Attachment 3.

A Review of the Biology and Fisheries of the Box Crab (Lopholithodes foraminatus Stimpson) in British Columbia

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A Review of the Biology and Fisheries of the Box Crab (*Lopholithodes foraminatus* Stimpson) in British Columbia

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Abstract

Biological and fishery information on box crab, *Lopholithodes foraminatus*, and similar species relevant to the potential development of a box crab fishery in British Columbia was synthesised. Information was collected from published books and papers, unpublished reports, discussions with experienced fishermen and biologists, Fisheries and Oceans Canada databases, Oregon's commercial fishery, and experimental fisheries or surveys in California, Oregon, B.C. and Alaska.

The existing knowledge on the basic biology and ecology of box crab is very limited. The collected biological information includes taxonomy, geographic distribution, habitat, food sources, size, reproduction, species association, and a trap fishery in Oregon. Distribution and densities of box crab in B.C were assessed based on the by-catch data from the bottom trawl fisheries for ground fish and from shrimp trawl surveys. Knowledge on population structure, age, growth, longevity, mortality, recruitment mechanism, and larval duration does not exist.

Management strategies for this potential fishery are recommended based on the collected biological information. Lacking or insufficient information, which needs to be collected to make development and management decisions, is identified.

Résumé

Une synthèse de l'information sur la biologie et la pêche du crabe à pattes trouées, *Lopholithodes foraminatus*, et d'autres espèces semblables, en rapport avec le potentiel de développement de cette pêche en Colombie-Britannique a été effectuée. L'information a été tirée d'ouvrages publiés, d'articles, de rapports inédits et des bases de données de Pêches et Océans Canada, de discussions avec des pêcheurs et des biologistes d'expérience, de données sur la pêche commerciale en Oregon ainsi que des résultats de pêches expérimentales et de relevés réalisés en Californie, dans l'Oregon, en Colombie-Britannique et en Alaska.

Les connaissances actuelles sur la biologie de base et l'écologie du crabe à pattes trouées sont très limitées. Les données biologiques amassées portent sur la taxonomie, la répartition géographique, l'habitat, les sources de nourriture, la taille, la reproduction et les associations d'espèces ainsi que sur une pêche au casier dans l'Oregon. La répartition et les densités du crabe à pattes trouées en Colombie-Britannique ont été évaluées à partir des données sur les prises accessoires dans les chaluts de fond utilisés pour la pêche du poisson de fond et pour les relevés de la crevette. Les connaissances sur la structure des populations, l'âge, la croissance, la longévité, la mortalité, les mécanismes de recrutement et la durée de l'état larvaire sont inexistantes.

Des stratégies de gestion de cette pêche potentielle sont recommandées en fonction des données biologiques recueillies. On identifie la carence ou l'insuffisance d'information devant être récoltée et servant de base à la prise de décisions relatives ou développement et à la gestion.

1. Introduction

Box crabs, *Lopholithodes foraminatus* (Stimpson), have not been commercially harvested in British Columbia, although they have been caught as by-catch in commercial ground fisheries, shrimp trawl surveys, prawn and Dungeness trap fisheries in B.C. Interest in fishing for box crab has persisted among some fishermen for a number years. In 1997, a box crab association was formed in an attempt to conduct surveys and potentially develop a box crab trap fishery inside the Strait of Georgia as well as coast-wide (Chris Peterson, pers. comm.). The overall goal of the association is to establish an on-going cost effective and locally managed trap fishery for box crab based on sustainable harvesting practices to produce high quality fishery products.

There is little existing biological and fisheries information on box crab. Caution is required to potentially develop such a new fishery with very limited biological information. The guidelines for new and developing invertebrate fisheries (Perry et al. 1999) requires a 3-phased approach to ensure an orderly assessment and potential development of this resource:

Phase (0): Synthesising available biological and fisheries information on the target and similar species, identifying missing information, and providing potential management advice;
Phase (1): Conducting surveys to obtain the essential information that is lacking or insufficient from phase (0) analysis and to evaluate alternative management strategies;
Phase (2): Developing a fishery based on the chosen management strategies, monitoring fishing operations to increase the information base to refine the results from previous phases.

This working paper constitutes the Phase (0) for box crabs in B.C. The sources of the collected information are published books and papers, unpublished reports, Fisheries and Oceans Canada's trawling databases, Oregon's commercial fishery, and experimental fisheries or surveys in California, Oregon, B.C and Alaska. There are four objectives for this paper:

1. to collect and analyse all existing biological and fishery information on box crab and similar species relevant to the potential development of a box crab fishery in British Columbia;
2. to provide the biological information to managers in order to assist the decision of whether this species should be considered for development of a fishery;
3. to recommend possible management strategies for this potential fishery; and
4. to identify the essential lacking or insufficient information which would need to be collected.

2. Review of Biology

2.1. Taxonomy

Box crab, *Lopholithodes foraminatus*, like red or brown king crab, is an Anomuran crab. Unlike Brachyura (true) crab, such as Dungeness, having both antennae between the eyes, Anomuran crabs have the second pair of antennae outside (lateral to) the eyes. The 5th pair of legs of box crab are very small and are folded under the carapace, making it appear superficially that these crabs have only four pairs of legs (Schmitt 1921).

Box crab can be readily distinguished from red or brown king crab. The carapace of red or brown king crab contains a number of strong and long spines, while the outline of the carapace of box crab is very broad and convex with many short tubercles (Schmitt 1921). The walking legs of red or brown king crab are about twice as long as the carapace width, while the walking legs of box crab are usually much shorter than the carapace width, capable of being folded under the carapace (Schmitt 1921). This is likely a defence mechanism against predators. Box crab resembles the Puget Sound king crab, *Lopholithodes mandtii*, which is the other species of the genus living in the Pacific Northwest. The Puget Sound king crab, however, has brilliant coloration, with adults appearing red with yellow, orange and purple markings. Box crab lack this brilliant coloration, being predominantly a drab reddish-brown or tan colour (Jensen 1995).

The most distinctive feature of box crab is that its claws and first pair of walking legs each have a smooth, semicircular concavity that combines to form a nearly perfectly round opening when folded together (Schmitt 1921, Jensen 1995). By this feature, box crabs are distinguished from all other crabs (Schmitt 1921), and from this feature, the scientific name "*foraminatus*" was derived (Kato 1992). The circular openings are believed to aid in respiration when the crab is buried in the sediment (Jensen 1995).

2.2. Geographic and Depth Distribution

Box crab have been found in Alaska (Feder and Jewett 1978), British Columbia (Butler 1961), Washington (Perry 1916), Oregon (Chambers 1997) and California (Wicksten 1982). In short, box crab are distributed from Alaska to San Diego, California (Gotshall and Laurent 1979, Jensen 1995)

Box crab are deep-water dwelling crabs. Box crabs have been encountered from the low intertidal to 547 m, which is believed to be the record depth (Gotshall and Laurent 1979, Hart 1982, Jensen 1995, Kato 1992). They were caught in Washington at 139-165 m (Perry 1916), in California at 165-500 m (Wicksten 1982), 97-150 m (Parrish 1972), 27-38 m (Goodwin 1952), and in the Northeast Gulf of Alaska to 500 m (Feder and Jewett 1979). Box crabs were caught at 91-274 m and mostly at 128-165 m in the Oregon box crab fishery (Gene Law, pers. comm.). In

British Columbia, box crabs were found at 126-152 m from Estevan Point to Cox Island on the west coast of Vancouver Island, at 108-115 m in Smith Sound and at 88-110 m in the north of Banks Island, Hecate Strait (Butler 1961). These depth ranges agree well with what reported elsewhere.

Fisheries and Oceans Canada maintains a commercial trawl database and a biological shrimp trawl database. The commercial trawl database contains box crab by-catch information from onboard observers in the commercial bottom trawl fisheries targeted on ground fish during 1996-98. The shrimp trawl database contains box crab by-catch data from shrimp trawl surveys since 1973 and from onboard observers in the commercial shrimp trawl fisheries since 1997.

The bottom trawl fisheries were mainly conducted on the West Coast of Vancouver Island (WCVI), Queen Charlotte Sound (QCS), Hecate Strait (HS) and the northwest of Queen Charlotte Island. Bottom trawls took place inside the Strait of Georgia (SG) only in 1996 (Fig. 1-3). Crabs identified as *Lopholithodes*, were caught as by-catches. Apart from box crab, the other species of the genus *Lopholithodes* is Puget Sound king crab. However, Puget Sound king crab is known to live in shallower waters from the subtidal to 137 m (Jensen 1995). Almost no *Lopholithodes* crabs were caught as by-catch in the water shallower than 50 m (see below), suggesting that fewer Puget Sound king crab were caught in the bottom trawl gears. No Puget Sound king crabs were encountered in the box crab trap fishery in Oregon (Gene Law, pers. comm.). Thus, most of these *Lopholithodes* crabs were probably box crabs and we assume that they were all box crabs in this review.

Box crabs were observed in WCVI, QCS and HS (Fig. 1-3). The distribution pattern appears to be quite similar among the three years (Fig. 4). Thus, the three years of box crab by-catch data were combined for further analysis. Usually, only the total weight of captured box crabs was estimated. In 28 sets, both pieces and total weight were estimated, yielding an average weight of 0.64 kg per individual. The reported box crab by-catch, in general, was very small. Most box crabs (91.4% in weight) were caught between 50 and 250 m (Fig. 5). However, more than half of the bottom trawling (56.2%) occurred in this depth range. Only 2.3 kg (0.07%) box crabs were caught in waters shallower than 50 m, although there were 3484 bottom trawls (approximately 7%) taking place in this depth range. The maximum depth at which box crab catch was reported was 990 m. Examination of box crab catches in relation to trawling intensity at different depth ranges revealed that box crabs were relatively abundant at 50-250 m, as reported in the literature, and apparently also comparatively abundant at a much deeper range of 650-850 m off the WCVI (Fig. 5). The average weight of box crabs caught per kilometre of trawling was 11.8 g at a depth range of 50-250 m and 9.5g at a depth range of 650-850 m. Catches of box crabs between these two depth ranges at depths of 250-650 m were low with an average weight of about 0.6 g per kilometre of trawling. Box crab apparently exhibited a discontinuous distribution in the WCVI. However, it is questionable that those crabs caught from 650-850 m were indeed box crabs, not only because this depth range is much deeper than known in the literature, but also existence of such a discontinuous distribution is doubtful. Is it possible that those crabs observed at such deep waters may have been other Lithodid crab species such as

Puget Sound king crab or brown king crab? Puget Sound king crabs live in shallower waters than box crabs; thus it is unlikely that they were Puget Sound king crabs. Brown king crab do live in the deep continental slope waters (Drinnan and McCormack 1982). However, the obvious difference between brown king crab and the box crab, as described in the section of Taxonomy, should preclude this kind of mis-identification. Until species identification is verified, no further extrapolation of the box crab catch information from this deep water will be made. No box crabs were observed as by-catch in the commercial bottom trawls inside SG in 1996.

Crabs, identified as *Lopholithodes*, were also caught in the shrimp trawl surveys. All these crabs were also assumed to be box crabs in this paper. The shrimp trawl surveys have been conducted in a depth range of 8.5 to 299 m, in the area off the mouth of the Skeena river, Queen Charlotte Sound, Queen Charlotte Strait, Strait of Georgia, Howe Sound, Barkley Sound and WCVI since 1973 (Table 1, Fig. 6). Either otter trawl or beam trawl was used. Surveys were conducted mostly (70%) off the WCVI and 30% in the other areas. A larger disproportion of box crabs (96%) were caught from WCVI in the surveyed depth range of 43-254 m and few or no box crabs were caught in the other areas (Table 1, Fig. 6). Only one box crab was reported to be caught from the onboard observers in the commercial shrimp trawl fishery since 1997. It was caught in Howe Sound.

2.3. Habitat and Movement

Box crabs live on rock, sand, and mud bottom (Perry 1916, Kato 1992). Jensen (1995) reported that box crabs were typically found on muddy bottoms and occasionally seen on vertical rock faces overlooking soft bottoms. Several Oregon fishermen reported finding Box Crabs on muddy bottoms, near rocks (Chambers 1997). Based on the information provided by Gene Law, the favourable habitat is around the edges of rocky bottoms. They live in big aggregations, move together and moult at similar times within the aggregation. He observed that when one aggregation contains virtually all soft-shell crabs, other patches might still have hard shelled animals.

The 1997 Oregon survey and 1990 and 1991 experimental fishery (see Section 3.2 and 3.3 later for description) showed that males and females do not live separately. Sex ratio varied from 42% to 85% males among the sets where 20 or more box crabs were caught in the 1997 Oregon survey. Only males were caught in 3 sets where less than six box crabs were caught. The overall percentage of males was 65.7%, suggesting that both sexes were pretty well mixed. Among the 40 crabs caught in the 1990 experimental fishery, 18 were males and 22 were females. Among the box crabs caught in the 1991 experimental fishery, 61 box crabs were examined and 37.7% were found to be males.

Kato (1992) suggested that box crabs might undergo migrations from deep to shallow waters and vice versa during certain seasons. However, box crab by-catch data from the bottom trawl fisheries did not indicate any obvious seasonal movements. Box crabs were basically caught at similar locations in four different seasons (Jan. 1-Mar. 30, Apr. 1-Jun. 30, July 1 - Sept. 30 and Oct. 1 - Dec. 31) (Fig. 7).

Box crab may not as mobile as other crabs and lobsters, as long soak times are needed to catch them (Kato 1992). Their anatomical design (short walking legs and heavy shells) seem to indicate that their natural state is being immobile (Colomy 1989).

2.4. Food and Predators

Little is known about the feeding habits of box crab. It was postulated that box crab, like other crab, probably feed mainly on invertebrates (Kato, 1992), and may feed by filtering sediment (Jensen 1995).

The major predator of box crab is postulated to be octopus; other animals may find it difficult to eat box crabs when they assume their defensive position, with all the appendages folded under the body (Kato 1992). Octopus is the third and 12th most frequently observed invertebrate caught together with box crab in the bottom trawl fisheries and shrimp trawl surveys respectively (Table 2, 3).

2.5. Abundance Index

The abundance of box crabs in B.C is unknown. The box crab by-catch data from the commercial trawl database and biological shrimp trawl database may enable us to estimate the magnitude of box crab densities.

For the bottom trawl fisheries, only trawls from the depth of 50 to 250 m are used for density estimation, as box crab appear to live mainly in this depth range in WCVI, QCS and HS. A swept area for each set was calculated simply by multiplying the average doorspread of the net by the distance of trawling. We used an average doorspread of 49.429 m, calculated based on the information presented by Yamanaka et al. (1996), to represent the doorspread of every net. The density of box crab between 50 and 250 m was calculated by dividing the overall annual catches of box crab in weight by the total swept area in that year inside this depth range. The estimated density was 0.128, 0.291 and 0.317 kg/km^2 for 1996, 1997 and 1998 respectively.

In the shrimp trawl surveys, box crabs were predominantly caught from the WCVI. Only a small number of box crab catches were reported from the other area. For instance, from the surveyed locations inside the Strait of Georgia, box crabs were caught only in 3 sets (tows) out of 193 sets (1.6%) and on average 0.4 kg box crabs were accounted for in every 100 sets. In the WCVI, box crabs appeared in 68 sets out of 2394 sets (2.8%) and 4.5 kg box crabs were obtained in every 100 sets (Table 1). This box crab by-catch pattern seems to suggest that box crabs are much more abundant off the WCVI than in the surveyed locations inside SG. Density was estimated only for WCVI in the surveyed depth (45-255 m), which happens to match well with the depth range of box crab. As occurrences of box crab by-catches were small in any single year, box crab by-catch data from all these years were combined for the analysis. A swept area for each set was calculated by multiplying the effective opening of the net by the distance of trawling. The effective opening was estimated based on the method described in the shrimp trawl database. For beam trawls, the effective opening is the effective width of the net opening, which is about 2 feet less than the beam width. For otter trawls, it is about half the footrope length. The density was calculated by dividing the total catch of box crabs in weight by the overall swept area. The density was estimated to be 2.4 kg/km^2, which is over one magnitude higher than the estimation based on the commercial bottom trawl data.

Although box crab by-catch information was recorded by onboard observers in both the commercial bottom trawl fisheries and in shrimp trawl fishery, the percentage of recording or reporting of box crab occurrence appeared to be lower than in the shrimp trawl surveys. Only one box crab catch was recorded from the onboard observer in the commercial shrimp trawl fishery among 1131 sets since 1997, while box crab by-catch was recorded in 76 sets out of 3431 sets. Thus, the density estimated based on shrimp trawl surveys is probably more reliable. The estimated densities appeared to be low, when compared with the estimated density of box crab of 11.25 kg/km^2 in the Northeastern Gulf of Alaska based on the 1975 Alaska survey using a commercial sized 400-mesh Eastern otter trawl with a 12.2 meter horizontal opening (Feder and Jewett 1978). The difference in estimated density might partially result from the different purposes of the surveys. The Alaskan survey was designed to estimate benthic invertebrate abundance, while the shrimp trawl surveys were conducted to investigate shrimp populations.

The density of box crabs in weight in the locations, where box crab catch was reported in the shrimp trawl surveys, varied from 7 to 635 kg per square kilometer. The density was 20 kg or less in most locations (59%), between 20 and 120 kg in 32% of the locations, and above 180 kg in 9% of the locations (Fig. 8).

It is unknown how much the estimated density based on the by-catch data deviates from the true density. It may not be taken literately for the following reasons:

1) The survey protocol was designed for investigating shrimp populations not box crab populations; it is unknown whether box crab habitat was adequately sampled;
2) box crab may bury in the sediments and the degree of vulnerability to the trawl gears is unknown;
3) it is unknown what proportion of the crabs identified as Lopholithodes is box crabs.

2.6. Age, Growth and Size

Age and growth data are lacking for box crab. Males are larger than females (Kato 1992). Of the box crabs caught in the 1990 or 1991 experimental fishery in B.C, the average size of males were larger than that of females. Males grow to 185 mm and females grow to 175 mm in carapace width (Hart, 1982), but much larger animals have been observed (Jensen 1995). The carapace may reach 214.9 mm in width (Schmitt 1921) or even 300 mm in width (Gotshall and Laurent 1979).

Box crabs have been measured variably by carapace width or carapace length. Among the box crabs caught in the 1997 Oregon survey, 200 crabs were measured by the carapace width including the spines (CWWS), carapace width without spines (CWOS) and carapace length (CL). The relationships between CL and CWWS, and CL and CWOS are as follows:

$$CL = 0.703 \times CWWS + 13.219;\ r^2 = 0.93$$
$$CL = 0.751 \times CWOS + 12.775;\ r^2 = 0.94$$

The two equations are useful in comparing sizes of box crabs measured in different manners.

2.7. Reproduction

In many crustaceans sexual maturity can be divided into physiological maturity and functional maturity. The former is indicated by the presence of mature gametes and the latter by readiness to mate (Lawton and Lavalli 1995). To manage a fisheries stock, we are more interested in the functional maturity.

2.7.1. Females

Twelve females ranging from 66.7 to 108.8 mm in carapace length, caught in the 1997 Oregon survey were examined for physiological maturity. They were all found to be physiologically mature, as each of them contained well developed oocystes (Goddard 1997).

In the Oregon survey conducted in April 1997, the smallest females with eggs, or which appeared to have recently shed eggs, was 78 mm. The largest female with no sign of having eggs was 83 mm. It appears that the minimum size of functional maturity is somewhere in the range of 78 to 83 mm (Goddard 1997). In the Northern Pacific, size at maturity of lithodid crabs decreases with increasing latitude (Jewett et al. 1985; Somerton and Otto 1986; Blau 1990; Otto et al 1990). Box crabs possibly spawn at smaller size in B.C. than in Oregon.

When females have just shed eggs, they contain the "moss" of filaments to which the eggs were attached, and some have a scattering of single eggs still in the "moss" (Jean McCrae, pers. comm.). It was observed in the 1997 Oregon survey that some box crab females had shed their eggs by the time when they were caught by April. Eggs hatched from one female were observed to be in the zoea larvae stage in early May (Goddard 1997). It appears that eggs start to hatch in April or earlier off the Oregon coast. Off southern California egg-bearing females are common in February and hatching probably occurs sometime in the spring (Kato, 1992).

There was no mentioning of egg-bearing females among the box crabs caught in the 1990 experimental fishery in Barkley Sound, Clayoquot Sound and Nootka Sound, while egg-bearing females were consistently caught from June to Nov. in the 1991 experimental fishery in SG (Heizer 1992). One female box crab caught off the WCVI on June 1, 1972, was also found to bear a large number of eggs under its abdomen (Peden and Corbett 1972). This suggests that box crabs may spawn later along BC coast than Oregon or California coast.

The eggs of Anomuran crabs are fertilized shortly after mating, while Brachuran female crabs may store sperm for a fairly long time after mating before using it to fertilize their eggs (Jensen 1995). The breeding period for box crab is unknown. Puget Sound king crab breed during the late winter and spring (Jensen 1995). It is also unknown how long it takes for box crab eggs to hatch. The eggs of red King Crab hatched approximately 200-300 days after fertilization at temperature of 12-13^{o}C (Shirley et. al. 1990). Hiramoto and Sato (197) reported that along central Japan, approximately 200-300 days are needed for the embryos of brown King Crab to hatch. It may be postulated that box crab embryos also need a relatively long period (200-300 days) to hatch.

Twenty-one egg-bearing females ranging from 68 to 107 mm in CL were retained to determine fecundity in the 1997 Oregon survey. Four samples have been analyzed to date, with counts from 20,100 to 48,000 eggs per female (Jean McCrae, pers. comm.).

Red King Crab females reach maturity at a size of 76-105 mm in CL, the main spawning period is Feb.-May, and fecundity is about 300,000 per female at 160 mm CL (McBride et al. 1982). Brown king crab females reach maturity at a size of 110-140 mm CL, the spawning period is July-October, fecundity is 30,000 eggs per female at 160 mm CL, and the depth distribution is 64-914 m (McBride et al. 1982). It appears that the fecundity of box crabs is similar to that of brown King Crab, and its size at maturity is similar to that of Red King Crab.

2.7.2. Males

Thirty-three male crabs, ranging in carapace length from 62 to 130 mm were examined for physiological maturity in the 1997 Oregon survey. They were all found to be physiologically mature, as every one's tubular testes (vas deferens) were milky white in colour. This study suggests that off the Oregon coast, box crab males are probably gonadally mature upon reaching a carapace length of 62 mm.

In many Brachyuran and Anomuran crabs the onset of functional maturity in males is correlated with an increase in the size of the chelae relative to the rest of the body (Hartnoll 1969, 1978). This allometric shift presumably enhances the male's ability to grasp and compete for females during mating and has been used as an indicator of "morphometric maturity" (Conan and Comeau 1986, Lorvich and Vinuesa 1993). No morphometric or morphological changes which might indicate functional maturity were observed in either the chelae or 5th pair of pereopods of males. Goddard (1997) speculated that no allometric shift in the size of the chela relative to the rest of the body is due to the fact that box crabs are able to fold their legs and chelae against the body to form a tight-fitting whole. The necessity of a tight fit of the box crab's legs and chelae against its body may have precluded the allometric increases in the size of the chelae observed in several other types of crabs.

Some morphological differences were observed in the genital pore of large versus small males. The male genital pore is surrounded by a distinct, tapering group of straight to gently curing setae. The setose tips of the 5th pair of peropods can bend back to reach the genital pore setae and apparently used to transfer spermatozoa to the females (Goddard 1997). Microscopic examination of the setae surrounding the male genital pore suggested that larger individuals had a higher proportion of broken or abraded setae than smaller individuals. Crabs with worn genital pore setae had a mean carapace length of 106.4 mm (s.d = 23.4mm, n=6). They were significantly longer than both those with intact setae (mean length = 72.7 mm, s.d = 3.5 mm, n =5) and those with intermediate condition setae (mean carapace length = 77.6 mm, s.d = 11.4mm, n=5). There was no significant differences in mean carapace length between crabs with intermediate and intact setae. Damage to the genital pore setae may therefore reflect increased brushing associated with mating activity. Assuming that worn setae result from increased mating activity, the data suggest that mating has commenced in crabs with a carapace length of about 80 mm and active mating occurs when male crabs reach an average carapace length of 106 mm.

2.8. Larval Development

No knowledge exists on larval development for box crab, although there have been some studies on the larval development for other Lithodid species. Lithodidae of the northern North Pacific Ocean generally have four zoeal stages and one glaucothoe stage (Haynes 1984). Presumably, box crab larvae also go through the four stages of zoeal development and one stage of glaucothoe development. The duration for larval development can, at best, be postulated from studies on other lithodid species. The average larval duration for Blue king crab, *Paralithodes platypus*, from Alaska was 64.3 days, when the rearing temperature increased gradually from 4.5 to 7.2°C during the study in the laboratory (Hoffman 1967). Red king crab, *Paralithodes camatschatica*, needed 84 and 47 days to complete the larval development stages at low temperature(3.8-7.8 °C) and high temperature (9.0-12 °C) respectively (Sato 1958). Possibly, it takes approximately 40-90 days for box crab to accomplish the larval development.

2.9. Species Associations

The most frequent occurrences of fish caught together with box crabs are dogfish (86.2%) and arrowtooth flounder (81.2%) in the bottom trawl fisheries and Rex sole (88.2%) and dogfish (85.5%) in the shrimp trawl survey. The most frequent occurrences of invertebrates were starfish, sea urchins and octopus in the bottom trawl fisheries, and Brittle stars, starfish and sea cucumbers in the shrimp trawl survey (Table 2, 3). The amount of by-catch, especially of commercially important species such as sea urchin and Dungeness, was low for the 1997 Oregon survey. On average, catch of 1000 box crabs brought in 6 sea urchins, 3 Dungeness, 2.4 flat fish, 0.3 octopus and 0.3 rockfish (Table. 4).

Larval blacktail snailfish (*Careproctus melanurus*) have been found in large numbers inside the gill filaments of box crabs in California (Parrish 1972). A large number (424) of *Careproctus*, probably *C. melanurus*, embryos were also found in the gill cavity of a box crab on WCVI (Peden and Corbett. 1972). In the 1997 Oregon survey, 6 out of 43 box crabs examined were found to contain snail fish eggs. Parrish (1972) referred to such a relationships as symbiosis. Such symbiosis relationship between *Careproctus* species and king crabs (*Paralithodes camtshatica*) has also been observed (Hunter 1969). However, Peden and Corbett (1972) regarded the relationship as commensalism, based on the observation of a single crab, whose gills where *C. melanurus* embryos resided had collapsed completely. Occurrence of snail fish eggs inside box crab appears to be common and does not obviously damage the crab (Gene Law, pers. comm.).

3. Fisheries

3.1. Commercial Fishery in Oregon

In Oregon, when the abundance of Dungeness crab dropped and the price for crabs increased in the early 1980s, some fishermen there started to fish box crabs by traps as an alternative for the market. Commercial Dungeness traps with slightly enlarged opening were used (Jean McCrae, pers. comm.). Some fishermen used traps resembling the commercial Dungeness trap in shape, but much larger (Gene Law, pers. comm.). The diameter of a Dungeness trap is about 38 inches, while the diameter of this trap was 72-76 inches. The size of the opening was the same as a Dungeness trap opening (4 inches high and 8 inches wide). The height was also same (about 11.7 inch). These traps have been quite effective in catching box crabs (Gene Law pers. comm.). The size of most boats used in the box crab fishery is around 45 foot (Jean McCrae, pers. comm). Some fishermen, such as Gene Law, used 60 foot boat. Traps were mainly set at a depth range of 125-170 m, where box crabs are most abundant. Box crabs were found to be hardy, remaining alive after being kept in tanks for days (Gene Law, pers. comm.).

There were no restrictions on size, sex or quota (Jean McCrae, pers. comm.). Catches of box crabs started at 502 pounds in 1982, increased to 16,000 pounds in 1983, jumped to 272,000 pounds in 1984, and then declined to 93,000 pounds in 1985 (Table 5). As the Dungeness came back and the crab price came down, the market for box crabs diminished. Interest in box crab fishing had greatly reduced by late 1980s (Jean McCrae, pers. comm., Chambers 1997). Landing of box crabs was only 3060 pounds in 1986 and further dropped to 24 pounds in 1987. In 1988, there were no box crab landed. Catch of box crab was relatively low in 1989-96, varying between 412 and 10460 pounds. Landing jumped to 67,224 pounds in 1997, again because Dungeness supply was relatively low in that year and fishermen wanted to test the market again (Jean McCrae, pers. comm.). Catch dropped to 333 pounds in 1998, as the supply of Dungeness crab was particularly good (Jean McCrae, pers. comm.).

Currently in Oregon, there are still no limits on size, sex or quota. A developmental fishery license is needed to fish box crabs. To restrict number of fishermen entering this fishery, up to 25 such licenses are available annually in Oregon. The fishing season is almost open year round, closed only from November 1 until December 1 (Jean McCrae, pers. comm.). The closure is to prevent box crab fishermen from possibly taking advantages of catching Dungeness, as the ocean Dungeness season opens on December 1st. When Dungeness fishery closes between Aug. 15 and Dec. 1, box crab fishing must occur deeper than 73 m.

Catch of box crab in Oregon appears to be driven by supply of Dungeness crabs. Limited market requirement is the major restriction on expansion of box crab fishery there (Chambers 1997).

3.2. Box Crab Survey in Oregon

To study box crab distribution, abundance, sex and size composition, maturity and fecundity, the Oregon department of fishing and games conducted a survey in four areas between Newport and Florence, Oregon in a depth range of 120-156 m on April 18-19 and 24-26 1997. Commercial box crab trap fishing mainly occurred in this depth range in Oregon. Standard Dungeness crab traps (pots) were used with mackerel and squid as baits. Sixteen sets were made, four in area 1, four in area 3, three in area 2 and five in area 4. Each set was made up of 3-20 traps with an average of 19 traps. Most traps were set in the afternoon and retrieved in the following morning for an average of 15 hour soak time. One set of traps was dropped in the morning and retrieved in the afternoon for a 6.5 hour soak time and two sets of traps were left in the water for 6.5 days due to adverse weather. These three sets were made in Area 2.

A total of 2983 box crabs were caught, 884 from Area 1, 2071 from Area 2, 22 from Area 3 and 6 from Area 4. No box crabs were caught in 5 sets, which happened to be in Area 3 and 4. Box crabs were predominantly caught from Area 1 and 2. The average catch per trap was 13.8 and 39.8 for Area 1 and Area 2 respectively, compared with 1.1 and 0.2 in Area 3 and 4 respectively. Average catch per trap per hour of soak time was 0.2 and 0.1 for Area 1 and Area 2 respectively, in contrast with 0.02 and 0.0006 in Area 3 and 4 respectively. This catch pattern suggests that box crab might live in big aggregations in Oregon.

A total of 509 crabs were measured for carapace length. The crabs ranged from 67 to 144 mm with an average of 103 mm. Males ranged from 69 to 144 mm with an average of 106 mm. Females ranged from 67 mm to 113 mm with an average of 94 mm. Males are on average bigger than females.

Twenty-eight crabs were used to determine recovery rate of meat. These crabs ranged from 95 to 127 mm in carapace length and 0.377 to 0.915 kg in weight with an average of 112 mm in carapace length and 0.618 kg in weight. Total yield ranged from 12.5 to 27.0%, with an average of 20.4%. Leg meat accounted for almost 70% of the total meat yield. This observation agreed well with the percentage of 21.3% reported by McDaniel (1985). She also reported that Dungeness crab meat yield (calculated from live weight) was 27.7%. Box crab meat tastes much sweeter than that of Dungeness and is at least as well liked as the Dungeness meat (McDaniel 1985).

The percentage of sex composition, by-catch information, size of maturity and fecundity have been described in the pervious sections.

3.3. Experimental Fishery in California

To evaluate the box crab stock, a small experimental trap fishery was carried out by a fisher named James Colomy in southern California in Aug.-Sept. 1989 (Colomy 1989). James

Colomy used a 30 foot vessel and traps of 0.91×1.22×0.46 m in dimension with mackerel, rock cod, canned cat food, squid, shark and abalone as baits. He fished between 73 and 274 m, but mainly at 73-110 m. When he tried deeper than 110 m, he mostly caught sea urchins. The overall result of this experimental fishery was disappointing, as only a few box crabs were caught.

3.4. Experimental Fisheries in B.C.

No commercial fishery has ever occurred on box crab in British Columbia. There were only two experimental fisheries in early 1990s. Both fishermen were applied for and received a permit from the DFO. They were required to do biological sampling, and to provide these data and written reports to DFO at the conclusion of their fishing.

One fishermen fished box crabs by trap in Area 23, 24 and 25 (Barkley Sound, Clayoquot Sound and Nootka Sound respectively) between April 21 and May 3, 1990. Conditions of the permit restricted the fisherman for fishing with 100 traps, each with a 100 mm escape ring and rigged up with a biodegradable release mechanism, which allowed the trap door to open when the cord broke. Only male crabs with greater than 125 mm in carapace width were allowed to be retained. He used four different kinds of traps:

Type “A”

Type A resembled a cone 533 mm high with a 914 mm base. The entrance was at the top. Half of the traps had a collar inside to prevent re-exit of the crab after capture, the other half had no collar. Each trap had a 100 mm escape ring. The fisherman used 24 of these traps, more than the other 3 kinds put together.

Type “B”

These traps were six-sided , heavy wire mesh (plastic dipped) traps, 305 mm high with a 914 mm base. The traps have an oversized opening and conventional Dungeness triggers. This trap caught the largest crab as well as the most crab in a trap. The fisherman used two of this kind of traps.

Type “C”

These traps were conventional sport crab traps. They produced only one crab in the duration of the experiment. He used 15 of these traps.

Type “D”

These traps are conventional West Coast commercial Dungeness Crab traps. The fisherman found that they were not effective on catching box crabs. He used three of these traps.

He made 32 sets and each set comprised of 21-23 traps. The catch was very poor. He caught only 40 crabs, after a total of 706 trap hauls were made. The average number of crab caught per trap was about 0.06. Among the 40 crabs, 22 were males and 18 were females. The size range of males was between 81 and 169 with an average of 117 mm in carapace width. The size range of females was between 85 and 135 with an average of 107 mm in carapace width. On average, males are larger than females. The fishing depth approximately ranged between 31-170 m. Three sets were made above 64 m and 4 sets were made between 137 and 174 m. No box crabs were caught in these sets. All the 40 crabs were caught by the other 25 sets made between 64 and 137 m. The largest single catch comprised 15 crabs in 23 traps after a 17 hour soak at 112 m in Barkley Sound. Among the four traps he used, Type B traps caught the largest and greatest numbers of crabs (Heizer, 1992). This fisherman has not applied again for a permit to harvest box crabs.

Between June 13 and Nov. 30, 1991, another fisherman fished for box crabs in the SG, mainly at the north end of the Thormanby island, while he was fishing prawns at the same time. This fisherman was not restricted in the number of traps, but was required to fish with standard commercial Dungeness traps only. Each trap must have a 100 mm escape ring. Only male crabs were allowed to be retained. He reported consistent catches of large males and egg-bearing females from depths between 73 and 137 m. He made 729 trap hauls and caught 1481 crabs. He measured 61, of which 23 were males and 38 were females. The male ranged from 90 to 180 mm in carapace width and female from 95 to 135 mm in carapace width. Males are on average larger than the females. The average catch per trap was about 2 crabs, higher than that of the 1990 experimental fishery, although different traps were used in these two experimental fisheries. He felt it was worth the effort, as the appearance and taste of the product intrigued his customers, although he found it was difficult to fish prawns and box crabs at the same time. Although he reported an interest in fishing again, no application for a permit was received in 1992.

4. **Discussion**

The abundance of box crab populations in B.C. is unknown. There have been no commercial fisheries on box crab in British Columbia except for two experimental fisheries mentioned previously. The 1990 experimental fishery in Barkley Sound, Clayoquot Sound and Nootka Sound was a first attempt to evaluate the population size. The result was very disappointing. After 706 trap hauls, only 40 box crabs were caught, suggesting that box crab abundance or density might be low in these areas, although gear was not standardized and no strict survey protocol was observed. The 1991 experimental fishery offered an opportunity to examine the population size inside SG. The fisherman caught 1481 box crabs after 729 trap hauls with approximately 2 crabs, on average, by each trap. Catch per unit effort was higher than in the 1990 experimental fishery, suggesting the abundance in the SG was possibly higher, although different traps were used. The by-catch data from the shrimp trawl survey also seem to indicate that box crab are more abundant in SG than in the Barkley Sound. Box crabs were caught in 3 sets out of 193 sets in SG, while no box crabs were caught in the 102 sets in the Barkley Sound (Table 1).

Among the shrimp trawl surveyed areas (Table 1), box crab appeared to be most abundant off the WCVI in the surveyed depth range of 45-255 m. Based on the by-catch of box crabs in weight per 100 sets, the density in the WCVI appeared to be over one magnitude higher than in the SG, at least in the surveyed locations. However, this density was estimated to be only 2.4 kg/km^2. Assuming the average weight of captured crabs was 0.5 kg, there would be only about 5 crabs in every square kilometer! It is unknown how much this estimate deviates from the true density. Box crabs might bury in the sediments and largely not available to the trawling gears. In addition, they might also mainly live in big aggregations in areas such as around the edges of rocky bottoms and elude the trawling nets. If that is the case, the density would be seriously underestimated. The estimated density may, at best, serve as an index of abundance and warrant a comparison among different areas or periods.

Unlike males of some other crab species, box crab males did not exhibit morphometric or morphological changes in the chelae or 5^{th} pair of pereopods in relation to functional maturity. It is encouraging that larger individuals were found to have a higher proportion of broken setae surrounding the genital pore than smaller individuals. It provides a way for studying the significance of body size on reproduction capacity. However, this finding was based on the microscopic examination of a small number of male box crabs and should be verified.

Female box crabs reach maturity at a minimum size of 78 to 83 mm, similar to female red king crab and smaller than brown king crab. The fecundity is lower than red king crab and about the same as brown king crabs. The natural production of box crab may, therefore, be less than red king crab but more than brown king crab. We can assume that a relatively low fecundity compared to tanner crabs or Dungeness may mean a relatively higher survival rate for larvae and juveniles. This usually means specific settlement/rearing sites for successful recruitment, i.e.

population size may be habitat limited at a critical life phase. This avenue needs further exploration.

The Oregon box crab fishery demonstrated that commercial Dungeness traps with slightly enlarged entrances can be used effectively to catch box crabs. Larger traps resembling the Dungeness trap in shape could also be used successfully to trap box crabs. The fishery is currently managed with no restrictions on size, sex or total catch. The number of participants is limited to 25 annually. The market demand for box crab and the consequent intensity of the box crab fishery has been driven by the supply of Dungeness crab. It is, therefore, not possible to examine the effectiveness of Oregon's management policy and how the population will change in a long run, if there is a stable market demand for box crab. The habitat disturbance caused by a box crab trap fishery appears to be minimal. Box crab live in 50-250 m, generally deeper than the Dungeness crab, and the Oregon box crab survey showed that the amount of by-catch was very low.

4.1. Management Strategies

To have a viable and sustainable box crab fishery**,** the initial abundance of box crab has to be reasonably high and recruitment needs to be regular and of sufficient magnitude to account for the sum of natural and fishing mortality over the long term. We do not know the population size and how resilient the box crab population is. The estimated density level is low (e,g, about 5 box crabs/km^2 off WCVI), although it is unknown whether representative box crab "samples" were taken in the shrimp trawl surveys. An extensive amount of data collection is required of Phase 1 study, if this potential fishery is further considered. If there is going to be a fishery at al, it must be very small and will require a high level of data collection as well. The fishery should be geographically restricted to a few locations and limited to a very small number of fishers with observer coverage, leaving lots of reserved areas. By this way we may learn how long it takes to harvest that area to a point where there is an observable drop in CPUE. We may also gain other essential knowledge on biology and stock dynamics of box crab population without a risk of depleting the whole resource.

There are a number of management approaches available for new and developing fisheries. Each approach requires particular biological information. One of the simplest regulatory measures, and often the first to be applied in new fisheries, are size limits in an attempt to control recruitment and growth overfishing (Perry et. al. 1999). This management approach requires the least amount of biological information and may be imposed on this small and geographically restricted fishery, as the biological information on box crab stocks is very scarce indeed. The aim of this approach is to reduce the chance of recruitment and growth overfishing. To further reduce the possibility of recruitment overfishing, we could additionally impose a sex-selective harvest restriction. Only male box crabs above certain size limit may be retained with an intention to protect females, which bear the egg-bearing responsibility, and allow males to have opportunities to mature and mate. Obviously, this requires knowledge on reproduction characters such as size at maturity. The preliminary study in Oregon indicated that males probably have actively commenced mating by the size of 106 mm in carapace length. Thus we may, tentatively, set the minimum size at 130 mm in carapace length. To evaluate the effectiveness of such a minimum size on controlling growth overfishing, we also must know the growth rate and natural mortality rate of box crab, which are currently unknown. This knowledge will enable us to assess the effect of different minimum size limits on yield in a long term by using the yield-per-recruit and biomass-per-recruit modelling. The size and sex restriction management strategy has been applied in other deep water crab fisheries. Tanner crab, *Chionoecetes ta*nneri, are very deep water dwelling crab, living in a depth range of 458-1784 m (Hart 1982). Due to limited biological information, the Alaska fishery for Tanner crab is managed by size and sex restriction with harvest limits set. In Atlantic Canada, Snow crabs, *Chionoecetes opilio*, have also been managed by harvesting only males above 95 mm in carapace width. Snow crab live in a depth range of 0-310 m and fishing depth is between 75 and 300 m (Miller and O'Keefe 1981), which is similar to the depth distribution of box crab. The effectiveness of this management approach on box crab stock must be evaluated in a timely manner and regulations adjusted accordingly.

4.2. Lacking and Uncertain Biological Information

Biological knowledge on box crab population is poor and there are a lot we need to learn to successfully develop and manage such a potential fishery. The following information may be collected in phase1 and/or phase 2 study.

1) We need to determine population structure and on what scale that population functions as a reproductive entity.
2) We need to verify the density estimation based on the by-catch information from the shrimp trawl survey and reliably determine the abundance of box crab populations. For instance, we have to determine whether the main population of box crabs may live in areas, such as the edges of rocky bottoms, and avoid being "sampled" by the trawling gears.
3) We need more information to enable us to manage this fishery based on size and sex limit approach. Studies should be carried out to further evaluate the finding that degree of damage to the male genital pore setae is related to male mating behaviour. More knowledge of this kind will enable us to know more confidently at what size males start to actively mate in B.C. We also need to know how many times a male can repeatedly and successfully mate in a mating season and the relationship between success of repeated mating and body size. These understandings will help us in assessing the effect of removing male box crabs above certain size on the reproduction potential of the harvested population.

4) To evaluate the effect of size limit on population growth potential, we have to find out their growth rate and natural mortality rate. If we wish to manage at a rate based on natural mortality calculated by using Hoenig's equation (Hoenig 1983), we also need to know the maximum size and age of box crab in B.C.

5) We need to know the spawning season, egg duration, larval duration and recruitment mechanism including interannual variations in recruitment and specific habitats necessary for successful recruitment.

6) In addition, we need to know the survival rate after capture and release.

5. Summary

Box crab are distributed from Alaska to California. It has been reported that they live on muddy and rocky bottoms from the low intertidal to 547 m. They may prefer to live around the edges of rocky bottoms. Males are, on average, larger than females and may reach 300 mm in carapace width. Box crab did not appear to exhibit segregation in sex and show no obvious seasonal movement. The Oregon survey showed that they like to live in aggregations. Females reach functional maturity at a minimum carapace length of 78-83 mm. Preliminary data suggests that the fecundity is in a range of 20100-48000 eggs per female. Some males are functionally mature possibly at carapace length of about 80 mm. Active mating probably does not occur until males reach a carapace length of about 106.4 mm. Eggs start to hatch in spring in California and Oregon and maybe later in B.C. Their egg and larval duration is postulated to be 200-300 and 40-90 days respectively based on the information on other Lithodid species. It is not uncommon (14%) for larval snaifish live inside the gill filaments of box crabs, generally causing no obvious damage.

In British Columbia, box crab has been found in the West Coast of Vancouver Island (WCVI), Strait of Georgia (SG), Queen Charlotte Strait (QCS) and Hecate Strait (HS). They were mainly found in a depth range from 50 to 250 m. They appear to be more abundant off the WCVI than inside SG based on the box crab by-catch data. The density of box crab was estimated to be 2.4 kg/km^2 in the depth range of 45-255 m off WCVI based on by-catch data from the shrimp trawl survey. Geographic scale for unit stocks is unknown. However, it may be reasonable to assume that box crabs off the WCVI and inside SG are two separate stocks. Population age structure, longevity, growth rate and natural mortality and recruitment mechanism are unknown

In Oregon, there has been a box crab fishery since early 1980s. This fishery is basically driven by the supply of Dungeness crabs. Landings were high in the mid-1980s, when Dungeness abundance was low. Catch was relatively low in later years, when Dungeness supply was high and stable. A new fisheries developmental licence is required to fish box crab in Oregon. No restrictions on quota, size or gender are imposed. This fishery is currently limited to a maximum of 25 licenses annually. The commercial Dungeness traps with slightly enlarged opening were largely used for box crab fishing. This trap fishery causes minimum habitat disturbance, as by-catches were very low.

There have been two experimental permit fisheries in B.C. The first one took place in Barkley Sound, Clayoquot Sound and Nootka Sound and the second one in the SG. The catches were small especially for the first one.

Any potential fishery development for box crab in B.C. has to be cautious, as there is little or no knowledge on the population structure, growth, mortality and recruitment, and the “virgin” population size is possibly low.

6. Acknowledgements

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Personal Communication

Gene Law -- an Oregon crab fisherman. He was among those who initiated box crab fishery in early 1980s in Oregon. He has been fishing box crab ever since.

Jean McCrae – A biologist of the Oregon department of fishing and games, responsible for the box crab fishery.

Chris Peterson -- A leader of the box crab association. He is fish from the Vancouver Island and has over 30 years of experience on herring and salmon seine fisheries.

Table 1. Shrimp survey area and box crab by-catch since 1973.

Survey Location	Statistical Area	Fishing Depth (m)	Average Depth (m)	Number of Sets	Number of Sets with Box Crab	Total Box Crab Catch (kg)	Catch of Box Crab (kg) per 100 Sets
Off the mouth of Skeena River	3, 4	60-221	115.8	43	1	0.1	0.232558
Queen Charlotte Sound	7-10, 107-110	59-245	168.3	464	4	3.45	0.743534
Queen Charlotte Strait	12	8.5-226	104.6	190	0		
Strait of Georgia	14-18, 29	42-214.5	120.2	193	3	0.75	0.388601
Juan de Fuca	19	58-216.5	110.8	13	0		
Barkley Sound	23	41.5-175.5	92.2	102	0		
Howe Sound	28	47.5-299	108.1	32	0		
west coast of Vancouver Island	121. 123-126	43-254.5	125.7	2394	68	106.8	4.461153

Table 2. Most frequent occurrence of fish and invertebrates caught together with box crab in the commercial bottom trawl fisheries.

Common Name	Scientific Name	Number of Occurrence	% of Occurrence
Fish			
Spiny dogfish	*Squalus acanthias*	361	86.16%
Arrowtooth flounder	*Atheresthes stomias*	341	81.38%
Lingcod	*Ophiodon elongatus*	337	80.43%
Sablefish	*Anoplopoma fimbria*	328	78.28%
Pacific cod	*Gadus macrocephalus*	324	77.33%
Pacific halibut	*Hippoglossus stenolepis*	314	74.94%
Rex sole	*Errex zachirus*	297	70.88%
Dover sole	*Microstomus pacificus*	280	66.83%
Silvergray rockfish	*Sebastes brevispinis*	253	60.38%
Spotted ratfish	*Hydrolagus colliei*	252	60.14%
English sole	*Pleuronectes vetulus*	236	56.32%
Longnose skate	*Raja rhina*	196	46.78%
Invertebrates			
Starfish	Asteroidea	127	30.31%
Sea urchins	Echinacea	59	14.08%
Octopus	Octopoda	32	7.64%
Sea Cucumbbers	Holothuroidea	31	7.40%
Prawn	Pandalus platycerous	29	6.92%
Jellyfish	Scyphozoa	22	5.25%
Sponges	Phylum porifera	21	5.01%
Squid	Teuthoidea	20	4.77%
Tanner Crab	Chionoecetes spp	14	3.34%
Dungeness Crab	Cancer magister	13	3.10%
Anemone	Actiniaria	9	2.15%
Hermit Crab	Paguridae	8	1.91%

Table 3. Most frequent occurrence of fish and invertebrates caught together with box crab in the shrimp trawl surveys.

Common Name	Scientific Name	Number of Occurrence	% of Occurrence
Fish			
Rex sole	*Errex zachirus*	67	88.16%
Spiny dogfish	*Squalus acanthias*	65	85.53%
Dover sole	*Microstomus pacificus*	62	81.58%
Arrowtooth flounder	*Atheresthes stomias*	59	77.63%
Slender sole	*Eopsetta exilis*	57	75.00%
Eulachon	*Thaleichthys pacificus*	51	67.11%
Sablefish	*Anoplopoma fimbria*	49	64.47%
Pacific herring	*Clupea pallasi*	47	61.84%
Skates	Rajidae	46	60.53%
Lingcod	*Ophiodon elongatus*	44	57.89%
Spotted ratfish	*Hydrolagus colliei*	43	56.58%
Walleye pollock	*Theragra chalcogramma*	39	51.32%
Invertebrates			
Brittle stars	Ophiurae	39	51.32%
Starfish	Asteroidea	33	43.42%
Sea cucumbers	Holothuroidea	32	42.11%
Squat squid	Rossia pacifica	32	42.11%
Scallop	Pectinidae	11	14.47%
Heart urchins	Atelostomata	9	11.84%
Prawn	Pandalus platyceros	8	10.53%
Sidestripe shrimp	Pandalopsis dispar	8	10.53%
Sea mouse	Aphrodita	7	9.21%
Jellyfish	Scyphozoa	7	9.21%
Sponges	Porifera	5	6.58%
Octopus	Octopoda	5	6.58%

Table 4. By-Catches of 1997 Oregon Box crab Survey (data source: Jean McCrae).

By-catch Species	Pieces	Ratio**
Hagfish	49	16.4
Sea Urchin	18	6.0
Dungeness Crab	9	3.0
Flat Fish	7	2.4
Sea Stars	2	0.7
Octopus	1	0.3
Sculpin	1	0.3
Rockfish	1	0.3
Ratfish	1	0.3

** The total number (TN) of box crabs caught in the survey was 2983.
Ratio = 1000×(Pieces/TN)

Table 5. Box crab landings in Oregon from 1982-1998 (data source: Jean McCrae).

Year	Landing (lbs)	Year	Landing (lbs)
1982	502	1990	8586
1983	16207	1991	10460
1984	271881	1992	620
1985	93431	1993	830
1986	3060	1994	3449
1987	24	1995	814
1988	0	1996	3646
1989	412	1997	67224
		1998	333

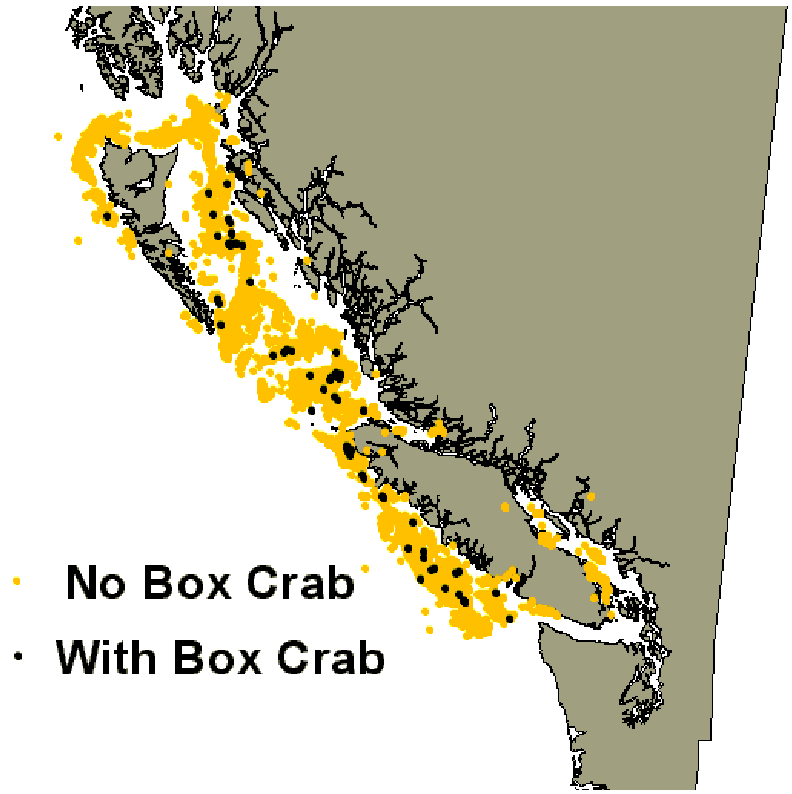

Fig. 1. Distribution of Box Crab Catch in the Bottom Trawl Fisheires in 1996

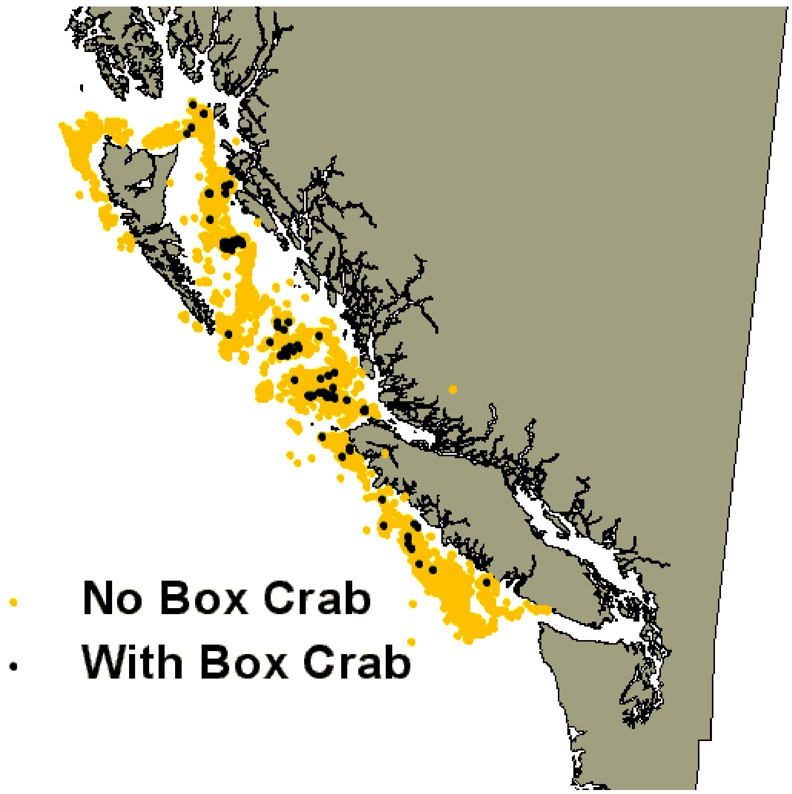

Fig. 2. Distribution of Box Crab Catch in the Bottom Trawl Fisheries in 1997

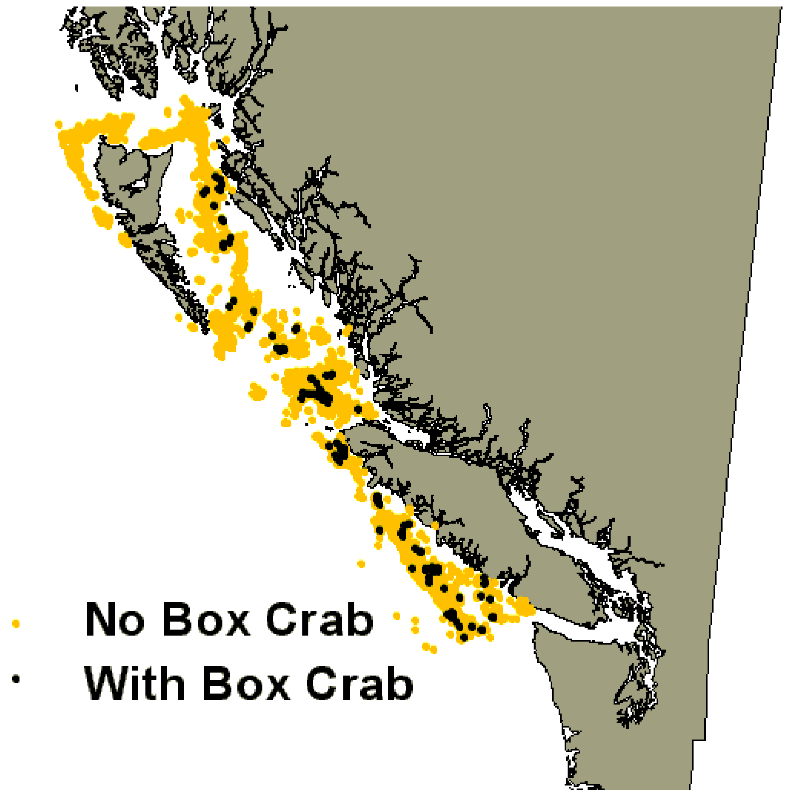

Fig. 3 Distribution of Box Crab Catch in the Bottom Trawl Fisheries in 1998

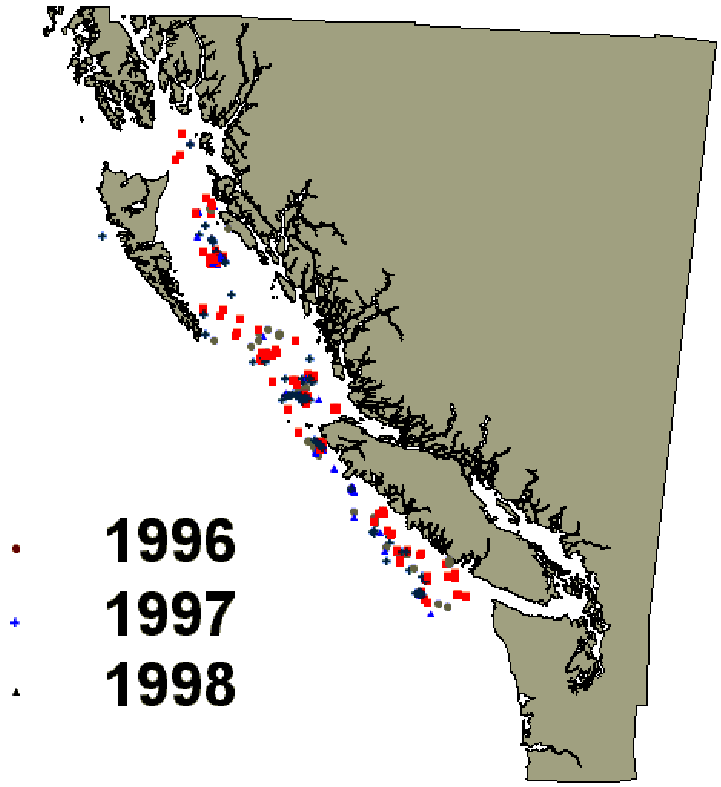

Fig. 4. Annual Variation in Distribution of Box Crab Catch in the Bottom Trawl Fisheries in 1996-98

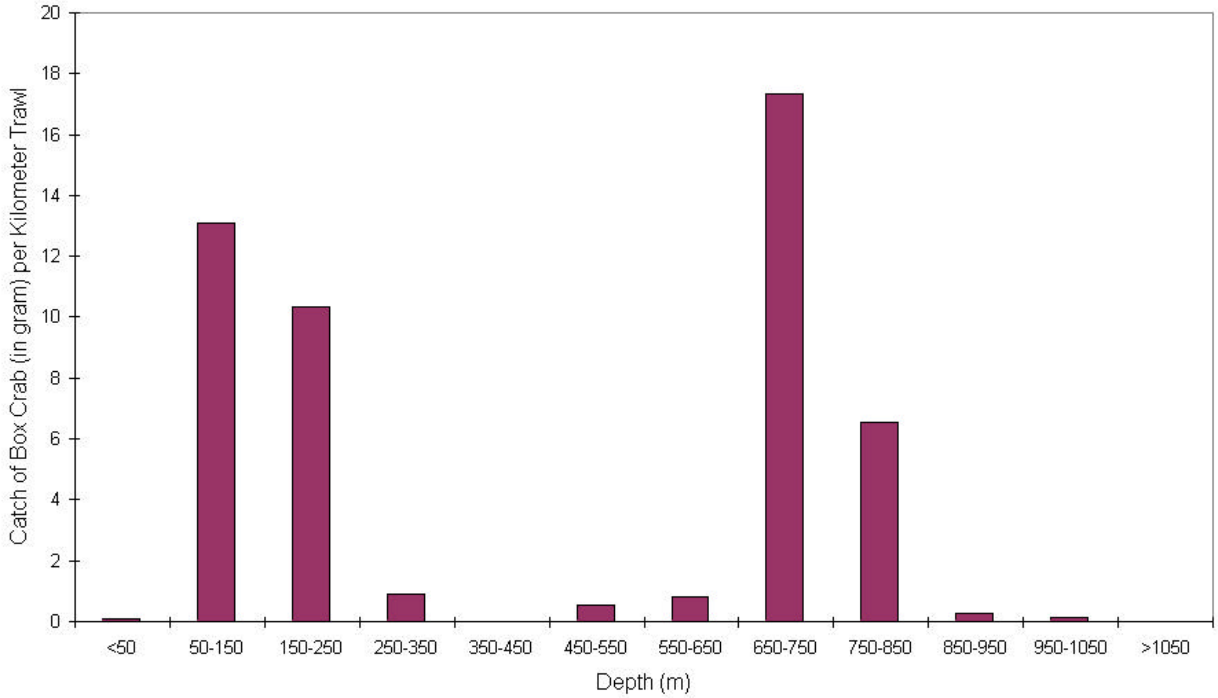

Fig. 5. Catch of Box Crabs in Weight Relative to Trawling Intensity at Various Bottom Depth in the Commercial Bottom Trawl Fisheries in 1996-98

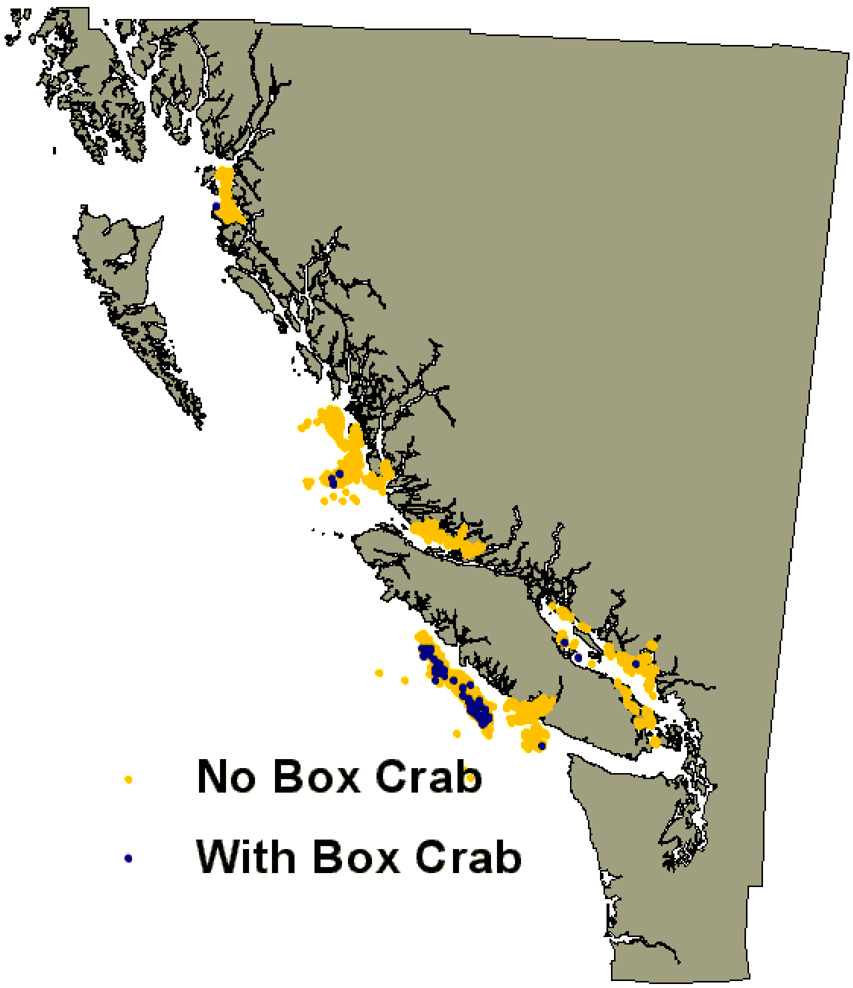

Fig. 6. Distribution of Box Crab Catch in the Shrimp Trawl Surveys since 1973

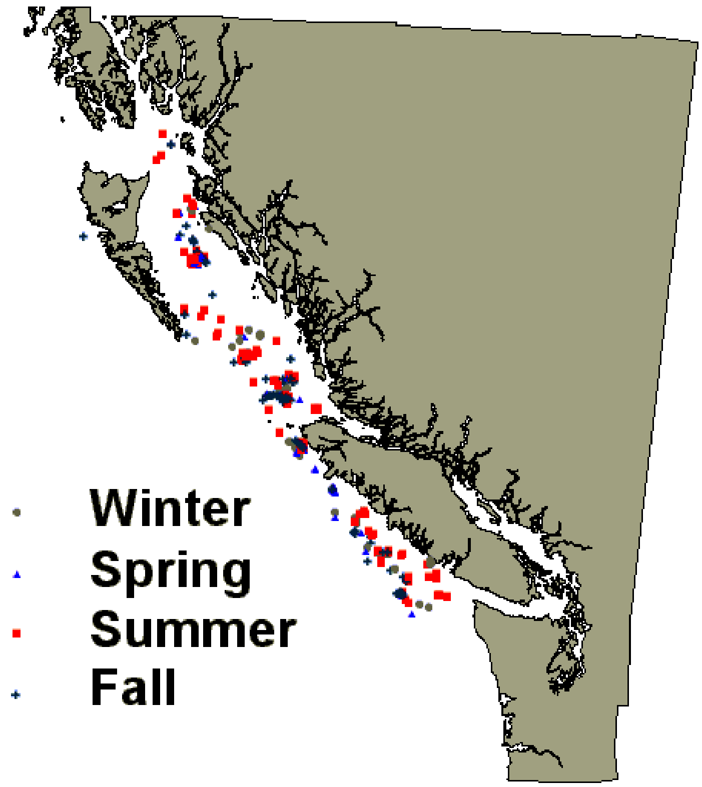

Fig. 7. Seasonal Distribution of Box Crab Catch in the Bottom Trawl Fisheires in 1996-98

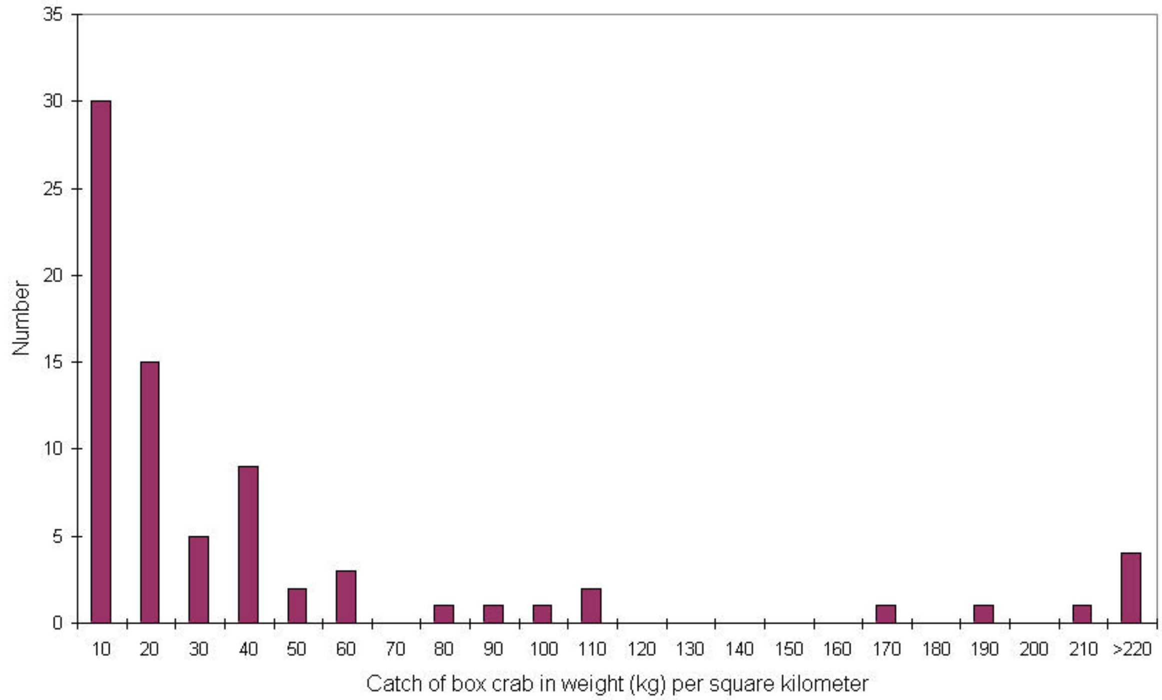

Fig. 8. Amount of Box Crab Catch in the Srimp Trawl Surveys