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Inshore Tanner crab (Chionoecetes bairdi) biology in a central coast inlet, British Columbia, Canada.Ken H. Fong and Jason S. Dunham. ***Journal of Shellfish Research*** 26.2 (August 2007): p581(15). (9733 words)

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ABSTRACT Fisheries and Oceans Canada (DFO) and the Oweekeno Nation (ON) have undertaken a cooperative assessment of inshore Tanner crab, Chionoecetes bairdi, in support of developing a fishery for this species in Rivers Inlet, British Columbia (B.C.). This paper presents information regarding distribution, relative 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 ON are presented. 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 50-150 m and females at 100-200 m. Male C. bairdi ranged in size from 4-137 mm carapace width (CW). The mean size of 50% maturity is 94 mm CW for males and 81 mm CW for females. A twenty-percent growth rate was estimated for mature males. Our data show a small proportion of mature males molt throughout the year with a molt event possibly taking place in the spring or summer. Breeding in Rivers Inlet might occur in the fall with an egg-release period in the spring. Natural mortality (M) for male Tanner crabs was estimated two ways to be 0.69 and 1.12. Tagging showed that Tanner crab movements ranged between 39 and 4,592 m over a period of 7-422 days. Tanner crabs did not move between major areas within Rivers Inlet. The relatively small size of C. bairdi found in Rivers Inlet compared with those in Alaska, and the lack of significant abundance of legal male Tanner crabs, raises doubt whether a fishery for C. bairdi in Rivers Inlet would be economically viable.

KEY WORDS: Tanner crab, Chionoecetes bairdi, biology, mark-recapture

INTRODUCTION

Four species of Chionoecetes crabs are found in the eastern Pacific Ocean: Chionoecetes bairdi (Rathbun, 1924) or inshore Tanner crab; C. opilio (Fabricius, 1788) or snow crab; C. tanneri (Rathbun, 1893) or grooved Tanner crab; and C. angulatus (Rathbun, 1924) or angle Tanner crab (Jadamec et al. 1999). Three of these species (C. bairdi, C. tanneri, and C. angulatus) are found in British Columbia (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).

Tanner and snow crabs (Chionoecetes sp.) are important commercially exploited species in Alaska, Japan, and the Atlantic region of Canada. In B.C., prior to 1993 permits were issued by Fisheries and Oceans Canada (DFO) to fish inshore Tanner crabs. 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 & Phillips 2002).

Interest in developing a fishery for C. bairdi (herein called Tanner crabs) occurred when Tanner crabs were caught incidentally in other crab fisheries. In the early 1980s, 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).

In this study, we present biological information for C. bairdi in a NE Pacific coastal inlet system using trap and trawl gear and a mark-recapture program. We present information about Tanner crab distribution, size and growth, molt timing, reproduction, size of maturity, natural mortality, disease, and movements.

MATERIALS AND METHODS

Study Site

The study area (approximately 51[degrees]42', 127[degrees]57') is located in the Central Coast region of B.C. (Fig. 1). The study area is approximately 642 [km.sup.2] and maximum depth is 395 m. The study area was divided into 10 subareas: Upper and lower Fitz Hugh Sound; Upper and lower Moses Inlet; Upper, middle and lower Rivers Inlet; Hardy Inlet; Draney Inlet; and Darby Channel.

Sampling Methods

Surveys for Tanner crabs were conducted by DFO and trained Oweekeno Nation (ON) fisheries technicians who were supervised by a qualified biologist. Six surveys were conducted between January 2004 and March 2005, each approximately 3 mo apart. DFO research vessels Neocaligus, a 25 m vessel, and Vector, a 40 m vessel, completed 3 and 1 surveys, respectively. The ON fishery vessel Western Bounty, a 16.7 m trawler/longliner, completed 2 surveys (Table 1). Depths shallower than 35 m were not sampled.

Trawl Sampling Methods

The purpose of trawling with the shrimp net was to determine densities of C. bairdi. The smaller, more versatile beam trawl net was used to capture juvenile Tanner crabs.

The shrimp trawl was a 13.4-m net fished with 1.7-[m.sup.2] Thyboron trawl doors (Fong et al. 2004, 2005). 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. 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.

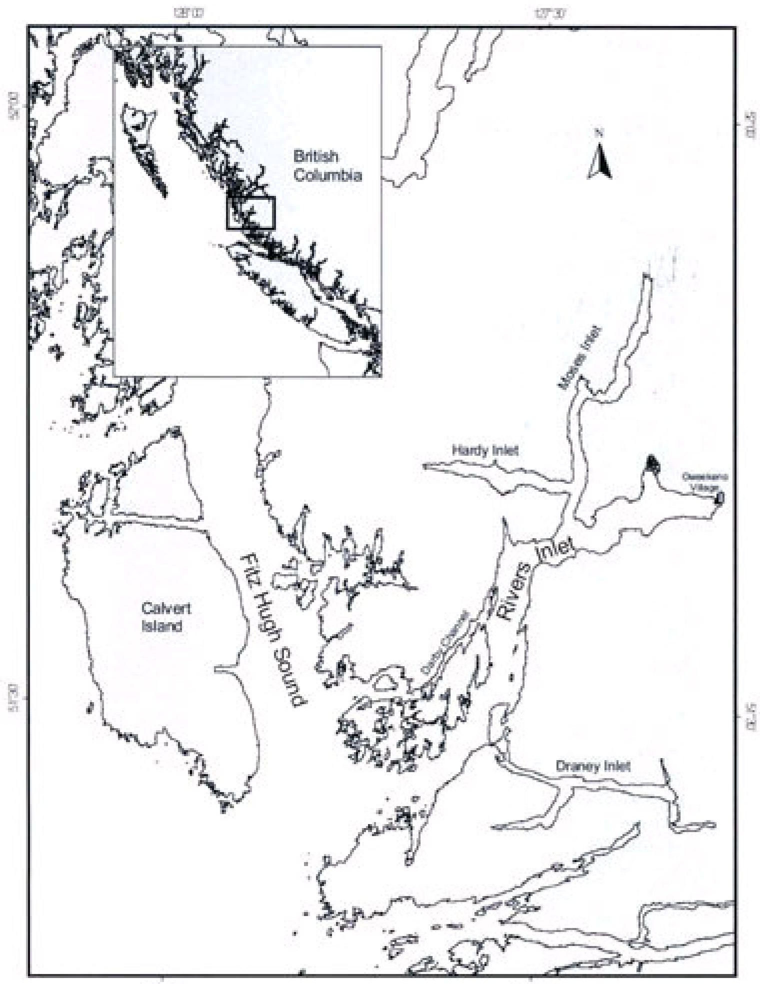

Figure 1. Trawl and trap sampling locations in Rivers Inlet, B.C.

A systematic design was used and trawl locations were predetermined; considerations for location 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. Actual set locations were determined using a Furuno GPS and trawl tracks were plotted using NOBELTEC software.

Trap Sampling Methods"

DFO trap surveys used 3 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. Dungeness traps were baited with one 0.5 L perforated bait jar containing 0.5 kg of herring. Baits were used only once and soak times were approximately 24 h. Prawn traps were baited with one can of cat food grade tuna. Escape ports were closed on all traps, except on prawn traps, which are not equipped with escape ports.

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

The ON used 1.35-m square pyramidal top-loading Tanner traps with 7.0-cm nylon mesh with closed escape ports. 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 h.

The ON deployed their Tanner traps 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 m and 100 m with 50-300 m spacing depending on the available area. Groundlines were deployed at specified depths throughout the study area with 5 Tanner crab traps attached at 80 m spacing along the groundline.

Systematic designs were used for the DFO and ON surveys. Random locations were not chosen because of the limited knowledge of Tanner crab distribution in the study area. Sampling locations were based on habitat type, depth, vessel capability, anecdotal information supplied by local First Nations traditional knowledge, and replication of sets from previous surveys to recapture tagged crabs. All areas were sampled by stratified 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.

Catch rates (CPUE) from all trap surveys were calculated as the total sum of Tanner crabs captured divided by the total number of Tanner traps. Dungeness and prawn trap catches were very low and, therefore, not used in CPUE calculations. Catch rates were summarized by subarea.

Biological Sampling, Methods

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. Descriptions of biological characteristics and field codes are in Fong et al. (2004, 2005).

TABLE 1.

Vessels and gear used to collect Tanner crabs (*Chionoecetes bairdi*) in Rivers Inlet, B.C., 2004 and 2005.

Date	Vessel	Gear Type
2004		
Jan 20–Feb 20	*Western Bounty*[1]	Trap
Mar 10–16	*Neocaligus*[2]	Shrimp trawl, trap
Jun 4–5	*Vector*[2]	Trap
Sep 2–14	*Western Bounty*	Trap
Dec 2–9	*Neocaligus*	Shrimp trawl, beam trawl, trap
2005		
Mar 17–24	*Neocaligus*	Trap

[1] ON = Oweekeno Nation.
[2] DFO = Fisheries and Oceans Canada.

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). 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 (see also Paul & Paul 1995, Paul & Paul 1996a, Jadamec et al. 1999). If the right claw was missing, the left claw was not measured. For females, abdominal width (AW) was measured to the nearest 1 mm (see also Stevens et al. 1996) and the presence of eggs and their respective color noted.

Maturity

Male Tanner crabs

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

Two general methods, and variants of, were used to determine size at morphometric maturity for male Tanner crabs based on morphometric allometry, in this case the ratio of CH to CW. These methods were developed for male C. bairdi around Kodiak Island, AK by Stevens et al. (1993) (see also Paul & Paul 1995, Paul & Paul 1996a).

1) Discriminant Score

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

where S = discriminant score, CW = carapace width exclusive of spines, and CH = chela height. Juveniles have discriminant score values less than -0.6 and morphometrically mature males have values greater than -0.6. Male Tanner crabs must also be greater than 75 mm CW to be considered mature.

2) CH/CW ratios

CH/CW ratios > 0.17 and CH > 17 ram. Crabs must also be >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 recently mentioned methods, 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.

There is some debate in the literature whether male Majid crabs undergo a terminal molt at maturity (see Donaldson et al. 1981, Conan & Comeau 1986, Dawe et al. 1991, Stevens et al. 1993, Paul & Paul 1995). If there is a terminal molt 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 molt exists, then it would be precautionary to assume the mean size of maturity lies somewhere between SM_{50} and the mean size of mature males (Stevens et al. 1993).

Female Tanner crabs

Female C. bairdi do not molt 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, because 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:

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

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 84-365 days). Trap CPUE data collected by DFO research vessels were analyzed separately from data collected by the ON 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 include molting crabs, because we could not detect a particular time between two surveys when a definite molt 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 fishing for Tanner crabs 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.sup.-z]

Survival rate (S):

S = [e.sup.-z]

Diseases

Tanner crabs were macroscopically examined in the field for bitter crab disease (BCD) and black mat fungus. Tanner crabs with signs of infection were sampled by clipping a small section of leg and placing it in Davidson's solution. Samples were then examined histologically by the Shellfish Health Program section at the Pacific Biological Station for confirmation.

Tagging and Recovery

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

Research Surveys

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 after biological sampling. Tagged crabs recovered in surveys were sampled for biological information, the tag number recorded and 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 Oweekeno 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.

RESULTS

Tanner Crab Distribution and Relative Abundance

Tanner crabs were not evenly distributed throughout the Rivers Inlet system. The highest abundance occurred in Draney and Darby Channel and, to a lesser extent, in upper Rivers Inlet (Table 2). Few crabs were caught in the outer areas of the Rivers Inlet system, lower Rivers Inlet and Fitz Hugh Sound.

Tanner Crab Biological Information

Size and Growth

Size of male C. bairdi caught in Rivers Inlet ranged from 4 mm, probably the first instar (Jadamec et al. 1999), to 137 mm CW (Fig. 2). Females ranged in size from 4-106 mm CW (Fig. 3). The mean sizes of trap captured males and females were 102.0 and 79.5 mm CW, respectively.

TABLE 2.

CPUE (crabs/trap) of Tanner crabs, *Chionoecetes bairdi*, by subarea from the *Neocaligus* and *Western Bounty* trap surveys in Rivers Inlet, B.C. *Neocaligus* surveys were conducted March and December 2004 and March 2005. The *Western Bounty* surveys were conducted January/February and September 2004.

	Neocaligus			*Western Bounty*		
Sub-area	No. Traps	No. Crabs	CPUE	No. Traps	No. Crabs	CPUE
Upper Moses Inlet	17	14	0.82	87	80	0.92
Lower Moses Inlet	14	3	0.21	62	46	0.74
Hardy Inlet	15	12	0.80	103	61	0.59
Upper Rivers Inlet	76	132	1.74	120	135	1.13
Middle Rivers Inlet	33	30	0.91	135	46	0.34
Lower Rivers Inlet	23	0	0.00	99	15	0.15
Upper Fitz Hugh Sound	0	—	—	80	0	0
Lower Fitz Hugh Sound	0	—	—	105	0	0
Draney Inlet	49	261	5.33	71	129	1.82
Darby Channel	95	259	2.73	35	23	0.66

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 molt up to 18 mm CW. It is important to note that crabs in the size range between 20 and 60 mm CW were not caught by the fishing gear, including the smaller mesh beam trawl and prawn trap, so we cannot estimate the growth rate of preadults. 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 ram, and 20% at a possible molt to 120 mm CW (Fig. 2). It could be argued that the broad size range (72-137 mm) of males could represent one mode indicative of a terminal molt.

The size frequency data for females shows two modes around 78 and 90 mm CW (Fig. 3) suggesting that instars of two different sizes are molting to these maximum widths. Unfortunately, because we collected few crabs in the 60-70 mm CW range, the size distributions of these smaller crabs is not obvious.

Two (one female, one male) of the 26 tagged Tanner crabs recovered had molted and grown (Table 3). The male grew 28.7% (94-121 mm CW) in just over a year from March 16, 2004 to March 21, 2005. CL and CH increased 47% and 50%, respectively. This male increased its weight by 217% (285 g to 620 g). The female grew 17.8% in size (68-80 mm CW) and its telson size increased 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.

Shell Condition and Molting

Shell condition is a subjective evaluation based on the number of well defined criteria (Fong et al. 2004, Fong et al. 2005, Jadamec et al. 1999). The new-shell component of mature male Tanner crabs appears to decrease from 63% in the January ON survey to 51% during the DFO June survey and then increase to 76% in the ON September survey (Fig. 4). This might suggest molting in males occurs during the summer months from July to September.

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

One tagged male probably molted in the summer to a larger size (Table 3). It had a new-shell in March 2004 and probably would not have molted until the shell became worn, possibly at least three months later, meaning it might have molted sometime between June and August. It was an old-shell crab in March 2005 suggesting at least six months of shell wear.

Two softshell mature female Tanner crabs were captured in March 2004, but none in other surveys (Fig. 5). One explanation is that newly molted female Tanner crabs might not be feeding, but rather remain hidden because they are more vulnerable to injuries and predation.

Reproduction

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 (Fig. 6). 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 (Fig. 7). 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 either berried or spent was 95% indicating that many of the females were being bred.

Maturity

Male Tanner Crabs

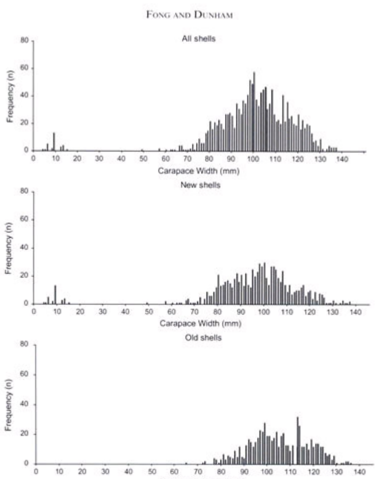

Figure 2. Size distribution of male *Chionoecetes bairdi*, from ON and DFO surveys in Rivers Inlet, B.C., January 2004 to March 2005. Upper panel (all-shells); Middle panel (new-shells); Lower panel (old-shells).

A positive relationship exits between CH and CW for male Tanner crabs (Fig. 8). However, there is no clear distinction between morphometrically immature and mature individuals as has been reported for Majid crabs. There is much variability in CH for crabs 75-95 mm CW. Figure 8 reflects 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 81-108 mm CW depending on the methodology used and whether a terminal molt is assumed to take place (Table 4, Figs. 9 and 10).

Female Tanner crabs

Female Tanner crabs undergo a terminal molt when mature (Somerton 1981a, Stevens et al. 1993). The abrupt increase in AW compared with CW is clearly evident for females when they molt to maturity (Fig. 11). The mean CW of all egg-bearing and spent females (new and old-shell) was 81 [+ or -] 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 10-17 y in Rivers Inlet, Hoenig's (1983) equation calculates the instantaneous annual rate of natural mortality M from these potential lifespans to range from 0.44-0.26. 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 -0.81-4.34. 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 because of no targeted fishing in the inlet.

The natural mortality rate based on mean CPUE estimates collected from 96 paired trap sets throughout Rivers Inlet ranged from -2.78-6.47 (Table 5). 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.

Disease

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 hemocyte infiltration in the underlying connective and muscle tissues (G. Meyers pers. comm. 2005).

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 nontagged crabs during the first 3 mo 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 none was 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. During all surveys, 26 tagged Tanner crabs were recovered by trap gear, none by trawling. Of the 26 recoveries, 22 were males and 4 were females; two (one female and one male) had molted and grown (Table 3).

Other Fisheries

Six tagged Tanner crabs were returned by the public that had been captured in Darby Channel and Upper Rivers Inlet. Three crabs were female and three were male, none of which had molted. There were no Tanner crabs reported from any members of the Oweekeno Nation even though there was a separate reward program for members of the community.

Movement

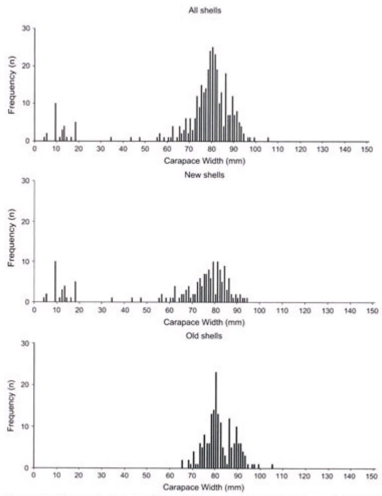

Figure 3. Size distribution of female *Chionoecetes bairdi*, from ON and DFO surveys in Rivers Inlet, B.C., January 2004 to March 2005. Upper panel (all-shells); Middle panel (new-shells); Lower panel (old-shells).

Tanner crab movements ranged from 39-4,592 m and averaged 1341 [+ or -] 1371 m (mean [+ or -] SD). We excluded crabs recaptured after being liberated less than a week. All recovered crabs had remained in the same subarea or inlet where they were tagged. Movement appeared to be random; there was little correlation ([R.sup.2] = 0.067) between distance moved and the time elapsed between initial tagging and recovery.

DISCUSSION

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 sloped areas near creek outflows and river mouths.

Depth distribution for C. bairdi in Rivers Inlet from trap and trawl survey data ranges between 36 and 340 m. Hart (1982) reported crabs between 6-474 m. Our information from beam trawling found juveniles near shores at depths between 43-68 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.

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 such as hatching, spawning and molting. Our tag return information suggests Tanner crabs do not actively move throughout the inlet. This suggests there might be little mixing of adult populations and only one distinct population in Rivers Inlet made up of several smaller subpopulations.

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 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 trap survey data probably provides a true reflection of size of adult Tanner crabs for both sexes. The peak abundance of males is around 100 mm CW. The size range of Tanner crabs 20-60 mm CW missing from our size frequency distribution suggests that traps are not useful for capturing preadults, possibly because of selectivity characteristics of trap gear. There might be aggressive competition by larger Tanner crabs for bait.

The largest male caught in Rivers Inlet was 137 mm CW. Comparatively, male Tanner crabs in Alaska are much larger, capable of reaching a size of 200 mm CW (Donaldson et al. 1981). 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 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.

TABLE 3.

Size of *Chionoecetes bairdi* from tag return information in Rivers Inlet, B.C.

		Biological Information								
				Missing				Male claw		
Tag No.	Dates Caught/Recaptured	Sex	Shell Condition	Claws	Legs	Carapace Width	Weight (g)	Length	Width	Female Abdominal
43050	22-Jan-04	Female	New shell	0	0	68	—	—	—	31
	6-Dec-04	Gravid	Not new/Not old	0	1	80	—	—	—	48
43655	16-Mar-04	Male	New Shell	0	0	94	285	36	18	—
	21-Mar-05		Old Shell	0	0	121	620	53	27	—

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. Juvenile C. bairdi also probably grow quickly. Estimates of growth per molt, 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, a 22% rate for pre-adults, and a 20% rate for a possible molt past morphological maturity. Later stage growth rates could be higher, however, as a tagged crab grew 29% to 121 mm CW.

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

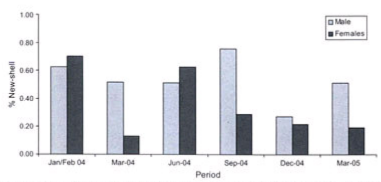

Figure 4. **Percentage of new-shell mature *Chionoecetes bairdi* by sex in each survey time period in Rivers Inlet, B.C., January 2004 to March 2005. There were no surveys during the months not labeled.**

Fishery managers need to ensure long-term viability of crab populations 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 breeding (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).

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, Somerton 1981 b, Stevens et al. 1993), snow crab (C. opilio; Conan & Comeau 1986, Dawe et al. 1991, Sainte-Marie et al. 1995), and offshore Tanner crab (C. tanneri: Workman et al. 2000, Workman et al. 2001). However, this relationship was not readily observable in our study even after data were standardized by research vessels. 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. 1993), 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 molted and its CH increased 50% suggesting it molted from being immature to mature sometime during the year. Catching more male crabs 20-80 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 molt at maturity for male Majid crabs has been debated. Conan and

Comeau (1986) concluded that C. opilio males underwent a terminal molt at maturity like females and this is characteristic of the genus. However, Dawe et al. (1991) provided evidence against the idea of a terminal molt in C. opilio. The presence of multiple modes among mature C. bairdi could result either from males maturing (and undergoing a terminal molt) over at least three instars, as suggested by Comeau et al. (1989), or from males continuing to molt and grow 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 molt it probably occurs after they reach the legal size (140 mm CW) in Alaska.

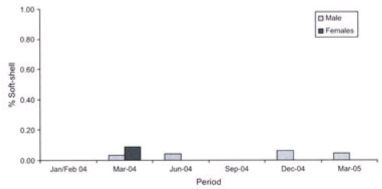

Figure 5. Percentage of mature softshell *Chionoecetes bairdi* by sex in each survey time period in Rivers Inlet, B.C., January 2004 to March 2005. There were no surveys during the months not labeled.

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 molt at maturity or one additional molt after they reach maturity. Crabs found over 130 mm CW could have molted 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 molt 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 molt.

In the absence of a clear incremental increase in claw size when male Tanner crabs molted to maturity, we determined size of maturity using methods developed from Alaskan C. bairdi males. If the assumption is that there is no terminal molt 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 molt at maturity, then the mean size of mature crabs is an appropriate size of maturity estimate (Conan & 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.

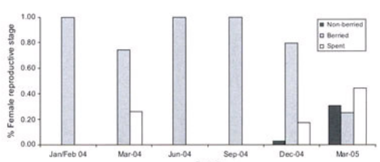

Figure 6. Reproductive stages for trap captured mature female *Chionoecetes bairdi*, Rivers Inlet, B.C., January 2004 to March 2005. There were no surveys during the months not labeled.

The discriminant score (S) type of analysis calculated a SM50 = 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 & 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 molt at maturity in male Tanner crabs, then [SM.sub.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 molt to maturity then [SM.sub.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, AK is 113 mm CW, from three different studies (Brown & Powell 1972, Donaldson et al. 1981, Stevens et al. 1993). Size in the eastern Bering Sea was determined to be 109 and 117 mm in the western and eastern subareas (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.

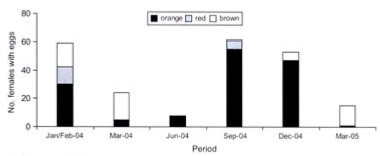

Figure 7. Female *Chionoecetes bairdi* egg color during various months of the year. There were no surveys during the months not labeled.

Female crabs undergo a true puberty molt (Hartnoll 1978) during which their abdomens increase in size disproportionately more than other body features. Somerton (1981a) stated that female C. bairdi do not molt after maturity, so the best definition of female sexual maturity is the median size of adults because [SM.sub.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 198 lb). 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.

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 & Donaldson 1992). Size of maturity is needed to manage the harvest of a crab species (prevent recruitment overfishing) because it allows the determination of size limits.

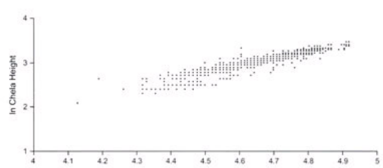

Figure 8. Plot of natural log chela height (mm) *versus* natural log carapace width (mm) for male *Chionoecetes bairdi* collected by DFO in Rivers Inlet, B.C., January 2004 to March 2005 (n = 932).

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 1981 b, Stevens et al. 1993). The size limit was derived by adding 25 mm to the 110 mm [SM.sub.50] (from Brown & 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 molt), then the size limit would be 113 mm (based on [SM.sub.50] = 94 mm and a 20% growth rate).

Natural mortality is assumed to be high for juveniles and low for terminally molted adult crabs (Workman et al. 2000). Longer life spans usually mean lower natural mortality rates, especially for larger terminally molted crabs. C. bairdi in the northern Gulf of Alaska may live 12 y (Donaldson et al. 1981), or 14-17 y (Somerton 1981b, Nevessi et al. 1996) and snow crab 19 y (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 10-14 y 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 nonmolting Dungeness crabs in an unharvested, but highly populated area (Vancouver Harbour, B.C.), to be 0.71 [over 7 y (1994-2000)]. This is similar to the value we calculated for a relatively undisturbed population of Tanner crab.

Our estimates of M include molting crabs because we were unable to definitively identify a specific timing of the molt. Molting crabs are more vulnerable to predation and their mortality rates would be higher than nonmolting crabs. Breeding is also a risky time for male Tanner crabs. Paul and Paul (1996b) showed that males in tanks have the ability to kill each other in competition for mates.

TABLE 4.

Sizes at maturity calculated for male *Chionoecetes bairdi* in Rivers Inlet, B.C., 2004/05.

Method	Size at Maturity (mm CW)	Terminal Molt at Maturity?	Reference
Discriminant Score (*S*)	81	No	Stevens et al. (1993)
Midpoint	93	Maybe	Stevens et al. (1993)
Mean CW mature crab	104	Yes	Conan & Comeau (1986)
CH/CW ratios	94	No	Stevens et al. (1993)
Midpoint	101	Maybe	Stevens et al. (1993)
Mean CW mature crab	108	Yes	Conan and Comeau (1986)

CW = carapace width, CH = chela height.

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 commercial shrimp and ground-fish 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 they 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.

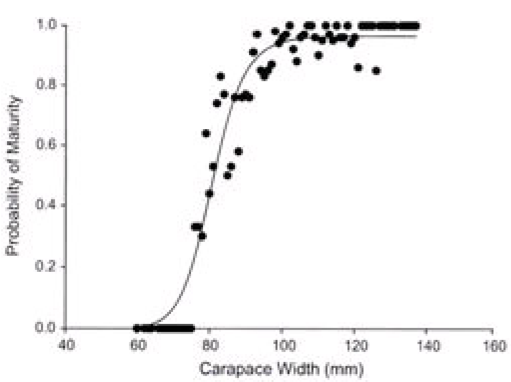

Figure 9. Male maturity ogive showing the proportion of male *Chionoecetes bairdi* in Rivers Inlet, B.C., at each 1-mm carapace increment that were mature (based on the discriminant score *S*; Stevens et al. 1993). A logistic curve was fitted to the data. The size of 50% maturity is 81 mm CW (n = 1406).

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 by increasing the sample size and sampling during periods when crabs are not breeding or molting. 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.

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 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 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.

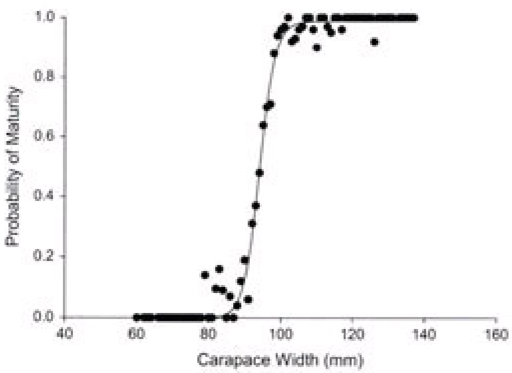

Figure 10. Male maturity ogive of *Chionoecetes bairdi*, from ON and DFO surveys in Rivers Inlet, B.C., January 2004 to March 2005, showing the proportion of male crabs at each 1-mm carapace increment that were mature (based on CH/CW ratios; Stevens et al. 1993, Paul & Paul 1995, 1996a). A logistic curve was fitted to the data. The size of 50% maturity is 94 mm CW (n = 1406).

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 behavior and not readily enter trap gear. Taylor et al. (2002) discussed problems and biases associated with selectivity of diseased crabs with trap gear.

In conclusion, we have presented information regarding the biology of a Tanner crab population inhabiting a central coast inlet in B.C. There is still considerable uncertainty associated with growth, molting 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 spring/summer molt period; however, additional tag returns in subsequent years could provide more information on molt timing and growth. More sampling of large old-shell males should include looking for evidence of molting. 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 precise measurements relating claw morphology to CW are needed to properly model the relationship between these two features. Additional tag return information would provide information concerning whether males undergo a terminal molt at maturity.

The information we have presented has implications for the management of a fishery for Tanner crabs in B.C. Information such as size of maturity and natural mortality are important factors for determining appropriate size limits and harvest levels, respectively. Fisheries managers would also want to avoid fishing during softshell periods and breeding times. Increasing our understanding of the biology of Tanner crabs will aid in the creation of effective management programs that should help protect stocks from overfishing.

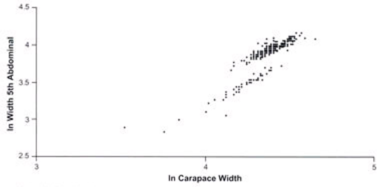

Figure 11. Plot of natural log width 5th abdominal segment (mm) *versus* natural log carapace width (mm) for female *Chionoecetes bairdi* in Rivers Inlet, B.C.

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TABLE 5.

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

	Mean CPUE							
Survey	Jan 04	Mar 04	June 04	Sept 04	Dec 04	Mar 05	M	No. paired sets
DFO					1.5	3.34	-2.78	18
DFO		0.63				2.46	-1.36	9
DFO		3.81			1.07		1.75	12
ON	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

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TABLE 1.
Vessels and gear used to collect Tanner crabs (Chionoecetes bairdi) in Rivers Inlet, B.C., 2004 and 2005.

Date	Vessel	Gear Type
2004		
Jan 20 Feb 20	Western Bounty (1)	Trap
Mar 10-16	Neocaligus (2)	Shrimp trawl, trap
Jun 4-5	Vector (2)	Trap
Sep 2-14	Western Bounty	Trap
Dec 2-9	Neocaligus	Shrimp trawl, beam trawl, trap
2005		
Mar 17-24	Neocaligus	Trap

(1) ON = Oweekeno Nation.

(2) DFO = Fisheries and Oceans Canada.

TABLE 2.
CPUE (crabs/trap) of Tanner crabs, Chionoecetes baivdi, by subarea from the Neocaligus and Western Bounty trap surveys in Rivers Inlet, B.C. Neocaligus surveys were conducted March and December 2004 and March 2005. The Western Bounty surveys were conducted January/February and September 2004.

Neocaligus

Sub-area	No. Traps	No. Crabs	CPUE
Upper Moses Inlet	17	14	0.82
Lower Moses Inlet	14	3	0.21
Hardy Inlet	15	12	0.80
Upper Rivers Inlet	76	132	1.74
Middle Rivers Inlet	33	30	0.91
Lower Rivers Inlet	23	0	0.00
Upper Fitz Hugh Sound	0	--	--
Lower Fitz Hugh Sound	0	--	--
Draney Inlet	49	261	5.33
Darby Channel	95	259	2.73

Western Bounty

Sub-area	No. Traps	No. Crabs	CPUE
Upper Moses Inlet	87	80	0.92
Lower Moses Inlet	62	46	0.74
Hardy Inlet	103	61	0.59
Upper Rivers Inlet	120	135	1.13
Middle Rivers Inlet	135	46	0.34
Lower Rivers Inlet	99	15	0.15
Upper Fitz Hugh Sound	80	0	0
Lower Fitz Hugh Sound	105	0	0
Draney Inlet	71	129	1.82
Darby Channel	35	23	0.66

TABLE 3.
Size of Chionoecetes bairdi from tag return information in Rivers Inlet, B.C.

Biological Information

Tag No.	Dates Caught/ Recaptured	Sex	Shell Condition	Missing Claws	Missing Legs
43050	22-Jan-04	Female	New shell	0	0
	6-Dec-04	Gravid	Not new-Not old	0	1
43655	16-Mar-04	Male	New Shell	0	0
	21-Mar-05		Old Shell	0	0

Biological Information

Tag No.	Dates Caught/ Recaptured	Carapace Width	Weight (g)	Male claw Length	Male claw Width	Female Abdominal
43050	22-Jan-04	68	--	--	--	31
	6-Dec-04	80	--	--	--	48
43655	16-Mar-04	94	285	36	18	--
	21-Mar-05	121	620	53	27	--

TABLE 4.

Sizes at maturity calculated for male Chionoecetes bairdi in Rivers Inlet, B.C., 2004/05.

Method	Size at Maturity (mm CW)	Terminal Molt at Maturity?
Discriminant Score (S)	81	No
Midpoint	93	Maybe
Mean CW mature crab	104	Yes
CH/CW ratios	94	No
Midpoint	101	Maybe
Mean CW mature crab	108	Yes

Method	Reference
Discriminant Score (S)	Stevens et al. (1993)
Midpoint	Stevens et al. (1993)
Mean CW mature crab	Conan & Comeau (1986)
CH/CW ratios	Stevens et al. (1993)
Midpoint	Stevens et al. (1993)
Mean CW mature crab	Conan and Comeau (1986)

CW = carapace width, CH = chela height.

TABLE 5.
Male Chionoecetes hairdi instantaneous rate of natural mortality (M) estimated at repeated sampling trap sets at two points in time. Values for M include molting crabs.

Survey	Mean CPUE Jan 04	Mar 04	June 04	Sept 04
DFO				
DFO		0.63		
DFO		3.81		
ON	0.94			0.24
DFO		4.80	1.08	
DFO			1.31	

Survey	Mean CPUE Dec 04	Mar 05	M	No. paired sets
DFO	1.5	3.34	-2.78	18
DFO		2.46	-1.36	9
DFO	1.07		1.75	12
ON			2.30	45
DFO			6.47	5
DFO	1.09		0.36	7
			1.12	96

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