0.08
Onchorhynchus tshawytscha	1	0.94	0.08
Malacocottus zonurus		0.70	0.06
Microgadus proximus		0.68	0.06
Bathyagonus nigripinnis		0.67	0.06
Lepidopsetta bilineata		0.45	0.04
Ophiodon elongatus		0.42	0.04
Clupea pallasi		0.32	0.03
Sebastes aleutianus		0.27	0.02
Leuroglossus schmidti		0.25	0.02
Icelinus burchami		0.16	0.01
Bothrocara pusillum		0.14	0.01
Lycodes brevipes		0.11	0.01
Icelinus filamentosus		0.10	0.01
Sebastes alutus		0.10	0.01
Lycodapus mandibularis		0.08	0.01
Palaeotaxodonta		0.06	0.01
Lumpenus sagitta		0.04	0.001
Malacocottus kincaidi		0.03	0.001
Nectoliparis pelagicus		0.03	0.001
Lipariscus nanus		0.02	0.001
Cryptacanthodes aleutensis		0.01	0.001
Gasterosteus aculeatus		0.01	0.001
Hemilepidotus hemilepidotus		0.01	0.001
Lampetra tridentata		0.01	0.001
Psychrolutes sigalutes		0.01	0.001
Radulinus asprellus		0.01	0.001
Total		1198.75	100.0

Table 23. Weight (kg) and number (n) of total trawl catch by species, Tanner crab trawl survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, December 2-9, 2004.

Species	Number (n)	Weight (kg)	Percent of Total
Crabs			
Munida quadrispina		33.40	8.04
Chionoecetes bairdi	39	9.17	2.21
Cancer magister	22	6.48	1.16
Lopholithodes foraminatus	7	1.96	0.47
Chorilia longipes		0.06	0.01
Paguridae		0.03	0.01
Other Crustaceans			
Pandalopsis dispar		25.99	6.26
Pandalus platyceros		2.78	0.67
Pandalus jordani		1.67	0.40
Pandalus borealis		1.59	0.38
Crangon communis		0.68	0.16
Pandalus hypsinotus		0.22	0.05
Eualus spp		0.11	0.03
Pandalus montagui tridens		0.08	0.02
Argis ovifera		0.02	0.01
Pasiphaea pacifica		0.02	0.01
Isopoda		trace	
Molluscs			
Berryteuthis magister		2.57	0.62
Palaeotaxodonta		2.40	0.58
Octopus rubescens		2.19	0.53
Gastropoda		0.10	0.02
Pectinidae		0.10	0.02
Rossia pacifica		0.09	0.02
Loligo opalescens		trace	
Echinoderms			
Brisaster latifrons		26.06	6.27
Ctenodiscus crispatus		0.59	0.14
Allocentrotus fragilis		0.42	0.10
Molpadia intermedia		0.30	0.07
Pseudarchaster dissonus		0.30	0.07
Solaster stimpsoni		0.07	0.02
Leptosynapta transgressor		trace	
Other Invertebrates			
Actiniaria		2.29	0.55
Brachiopoda		0.11	0.03
Scyphozoa		0.05	0.01
Porifera		trace	
Fish			
Hippoglossoides elassodon		59.41	14.30
Lyopsetta exilis		56.60	13.62
Merluccius productus		45.25	10.89
Hydrolagus colliei		34.80	8.38
Theragra chalcogramma		16.73	4.03
Squalus acanthias		15.65	3.77

Table 23. (Cont'd)

Species	Number (n)	Weight (kg)	Percent of Total
Fish			
Lycodes pacificus		11.69	2.81
Parophrys vetulus		6.30	1.52
Microstomus pacificus		6.05	1.46
Cymatogaster aggregata		5.77	1.39
Glyptocephalus zachirus		5.55	1.34
Platichthys stellatus		5.11	1.23
Anoplopoma fimbria		4.51	1.09
Raja rhina		3.93	0.95
Microgadus proximus		3.76	0.91
Lumpenella longirostris		3.50	0.84
Gadus macrocephalus		1.86	0.49
Atheresthes stomias		1.40	0.34
Dasycottus setiger		1.03	0.25
Rhacochilus vacca		0.81	0.20
Sebastes proriger		0.77	0.19
Sebastes zacentrus		0.73	0.18
Sebastes crameri	3	0.47	0.11
Leptocottus armatus		0.40	0.10
Lycodes diapterus		0.32	0.08
Bathyagonus nigripinnis		0.30	0.07
Lycodes brevipes		0.28	0.07
Ophiodon elongates		0.22	0.05
Sebastes saxicola	2	0.21	0.05
Xeneretmus latifrons		0.09	0.02
Radulinus asprellus		0.06	0.01
Malacocottus zonurus		0.04	0.01
Bothrocara pusillum		0.02	0.01
Elassodiscus caudatus		trace	
Leptoclinus maculatus		trace	
Psychrolutes paradoxus		trace	
Total		415.54	100.0

Table 24. Weight (kg) and number (n) of total beam trawl catch by species, Tanner crab beam trawl survey, Rivers Inlet, B.C., CCGS NEOCALIGUS, December 2 - 9, 2004.

Species	Number (n)	Weight (kg)	Percent of Total
Crabs			
Munida quadrispina		2.50	16.80
Cancer magister	3	1.29	8.67
Chionoecetes bairdi	53	0.52	3.49
Paguridae		0.11	0.74
Chorilia longipes		trace	
Other Crustaceans			
Pandalus platyceros		1.20	8.06
Pandalus jordani		0.54	3.63
Pandalus hypsinotus		0.48	3.23
Crangon communis		0.40	2.69
Pandalopsis dispar		0.31	2.08
Eualus spp		0.30	2.02
Eualus suckleyi		0.10	0.67
Pandalus borealis		0.10	0.67
Argis ovifera		0.02	0.13
Euphausiacea		trace	
Spirontocaris lamellicorni		trace	
Molluscs			
Rossia pacifica		0.25	1.68
Megayoldia thraciaeformis		0.20	1.34
Compsomyax subdiaphana		0.20	1.34
Clinocardium blandum		0.20	1.34
Lucinoma annulatum		0.20	1.34
Cardiomya pectinata		0.20	1.34
Mediaster aequalis		0.20	1.34
Austrotindaria gibbsii		0.20	1.34
Yoldia seminuda		0.20	1.34
Cyclocardia ventricosa		0.20	1.34
Macoma spp		0.20	1.34
Pandora filosa		0.20	1.34
Patellacea		0.10	0.67
Polyplacophora		0.10	0.67
Nuculana cellulita		0.10	0.67
Nuculana pernula		0.10	0.67
Echinoderms			
Phrynophiurida		0.11	0.74
Holothuroidea		0.10	0.67
Stylasterias forreri		0.09	0.60
Strongylocentrotus droebachiensis		trace	
Other Invertebrates			
Scyphozoa		0.31	2.08
Actiniaria		0.15	1.01
Brachiopoda		0.10	0.67
Crinodea		trace	

Table 24. (Cont'd)

Species	Number (n)	Weight (kg)	Percent of Total
Fish			
Theragra chalcogramma		0.77	5.17
Lyopsetta exilis		0.62	4.17
Hippoglossoides elassodon		0.55	3.70
Lycodes pacificus		0.32	2.15
Parophyrys vetulus		0.15	1.01
Sebastes elongatus		0.15	1.01
Xeneretmus latifrons		0.14	1.01
Hemilepidotus hemilepidotus		0.12	1.01
Microstomus pacificus		0.11	0.74
Dasycottus setiger		0.10	0.67
Lycodes brevipes		0.10	0.67
Icelinus tenuis		0.10	0.67
Radulinus asprellus		0.05	0.34
Merluccius productus		0.02	0.13
Total		14.88	100.0

Table 25. Growth information of *C. bairdi* from tag return information in Rivers Inlet, B.C.

Tag #	Date	Biological Information									
		Sex	Shell condition	Injuries	Missing Claws	Missing Legs	Carapace width	Weight (g)	Male claw Length	Male claw Width	Female abdominal
43050	22-Jan-04	Female	1				68				31
	6-Dec-04	Gravid female	8			1	80				48
43655	16-Mar-04	Male	1				94	285	36	18	
	21-Mar-05	Male	6				121	620	53	27	

Table 26. Sizes at maturity, size limits, and number of harvestable crabs calculated for male *C. bairdi* in Rivers Inlet, B.C., 2004/05. CW = carapace width, CH = chela height.

Method	Size at Maturity (mm CW)	Terminal Moult at Maturity?	Size Limit (mm CW)[a]	% Available for Harvest	No. Available for Harvest[b]	Reference
Discriminant Score (*S*)	81	No	81	93.9	26,746	Stevens *et al*. (1993)
			97	66.3	18,884	
Midpoint	93	Maybe	93	75.3	21,448	Stevens *et al*. (1993)
			112	26.5	7,548	
Mean CW mature crab	104	Yes	104	45.2	12,874	Conan and Comeau (1986)
CH/CW ratios	94	No	94	73.1	20,821	Stevens *et al*. (1993)
			113	25.2	7,178	
Midpoint	101	Maybe	101	52.7	15,011	Stevens *et al*. (1993)
			121	10.4	2,962	
Mean CW mature crab	108	Yes	108	34.5	9,827	Conan and Comeau (1986)

[a] Growth rate used was 20%.

[b] Based on the lower 95% confidence limit of 28,483 male crabs.

Table 27. Male *C. bairdi* instantaneous rate of natural mortality (*M*) estimated at repeated sampling trap sets at two points in time. Values for *M* include moulting crabs.

Survey	Mean CPUE						*M*	No. paired sets
	Jan04	Mar04	June04	Sept04	Dec04	Mar05		
DFO					1.5	3.34	-2.78	18
DFO		0.63				2.46	-1.36	9
DFO		3.81			1.07		1.75	12
WNFP	0.94			0.24			2.30	45
DFO		4.80	1.08				6.47	5
DFO			1.31		1.09		0.36	7
							1.12	96

Table 28. Information regarding movement of recovered tagged *C. bairdi* in the Rivers Inlet system, January 2004 – June 2005.

Tag Number	Date	Geographic Information Lat.	Long.	Depth (m)	Sex	Carapace width	Time elapsed (d)	Distance from tagging site (m)
43050	22-Jan-04	51 41.118	127 17.490	117	Female	68		0
	6-Dec-04	51 41.082	127 17.466	110	Gravid female	80	319	78
43061	23-Jan-04	51 40.182	127 17.700	132	Female	79		0
	25-May-04	n/a	n/a	n/a	Gravid female	78	123	Removed
43065	23-Jan-04	51 40.542	127 17.700	132	Male	101		0
	15-Mar-04	51 40.542	127 16.350	106	Male	100	52	1,551
43102	24-Jan-04	51 39.264	127 21.060	83	Male	108		0
	20-Mar-05	51 40.422	127 17.532	168	Male	108	422	4,592
43105	24-Jan-04	51 39.264	127 21.060	83	Gravid female	82		0
	25-May-04	n/a	n/a	n/a	Gravid female	83	123	Removed
43253	9-Feb-04	51 36.906	127 33.258	125	Male	98		0
	12-Sep-04	51 36.810	127 33.252	128	Male	95	217	186
43267	10-Feb-04	51 35.052	127 34.698	68	Male	123		0
	25-May-04	n/a	n/a	n/a	Male	120	106	Removed
43268	10-Feb-04	51 35.058	127 34.698	68	Male	126		0
	9-Dec-04	51 34.872	127 34.500	75	Male	126	304	421
43345	19-Feb-04	51 26.184	127 21.948	153	Male	117		0
	5-Dec-04	51 26.226	127 19.578	119	Male	115	291	2,740
43362	19-Feb-04	51 26.184	127 21.948	153	Male	107		0
	23-Mar-05	51 26.214	127 19.074	86	Male	108	399	3,328
43378	19-Feb-04	51 26.058	127 19.404	128	Male	107		0
	12-Mar-04	51 26.166	127 19.458	122	Male	106	22	215
43408	11-Mar-04	51 31.620	127 38.238	70	Male	108		0
	18-Mar-05	51 31.638	127 38.232	70	Male	108	373	39
43430	11-Mar-04	51 35.502	127 34.110	65	Male	119		0
	6-May-05	51 35.048	127 34.637	n/a	Male	119	422	1,033
43471	12-Mar-04	51 26.166	127 19.458	122	Male	129		0
	23-Mar-05	51 26.220	127 19.476	118	Male	130	377	96
43655	16-Mar-04	51 35.502	127 34.110	70	Male	94		0
	21-Mar-05	51 34.992	127 34.410	77	Male	121	371	1,006
43660	16-Mar-04	51 35.502	127 34.110	70	Male	122		0
	18-Mar-05	51 34.998	127 34.428	77	Male	122	368	997
43861	7-Sep-04	51 42.306	127 37.728	210	Male	91		0
	23-Jun-05	51 41.928	127 34.854	n/a	Male	90	288	3,382
44028	5-Dec-04	51 26.238	127 19.194	91	Male	110		0
	23-Mar-05	51 26.022	127 19.494	135	Male	111	109	535
44128	6-Dec-04	51 40.446	127 17.382	170	Gravid female	80		0
	28-Jun-05	51 40.160	127 18.170	n/a	Gravid female	80	205	1,055
44140	6-Dec-04	51 40.122	127 18.786	119	Male	100		0
	20-Mar-05	51 40.422	127 17.532	168	Male	100	105	1,551
44251	18-Mar-05	51 33.780	127 35.730	82	Male	115		0
	21-Mar-05	51 33.780	127 35.730	85	Male	115	4	0
44260	18-Mar-05	51 33.780	127 35.730	82	Male	115		0
	21-Mar-05	51 33.780	127 35.730	85	Male	115	4	0
44262	18-Mar-05	51 33.780	127 35.730	82	Male	123		0
	21-Mar-05	51 33.780	127 35.730	85	Male	123	4	0
44263	18-Mar-05	51 33.780	127 35.730	80	Male	122		0
	21-Mar-05	51 33.780	127 35.730	85	Male	122	4	0
44282	18-Mar-05	51 33.780	127 35.730	80	Male	125		0
	21-Mar-05	51 33.780	127 35.730	85	Male	124	4	0
44310	18-Mar-05	51 30.612	127 39.798	83	Male	106		0
	21-Mar-05	51 30.612	127 39.798	90	Male	107	4	0

Table 29. Tag and recapture data for male *C. bairdi* in Rivers Inlet, B.C., January 2004-March 2005.

Survey	Date	Total no. crabs caught (C_t)	No. crabs caught with tag (R_t)	No. crabs tagged and released (p_t)	Total crabs tagged in pop (T_t)[a]	C_tT_t	T_tR_t	$C_tT_t^2$	R_t^2/C_t
WNFP	Jan-04	301	0	301	0	0	0	0	0.000
DFO	Mar-04	311	2	292	280	87080	560	24382400	0.013
DFO	Jun-04	60	0	58	487[b]	29220	0	14230140	0.000
DFO	Sep-04	103	1	102	457	47071	457	21511447	0.010
DFO	Dec-04	162	2	152	472	76464	944	36091008	0.025
DFO	Mar-05	508	8	150	513	260604	4104	133689852	0.126
		1445	13	1055	2209	500439	6065	229904847	0.173

[a]adjusted for natural mortality
[b] minus one tagged crab because a crab was caught by a fisherman and reported to DFO.

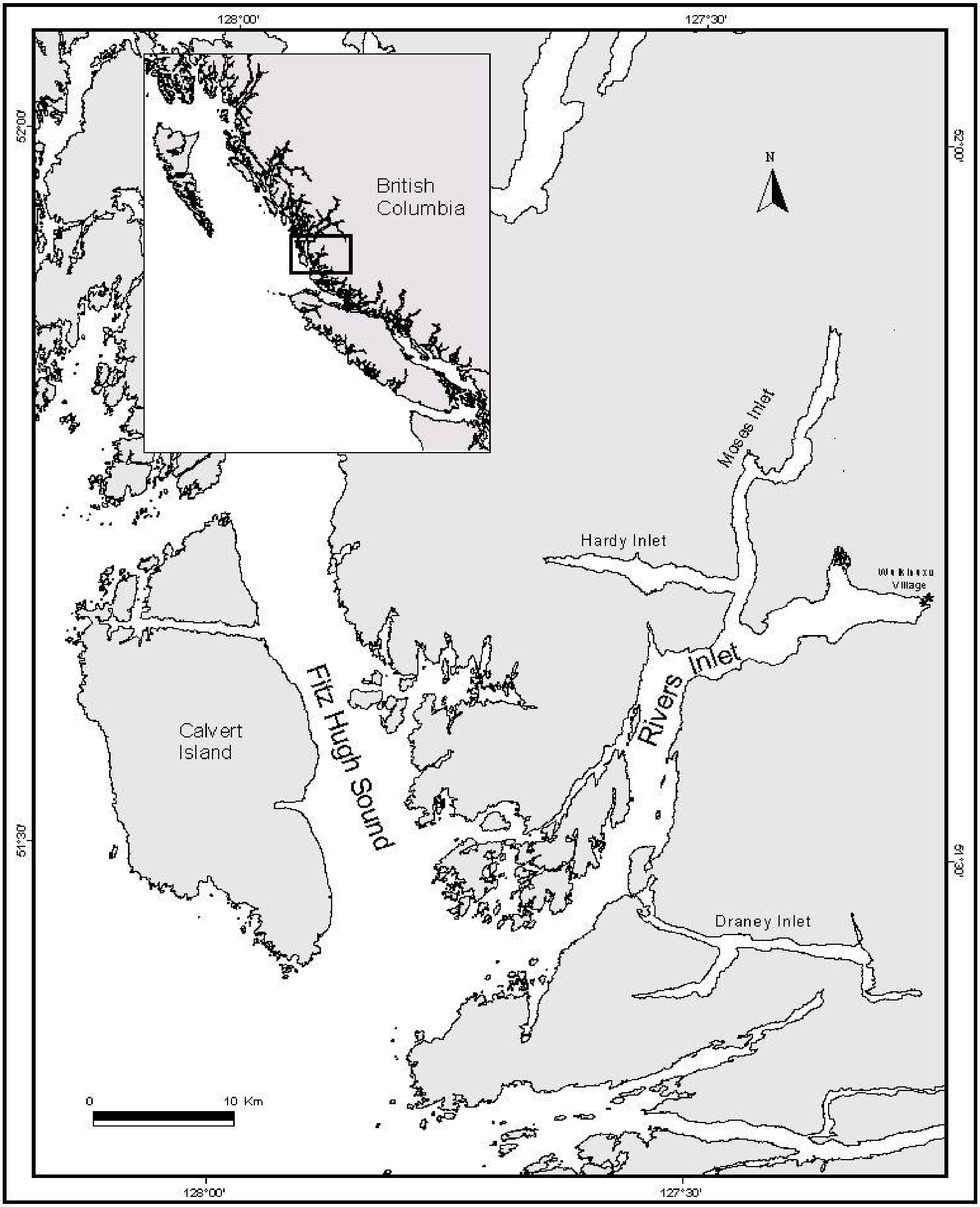


Figure 1. General location of Rivers Inlet and Fitz Hugh Sound, British Columbia.

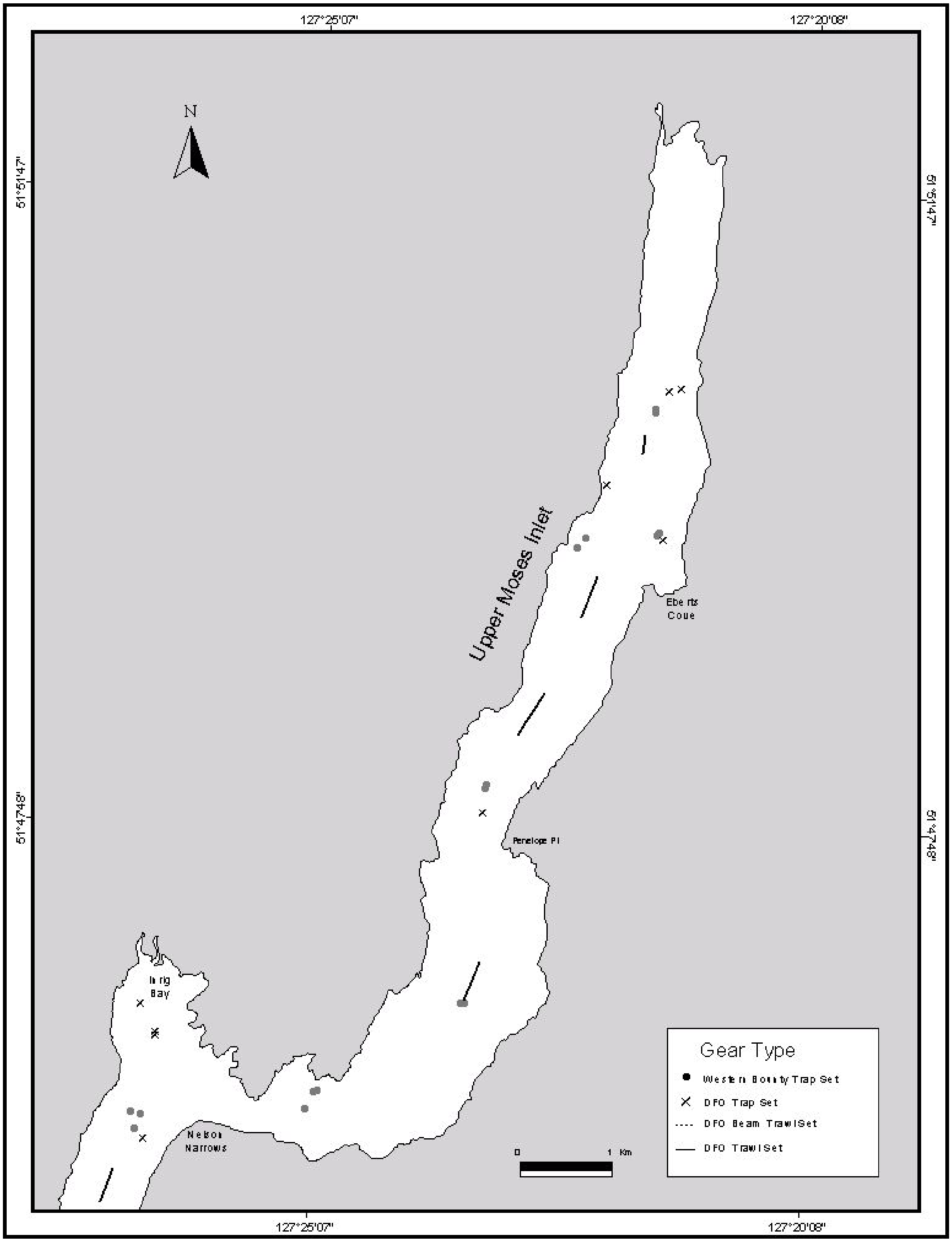


Figure 2. Set locations in Upper Moses Inlet, Tanner crab trap survey, January 2004 - March 2005.

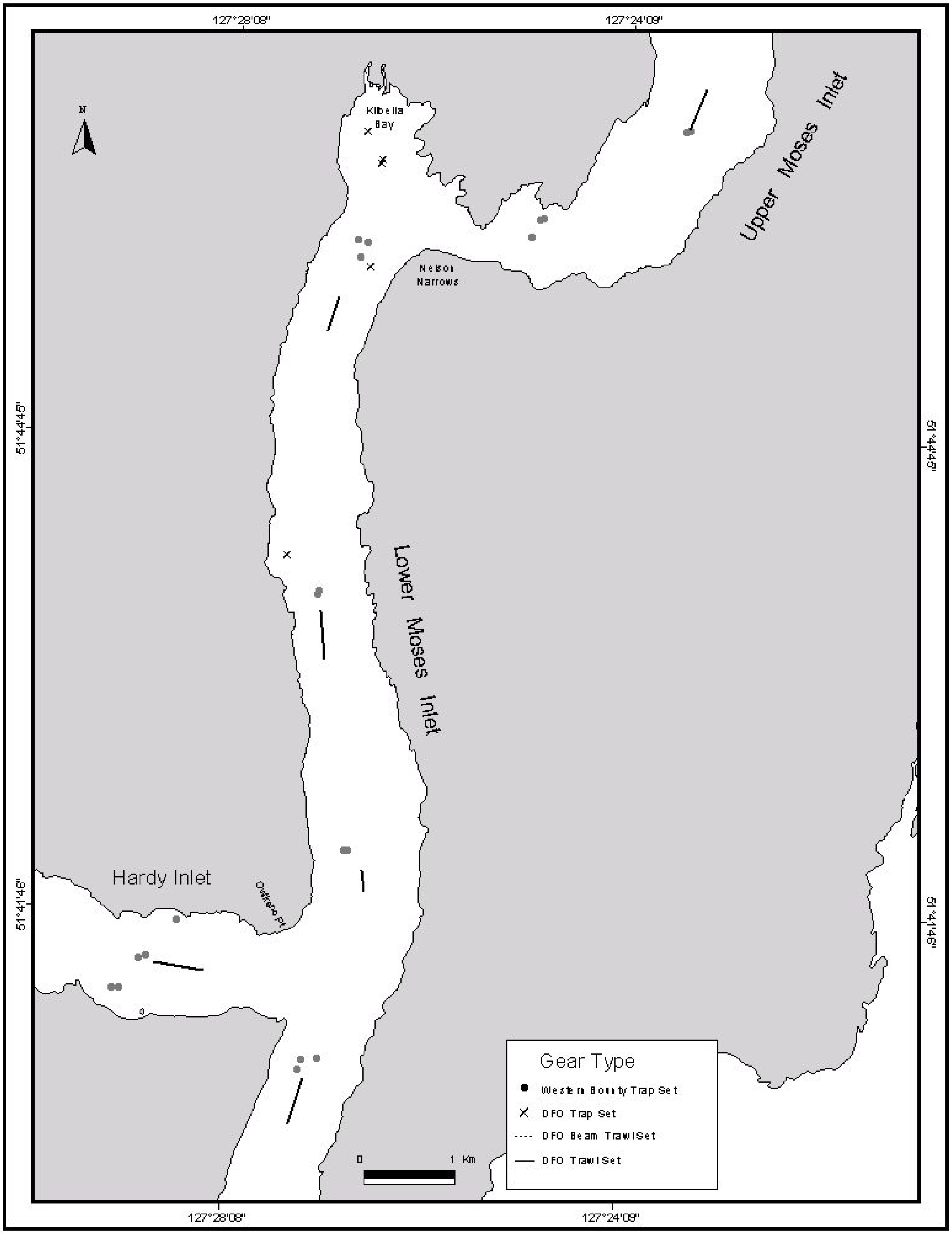


Figure 3. Set locations in Lower Moses Inlet, Tanner crab trap survey, January 2004-March 2005.

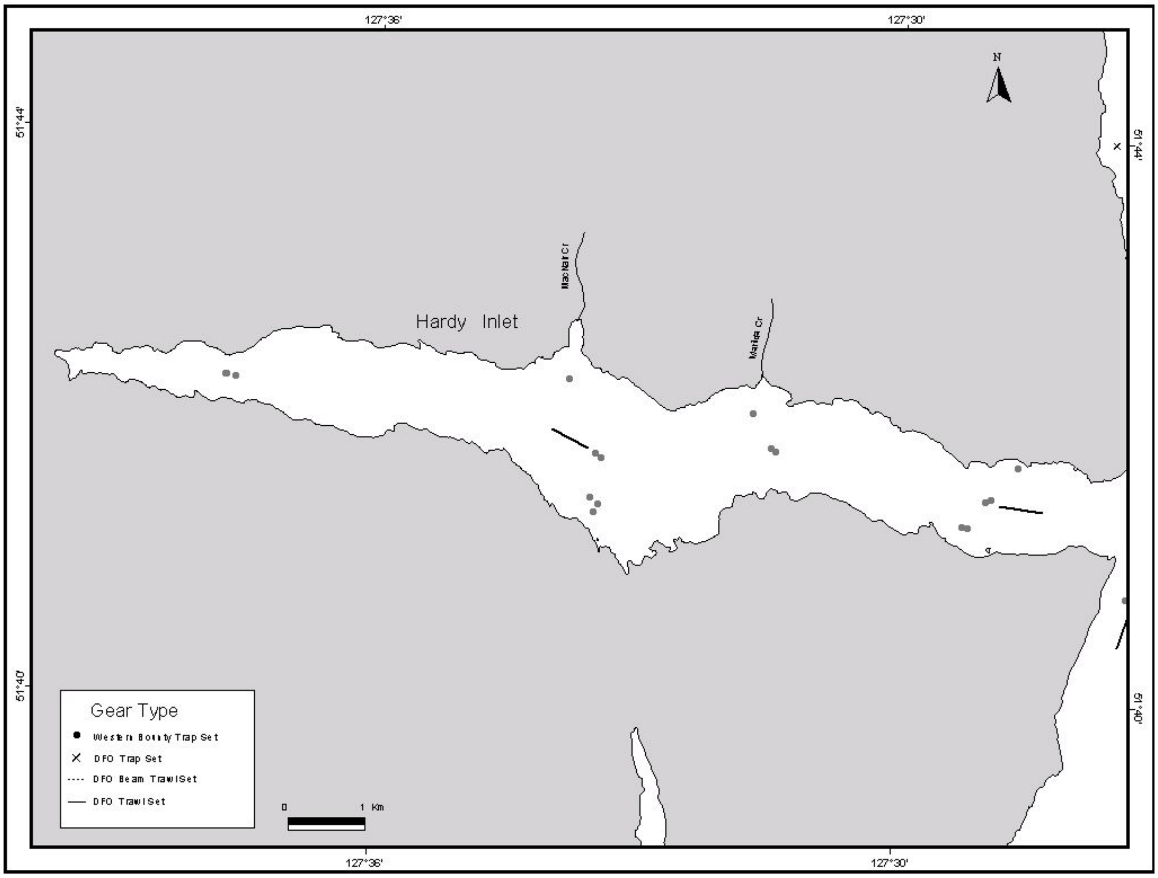


Figure 4. Set locations in Hardy Inlet, Tanner crab trap survey, January 2004 –March 2005.

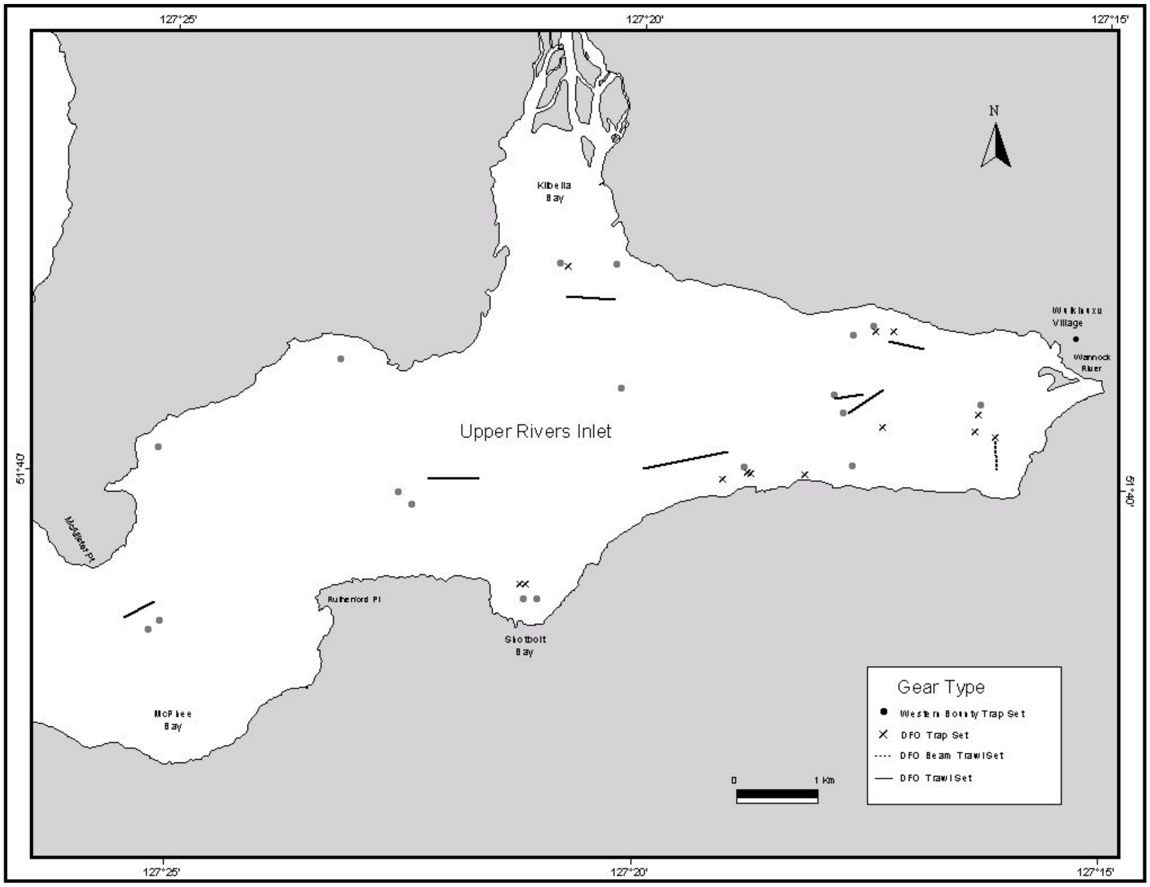


Figure 5. Set locations in Upper Rivers Inlet, Tanner crab trap survey, January 2004-March 2005.

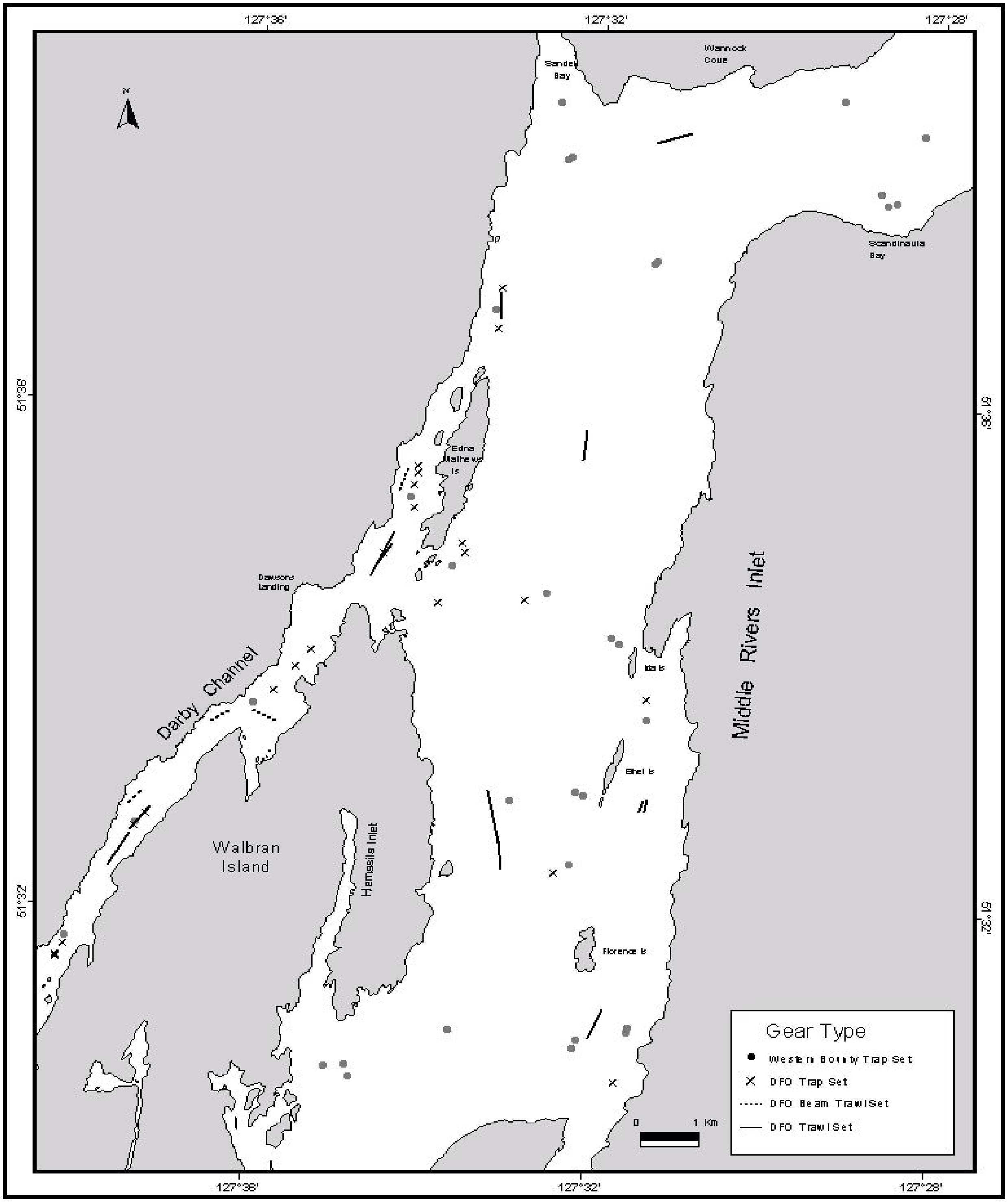


Figure 6. Set locations in Middle Rivers Inlet, Tanner crab trap survey, January 2004-March 2005.

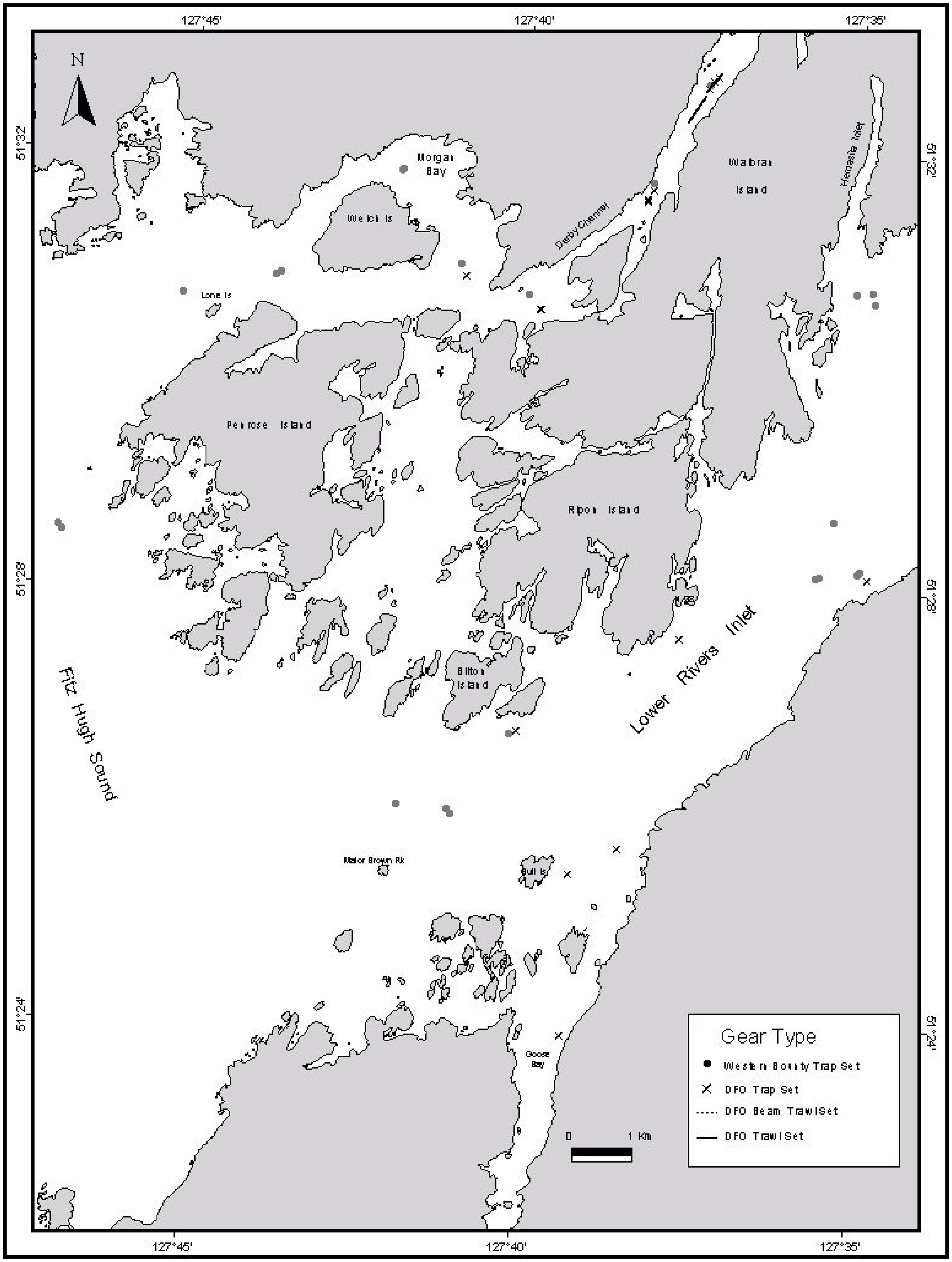


Figure 7. Set locations in Lower Rivers Inlet, Tanner crab trap survey, January 2005-March 2005.

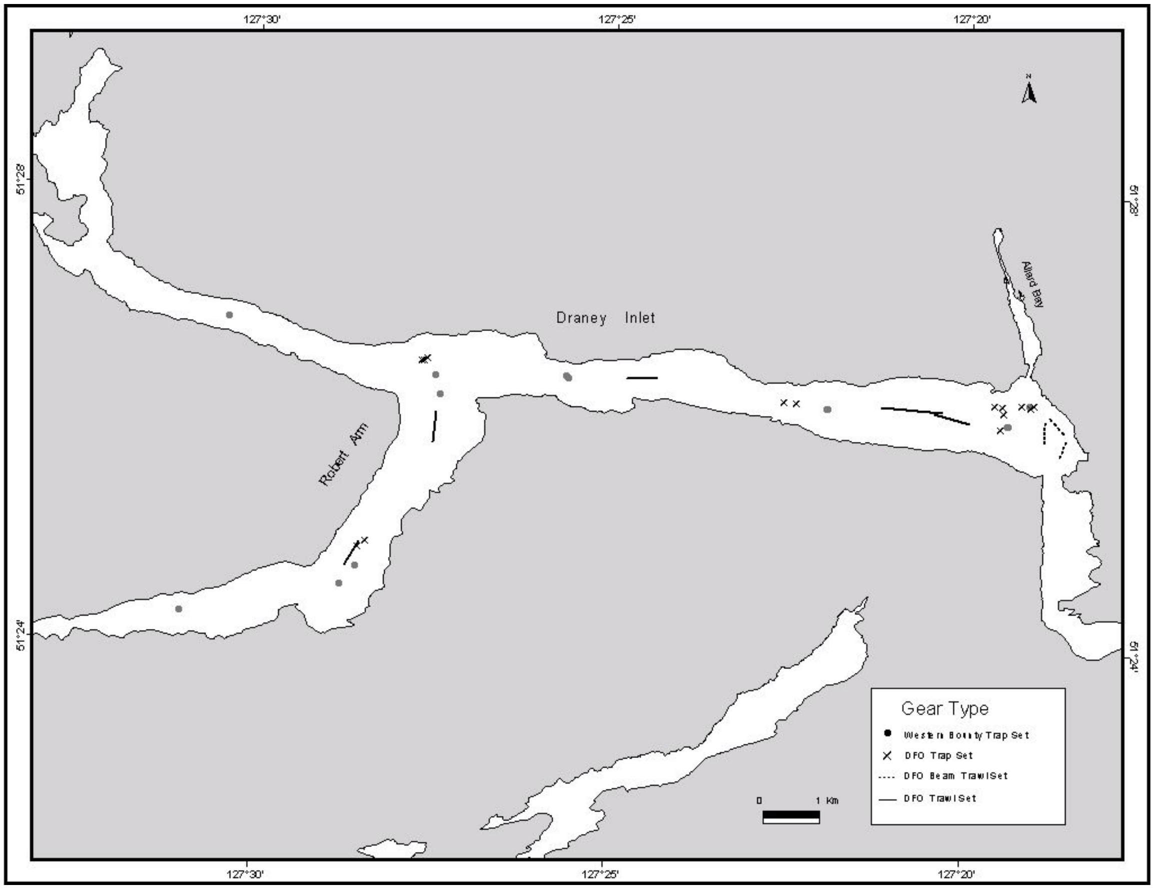


Figure 8. Set locations in Draney Inlet and Roberts Arm, Tanner crab trap survey, January 2004-March 2005.

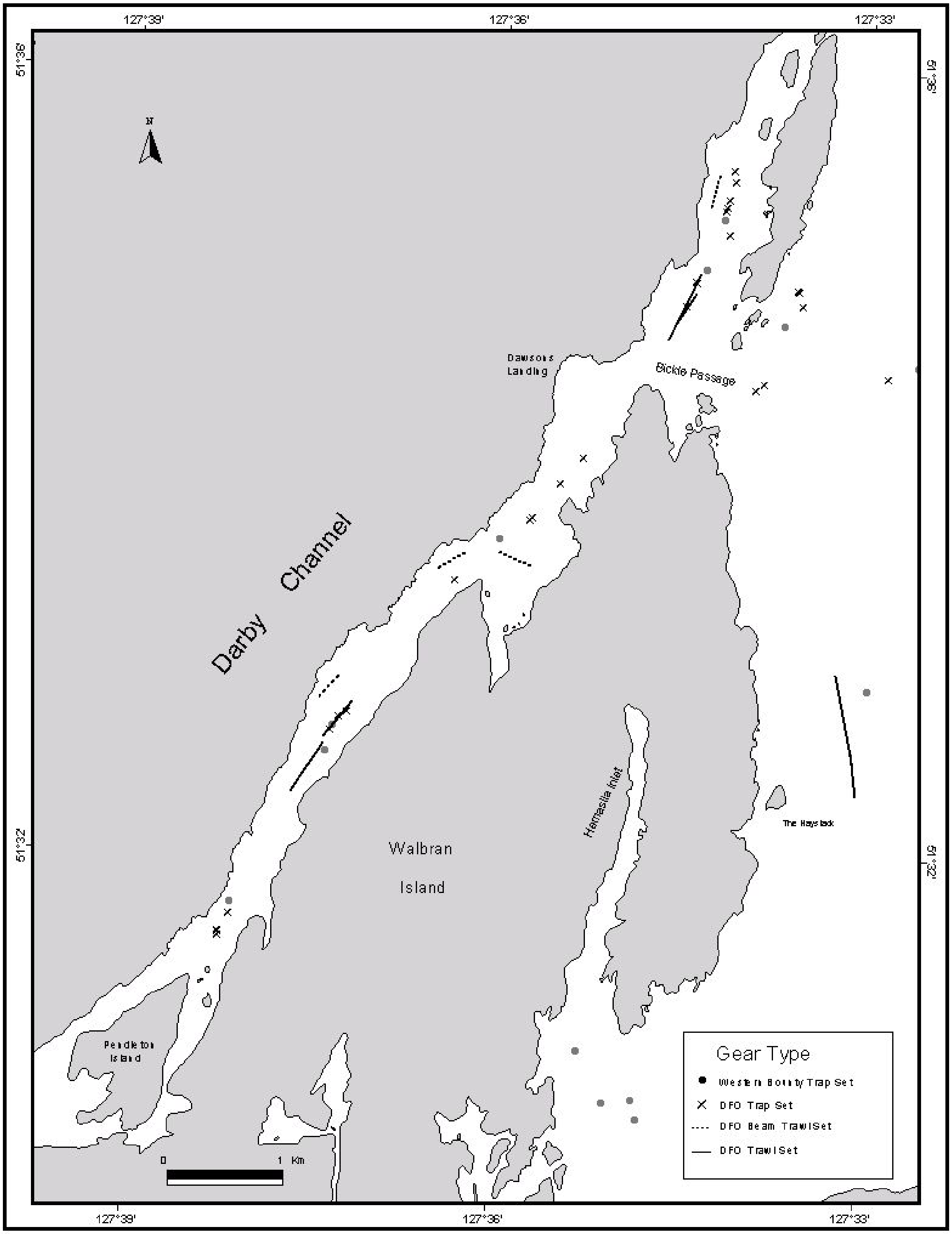


Figure 9. Set locations in Darby Channel, Tanner crab trap survey, January 2004-March 2005.

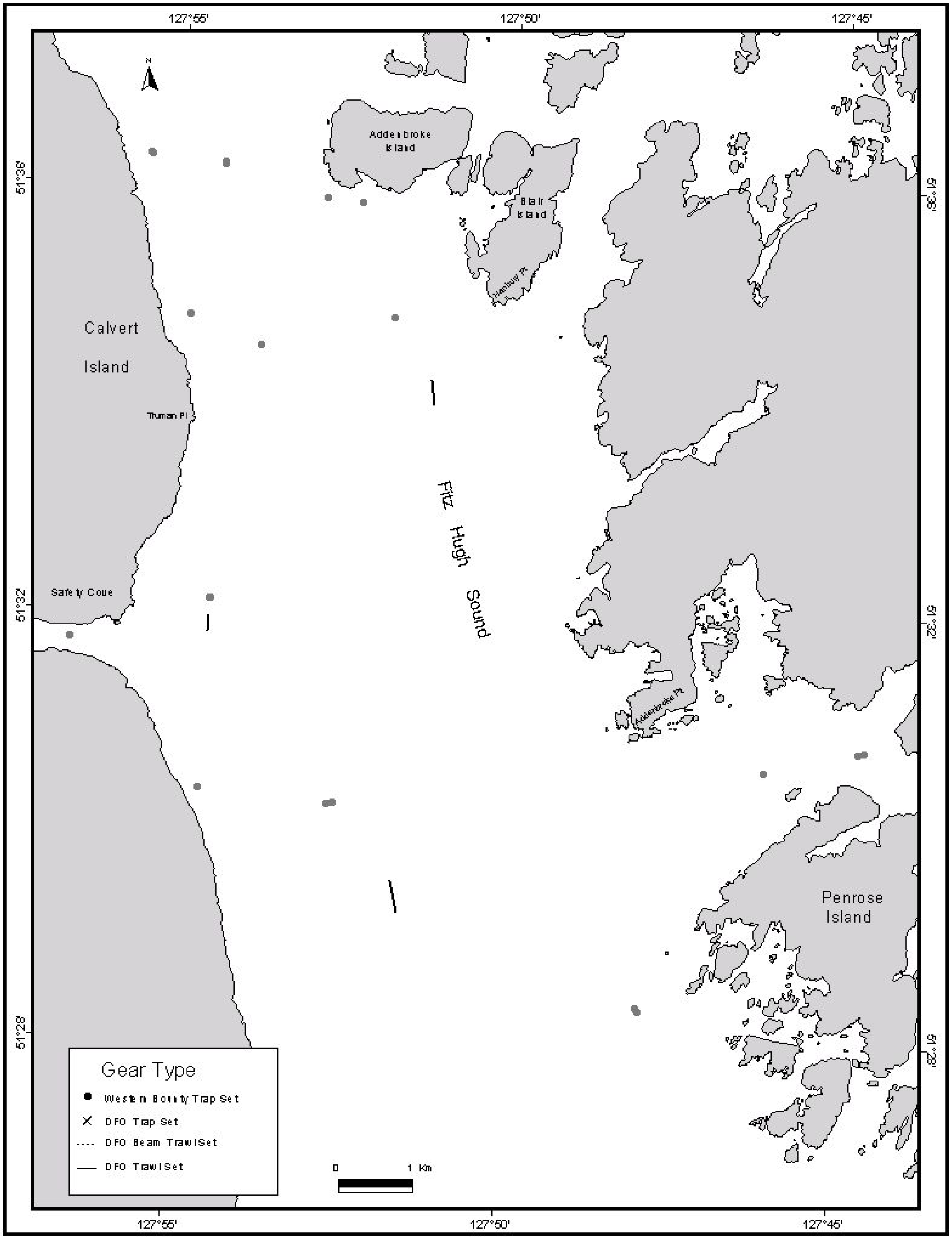


Figure 10. Set locations in Lower Fitz Hugh Sound, Tanner crab trap survey, January 2004-March 2005.

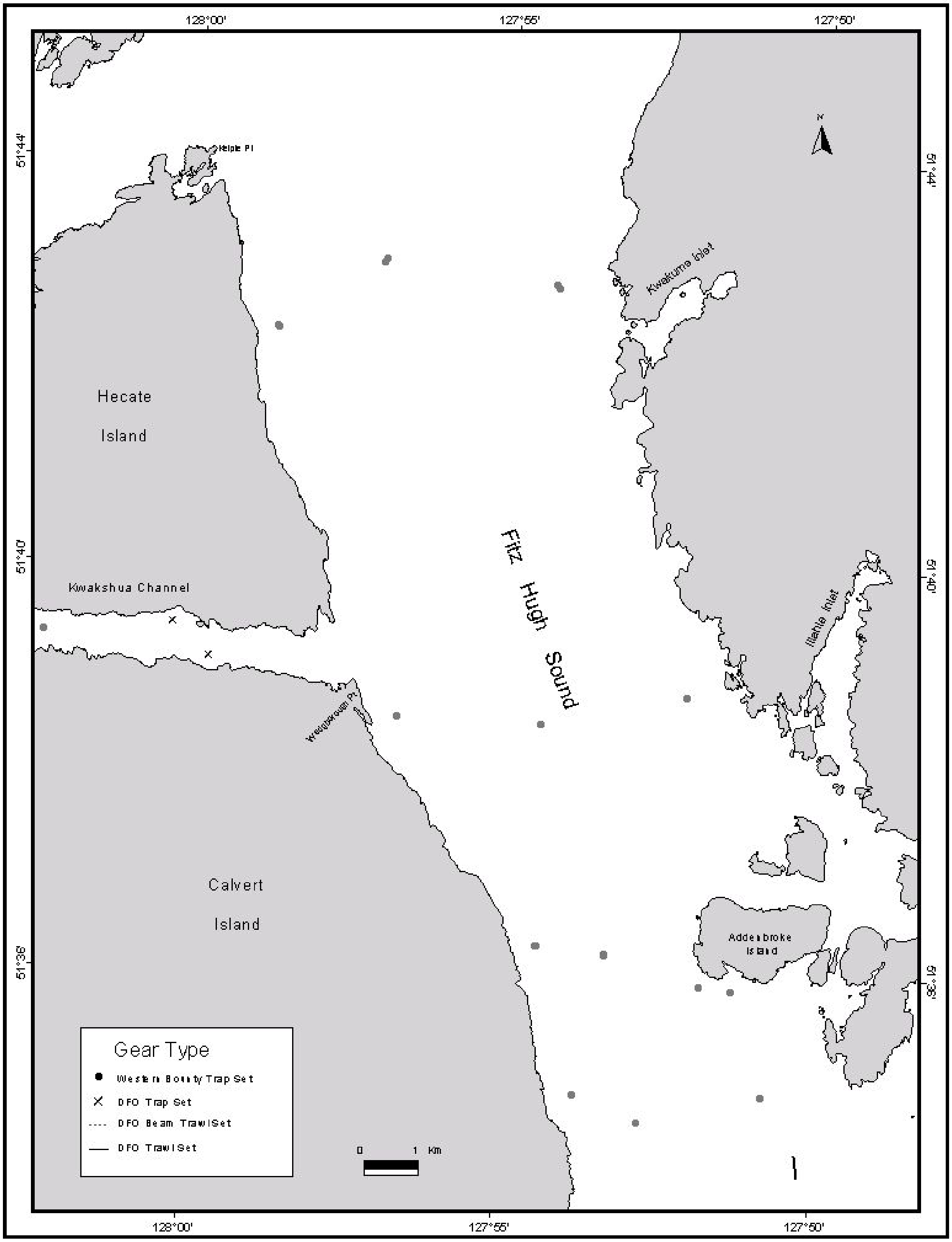


Figure 11. Set locations in Upper Fitz Hugh Sound, Tanner crab trap survey, January 2004-March 2005.

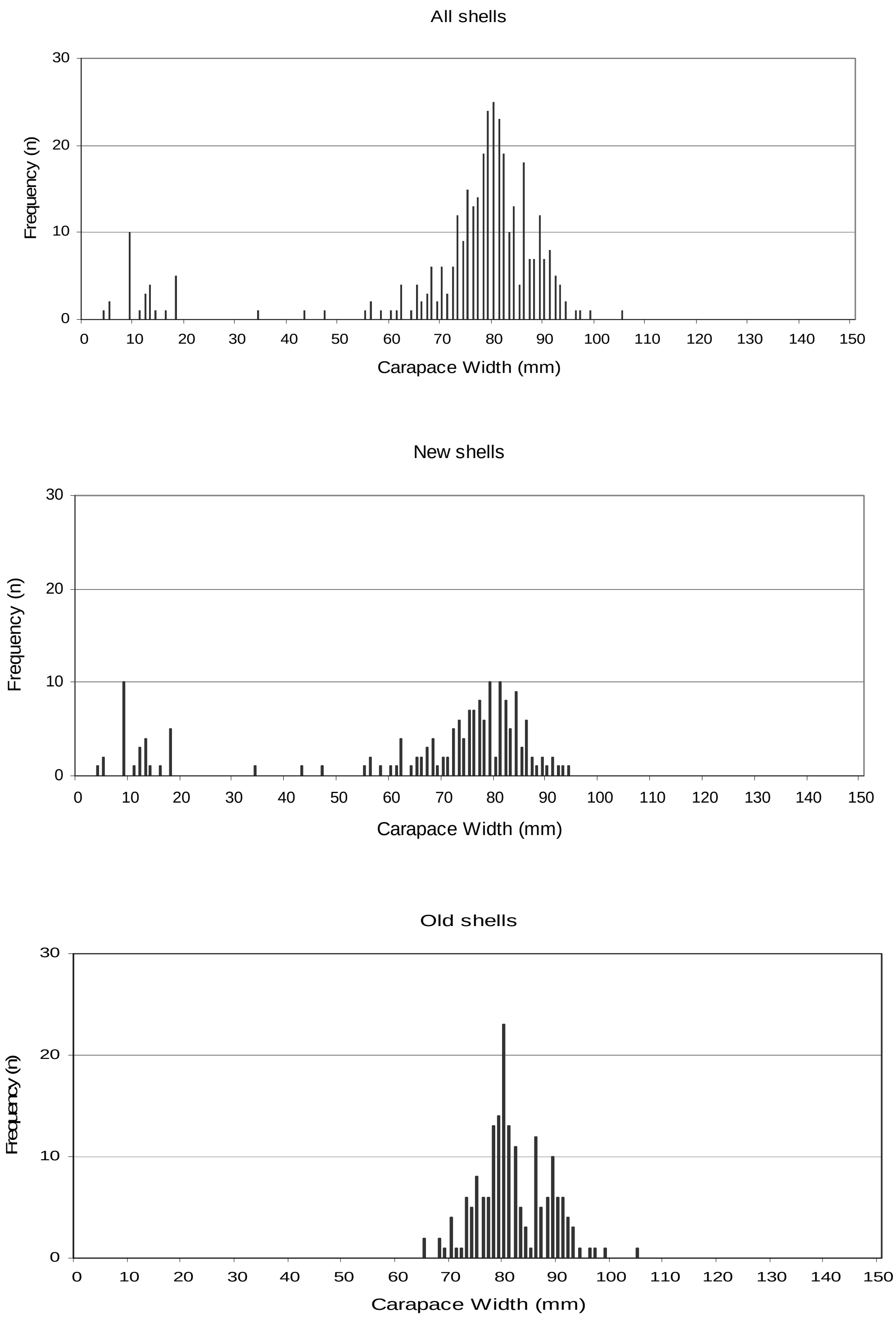


Figure 12. Size distribution of female *C. bairdi*, from WNFP and DFO surveys in Rivers Inlet, B.C., January 2004-March 2005. Upper panel (all-shells); Middle panel (new-shells); Lower panel (old-shells).

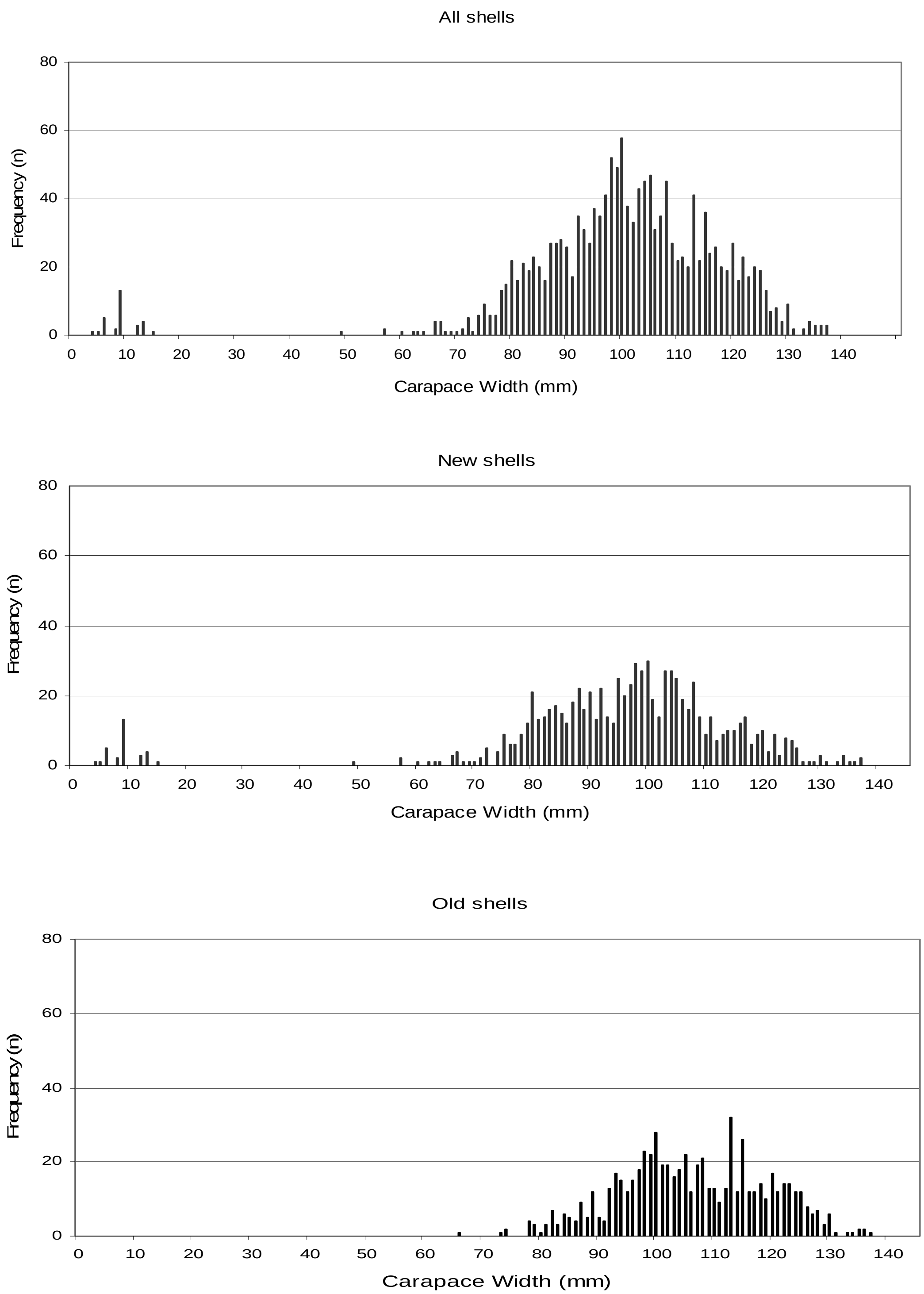
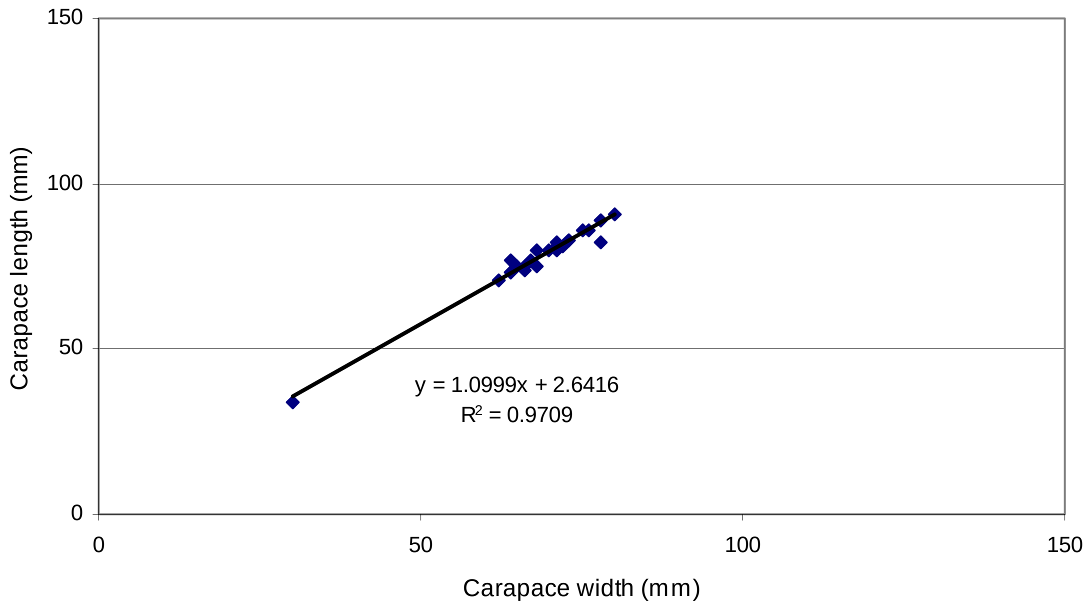


Figure 13. Size distribution of male *C. bairdi*, from WNFP and DFO surveys in Rivers Inlet, B.C., January 2004-March 2005. Upper panel (all-shells); Middle panel (new-shells); Lower panel (old-shells).



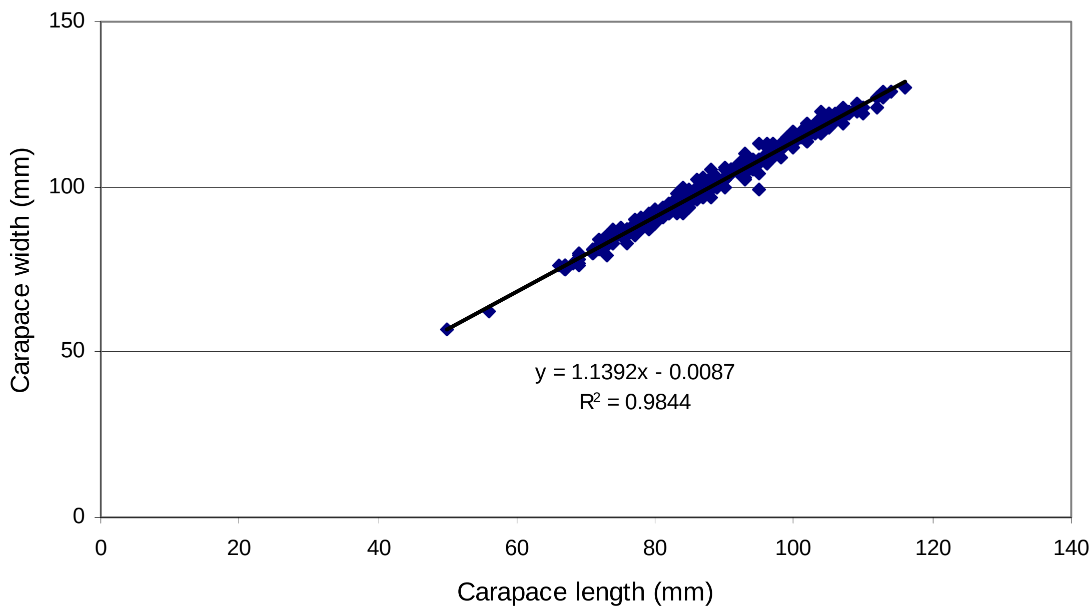


Figure 14. Relationship between carapace length and carapace width for *C. bairdi*. Upper panel (female, n=28); Lower panel (male, n=407).

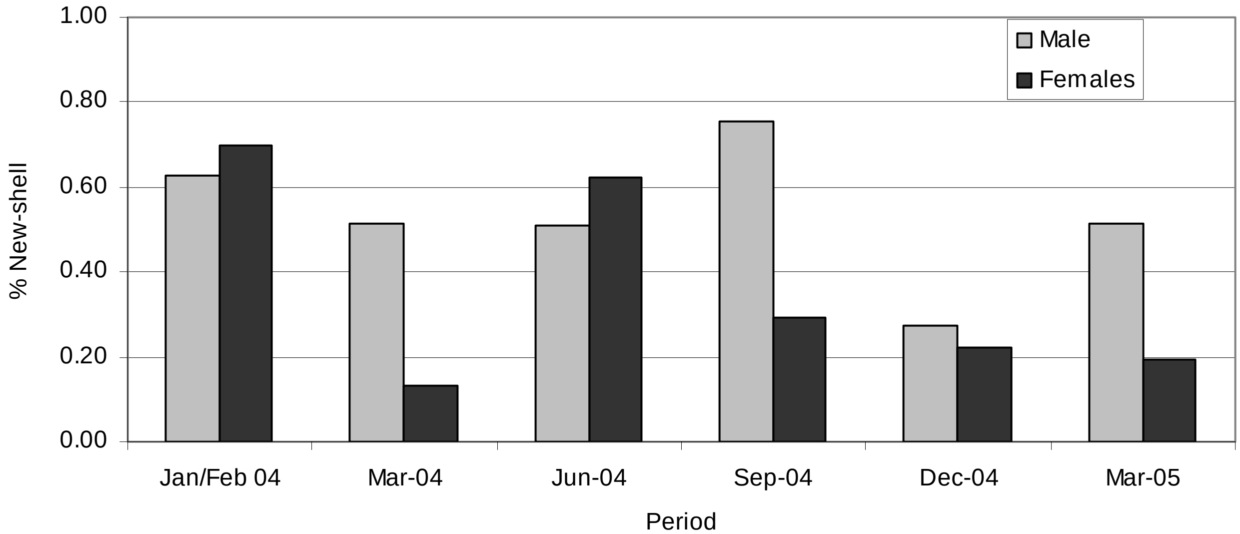


Figure 15. Percentage of new-shell mature *C. bairdi* by sex in each survey time period in Rivers Inlet, B.C., January 2004 – March 2005. There were no surveys during the months not labeled.

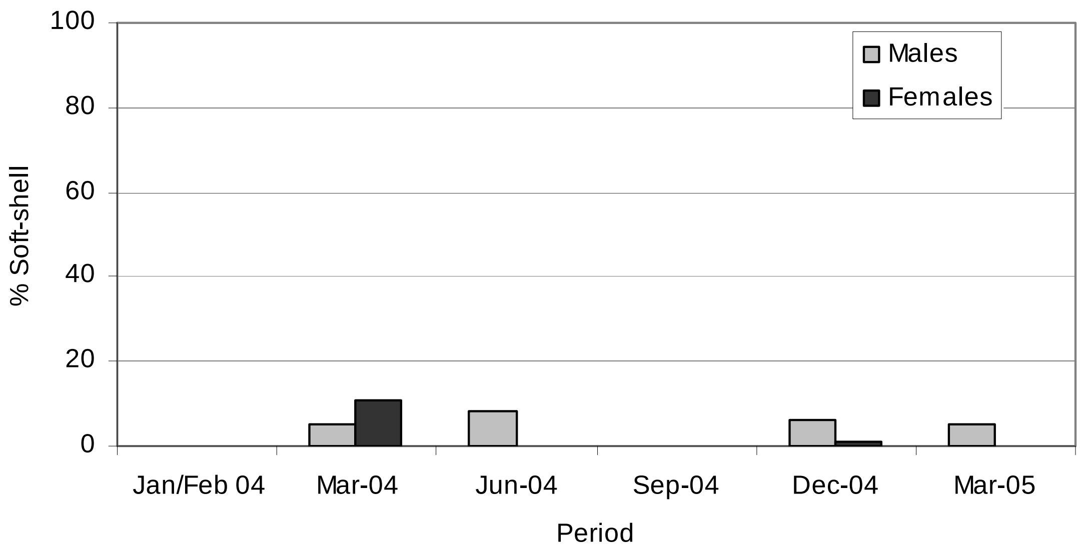


Figure 16. Percentage of mature soft-shell *C. bairdi* by sex in each survey time period in Rivers Inlet, B.C., January 2004 – March 2005. There were no surveys during the months not labeled.

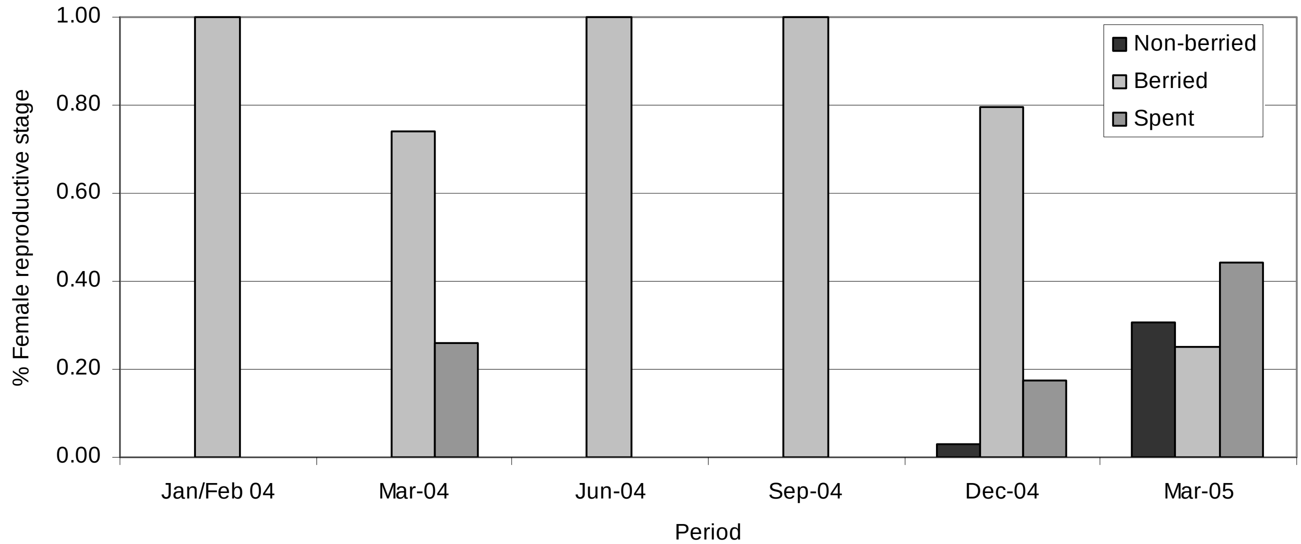


Figure 17. Reproductive stages for trap captured mature female *C. bairdi*, Rivers Inlet, B.C., January 2004 – March 2005. There were no surveys during the months not labeled.

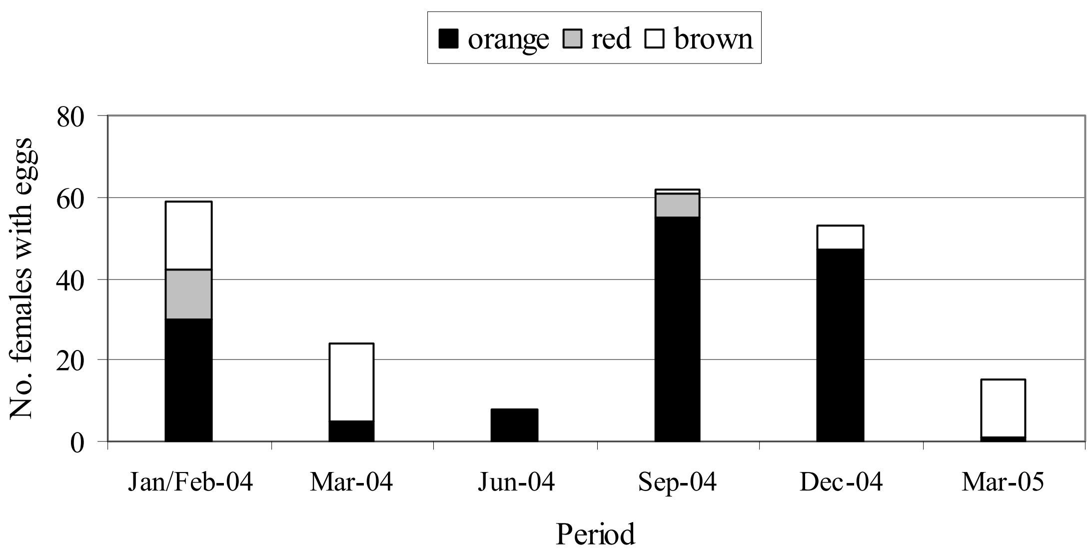


Figure 18. Female *C. bairdi* egg colour during various months of the year. There were no research surveys during the months not labeled. There were no surveys during the months not labeled.

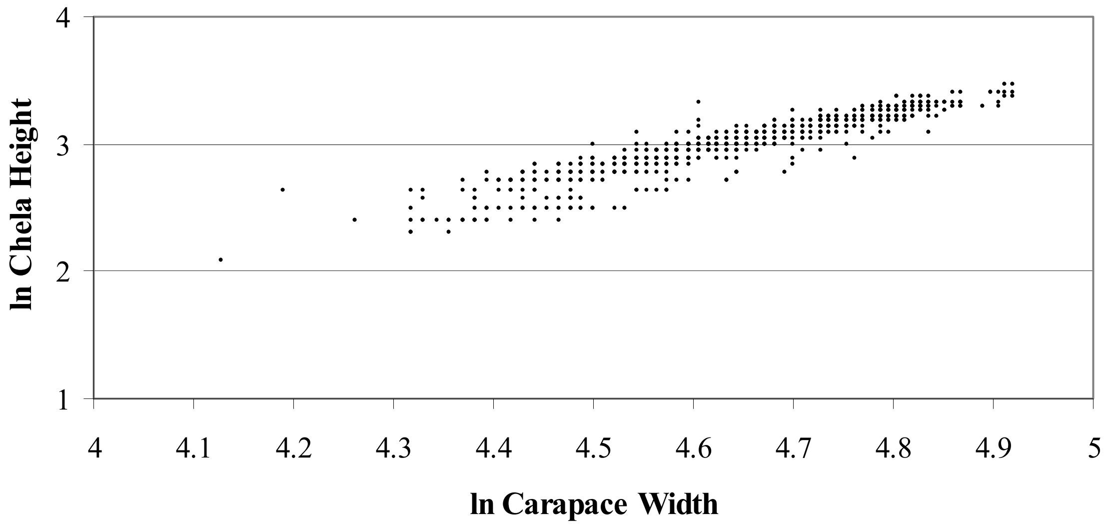


Figure 19. Plot of natural log chela height (mm) versus natural log carapace width (mm) for male *C. bairdi* collected by DFO in Rivers Inlet, B.C., January 2004- March 2005 (n = 932).

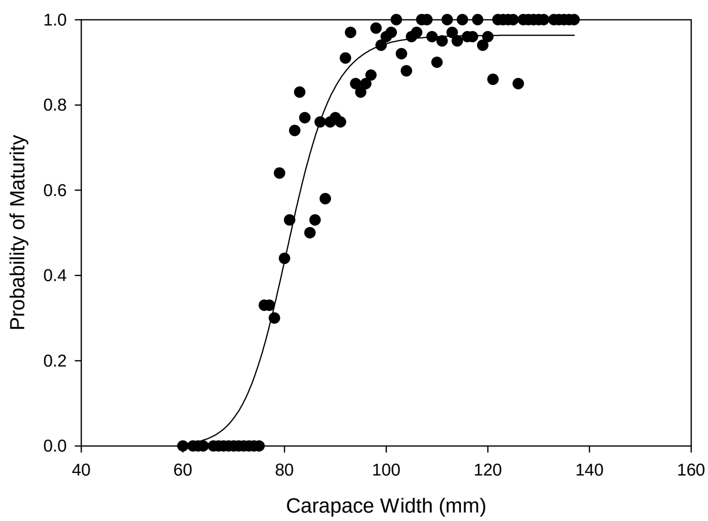


Figure 20. Male maturity ogive showing the proportion of male *C. bairdi* in Rivers Inlet, B.C., at each 1 mm carapace increment that were mature (based on the discriminant score *S*; Stevens *et al.* 1993). A logistic curve was fitted to the data. The size of 50% maturity is 81 mm CW (n = 1406).

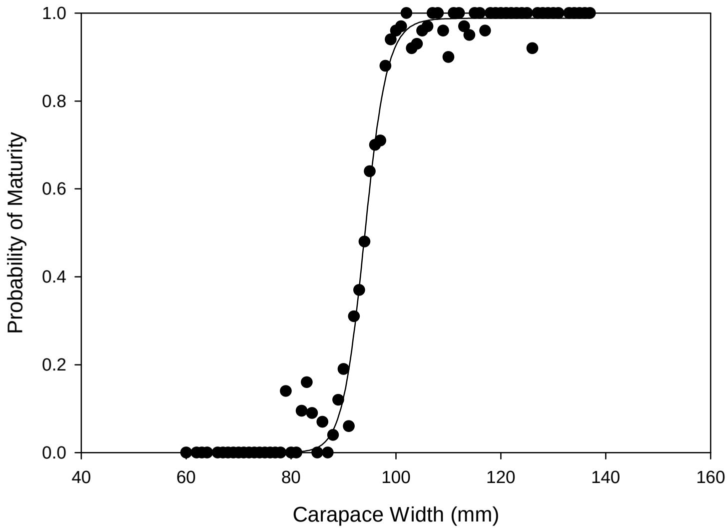


Figure 21. **Male maturity ogive of *C. bairdi*, from WNFP and DFO surveys in Rivers Inlet, B.C., January 2004-March 2005, showing the proportion of male crabs at each 1 mm carapace increment that were mature (based on CH/CW ratios; Stevens *et al*. 1993, Paul and Paul 1995, 1996a). A logistic curve was fitted to the data. The size of 50% maturity is 94 mm CW (n = 1406).**

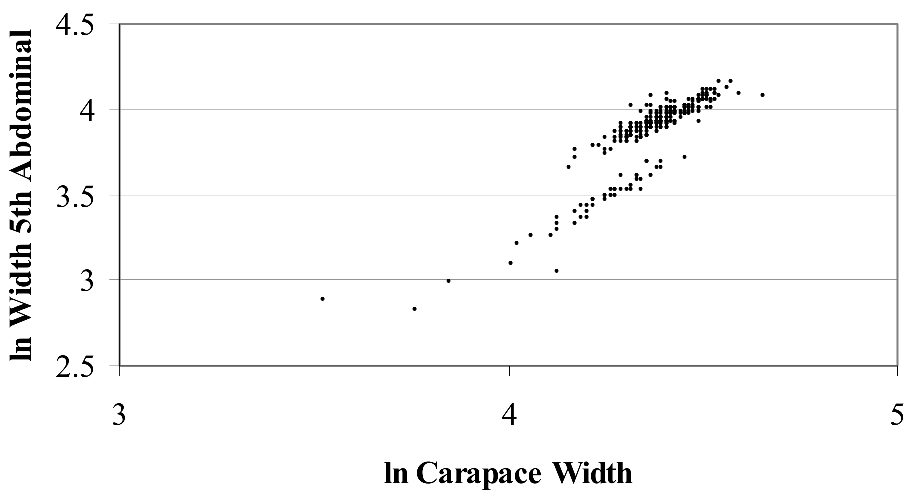


Figure 22. Plot of natural log width 5th abdominal segment (mm) versus natural log carapace width (mm) for female *C. bairdi* in Rivers Inlet, B.C.

APPENDIX

PSARC INVERTEBRATE SUBCOMMITTEE

REQUEST FOR WORKING PAPER

Date Submitted: November 10, 2005

Individual or group requesting advice:

- Bruce Burrows, Fisheries Manager, Wuikinuxv Nation
- Dennis Chalmers, Industry Development Officer, B.C. Ministry of Agriculture and Lands.

Proposed PSARC Presentation Date:

- November 2005

Subject of Paper (title if developed):

- A progress report on the development of a new fishery for inshore Tanner crabs (*Chionoecetes bairdi* Rathbun, 1924) in Rivers Inlet, British Columbia.

Science Lead Author(s):

- Ken Fong and Jason Dunham

Resource Management Lead Author:

Rationale for request:

- A Phase 0 literature review of the biology of inshore Tanner crab (*Chionoecetes bairdi*) was conducted in 2000 for the development of a new fishery for Tanner crab in Rivers Inlet. The project was initiated by the Wuikinuxv Nation and supported by the B.C. Ministry of Agriculture and Lands.
- The Phase 0 literature and data review identified information gaps on inshore Tanner crab in B.C. and recommended methods for obtaining the information.
- An MOU between the Wuikinuxv Nation and Fisheries and Oceans Canada was established to collect biological information on the distribution, biological characteristics, stock structure, and abundance of *C. bairdi* in Rivers Inlet, B.C. in order to assess the viability of a commercial fishery for inshore Tanner crab.

Objectives of Working Paper:

- Analyse data collected from trap and trawl surveys in Rivers Inlet, B.C. on the distribution, biological characteristics, stock structure, and relative abundance of *C. bairdi* in Rivers Inlet, B.C.
- Identify any uncertainty or gaps in the data or analysis.
- Identify any resource conservation concerns for any future development of the fishery.
- Present information on *C. bairdi* stocks and biological characteristics to managers and the Wuikinuxv Nation necessary to assess the commercial potential of a Tanner crab fishery in Rivers Inlet.

Question(s) to be addressed in the Working Paper:

1. What is the geographic distribution and abundance of inshore Tanner crab (*Chionoecetes bairdi*) in the Rivers Inlet system (Rivers Inlet and Fitz Hugh Sound)?
2. What are the biological characteristics and life history information of *C. bairdi* in Rivers Inlet including size distribution, growth, mortality, size at maturity, reproductive biology, and disease?
3. What are the information gaps that still need to be addressed?
4. What are the species interaction and gear selectivity?

Stakeholders Affected:

- Wuikinuxv Nation and Province of B.C.

How Advice May Impact the Development of a Fishing Plan:

- Advice will help managers and stakeholders to assess the viability of a commercial fishery for Tanner crab (*Chionoecetes bairdi*) in Rivers Inlet, B.C.

Timing issues related to when Advice is necessary:

- Advice is necessary to respond to stakeholders to continue investigation into this species.

Approval:

Head, Shellfish & Marine Mammals Assessment	Date
Regional Resource Manager – Invertebrates	Date