Biological Field Techniques for Chionoecetes Crabs

Luke S. Jadamec • William E. Donaldson • Paula Cullenberg

Published by University of Alaska Sea Grant College Program

Biological Field Techniques for Chionoecetes Crabs

Luke S. Jadamec • William E. Donaldson • Paula Cullenberg

Published by University of Alaska Sea Grant College Program
1999
AK-SG-99-02
Price $40.00

Elmer E. Rasmuson Library Cataloging-in-Publication Data

Jadamec, Luke S.
Biological field techniques for Chionoecetes crabs / Luke S. Jadamec, William E. Donaldson, Paula Cullenberg. — Fairbanks : Alaska Sea Grant College Program, 1999.

80 p. cm. — (University of Alaska Sea Grant College Program ; AK-SG-99-02)
Includes bibliographical references and index.

ISBN 1-56612-059-4

1. Tanner crabs. 2. Chionoecetes bairdi. 3. Chionoecetes opilio. 4. Biology—Field work. I. Title. II. Donaldson, William E. III. Cullenberg, Paula. IV. Series: Alaska Sea Grant College Program report ; AK-SG-99-02.

QL444.M33J33 1999

Credits

This book is the result of a joint effort by the North Pacific Fisheries Observer Training Center (OTC) and the University of Alaska Sea Grant College Program. Funding for OTC is from the University of Alaska Sea Grant College Program, project E/70-91. University of Alaska Sea Grant is cooperatively supported by the U.S. Department of Commerce, NOAA National Sea Grant Office, under grant no. NA86RG-0050, project A/75-01 (communications); and by the University of Alaska with state funds. The University of Alaska is an affirmative action/equal opportunity institution.

The OTC, in cooperation with the National Marine Fisheries Service and Alaska Department of Fish and Game, educates and trains fisheries observers to collect information necessary to conserve the marine resources of the Bering Sea and the North Pacific. The OTC is part of the Community and Technical College, University of Alaska Anchorage. The OTC website is http://www.uaf.edu/otc

Sea Grant is a unique partnership with public and private sectors combining research, education, and technology transfer for public service. This national network of universities meets changing environmental and economic needs of people in our coastal, ocean, and Great Lakes regions.

North Pacific Fisheries Observer Training Center

NOAA — National Oceanic and Atmospheric Administration — U.S. Department of Commerce

Sea Grant Alaska

Alaska Sea Grant College Program
P.O. Box 755040
Fairbanks, AK 99775-5040
Fax (907) 474-6285
FYPUBS@uaf.edu
http://www.uaf.edu/seagrant

Contents

About the Authors

Luke Jadamec has been a training specialist for the University of Alaska Anchorage North Pacific Fisheries Observer Training Center since 1995. He worked as an observer for the National Marine Fisheries Service and the Alaska Department of Fish and Game for three years, for groundfish, shellfish, and scallops. He now specializes in preservation of fish and shellfish specimens for use in a classroom setting. His research interests include crab and fish biology.

William E. Donaldson conducted fishery research for the Alaska Department of Fish and Game from 1973 through 1997. His career work focused on developing life history information for *Chionoecetes* crabs and management of crab fisheries. Now residing in Dublin, New Hampshire, he conducts specialty projects related to Alaska crabs through fisheries consulting firms, and he also leads nature hikes and other expeditions for substance abuse addicts of all ages.

Paula Cullenberg has been director of the North Pacific Fisheries Observer Training Center since 1995. She has worked in fisheries in Alaska since 1982, most recently as a project manager for the Alaska Fisheries Development Foundation and as a Sea Grant Marine Advisory Program agent in Bristol Bay. She is an affiliate faculty member with the University of Alaska Fairbanks School of Fisheries and Ocean Sciences.

Luke S. Jadamec
University of Alaska Anchorage
North Pacific Fisheries Observer Training Center
707 A St. Suite 207
Anchorage, Alaska 99501
Phone: 907 257-2772
Fax: 907 257-2774
Email: anlj@uaa.alaska.edu

William E. Donaldson
P.O. Box 271
Dublin, New Hampshire 03444
Phone: 603 563-8498
Fax: 603 563-8498
Email: wdonaldson@monad.net

Paula J. Cullenberg
University of Alaska Anchorage
North Pacific Fisheries Observer Training Center
707 A St. Suite 207
Anchorage, Alaska 99501
Phone: 907 257-2771
Fax: 907 257-2774
Email: anpjc@uaa.alaska.edu

Acknowledgments

The authors thank Deborah Mercy and Hank Pennington from the Marine Advisory Program, University of Alaska Fairbanks, for photographing the crabs. Susie Byersdorfer from the Alaska Department of Fish and Game (ADF&G) collected specimens and assisted in photo collection and editing. George Pappas from ADF&G and Eric Munk from the National Marine Fisheries Service (NMFS) provided additional photos. We are grateful to the following reviewers of the manuscript: R.A. "Rich" MacIntosh and Bob Otto from NMFS; Dan Urban, George Pappas, Gordon Kruse, Tim Koeneman, Donn Tracy, and Doug Pengilly from ADF&G; A.J. Paul and Tom Shirley from the University of Alaska Fairbanks School of Fisheries and Ocean Sciences; Bill Karp and Mike Brown from the NMFS North Pacific Groundfish Observer Program, and Dave Taylor from the Department of Fisheries and Oceans Canada.

Thanks to the many unnamed observers who assisted George Pappas in the collection of specimens and the vessel crews who provided the observers with the means to collect quality specimens. Rick Quinones and Greg Morgan from the North Pacific Fisheries Observer Training Center provided artistic and editorial assistance. Thanks to J.M. Paul of the School of Fisheries and Ocean Sciences for patiently holding live specimens while they were photographed.

Thanks to Sue Merkouris from ADF&G and Nicola Urbani from Fisheries and Oceans Canada for providing information on collection protocols for genetic studies, Dan Urban from ADF&G, and Lisa Mooney from NMFS for providing information on bitter crab detection.

Cover design is by Dave Brenner, editing is by Sue Keller, and format is by Carol Kaynor, all from University of Alaska Sea Grant. Digital image capture was done by Brian Walker from Brainstorm Digital Imaging, Anchorage. Layout and digital image processing are by Luke Jadamec.

Special thanks go to Doug Pengilly, ADF&G, for encouragement to complete this guide. The North Pacific Fisheries Observer Training Center, ADF&G, and NMFS provided funds to complete this guide.

Preface

This important publication enables standardization of data collection by fisheries observers and shoreside samplers, crab and shellfish biologists, and fishermen. Wide use of the book promises to improve data accuracy, and thus promote good management for these commercially important crabs. When data are collected citing this publication, there should be little or no ambiguity as to measurements made and definitions used. This guide is not all inclusive, but is intended to identify structures and organs, measurements and descriptions, and techniques that are commonly used in field studies.

All five species of *Chionoecetes* are harvested commercially. Sound fisheries management requires accurate data collection and consistency in methodology. This guide is the first published standard reference for collecting data on *Chionoecetes* crabs. The need for this publication was identified at interagency shellfish research meetings held in December 1996 and 1997 in Anchorage, Alaska.

About the Common Names

Several common names have been used interchangeably with this group of crabs because of their similar appearance, with "Tanner crab" being most commonly used. The name most likely originated with *C. tanneri,* named after Lt. Commander Z.L. Tanner, commander of the Bureau of Fisheries steamer *Albatross,* whose explorations produced the early Pacific records of this genus (hence the capitalization of Tanner). Historically, the name Tanner crab may have come into common use with the misidentification of *C. opilio* and *C. bairdi* as *C. tanneri.*

The terms "snow" and "queen" crab were used interchangeably in the past for marketing purposes. The common name snow crab likely came from the "chion" part of the name *Chionoecetes,* a Greek word meaning snow. Other common names used in the past to identify members of this genus are spider crab, Baird crab for *C. bairdi,* and deep sea spider crab for *C. tanneri.*

In Japanese, *C. opilio* are called zuwai crab, and *C. bairdi* are called Ou-zuwai which means large zuwai crab. The name for *C. japonicus,* beni-zuwai, means red zuwai crab (AFS 1989, Kon 1996).

1. Taxonomic Key

Classification of the genus Chionoecetes Krøyer 1838

Phylum:	Crustacea	Section:	Oxyrhyncha
Class:	Malacostraca	Superfamily:	Majoidea
Superorder:	Eucarida	Family:	Majidae (spider crabs)
Order:	Decapoda	Genus:	*Chionoecetes*
Suborder:	Dendrobranchiata		

Chionoecetes contains five species and three subspecies.

Species

C. opilio (Fabricius 1788), Snow crab
C. bairdi Rathbun 1924, Tanner crab
C. tanneri Rathbun 1893, Grooved Tanner crab
C. angulatus Rathbun 1924, Triangle Tanner crab
C. japonicus Rathbun 1932, Beni-zuwai crab

Subspecies

C. opilio elongatus Rathbun 1924
C. angulatus bathyalis Derjugin and Kobjakowa 1935
C. japonicus pacificus Sakai 1976

Key to the Species of *Chionoecetes*

Measurements used in this key are defined in the Morphometrics section.

1a. Carapace: branchial regions not extended beyond lateral margin of the carapace in frontal view (Fig. 1) ..... **2a** (page 2)

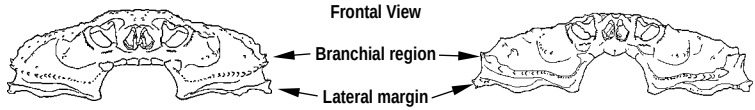


Figure 1. Frontal view showing the branchial region in comparison to the lateral margin of the carapace. (L.S. Jadamec)

1b. Branchial regions extended beyond lateral margin of the carapace in frontal view (Fig. 2) ..... **3a** (page 9)

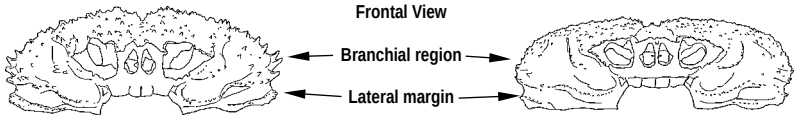
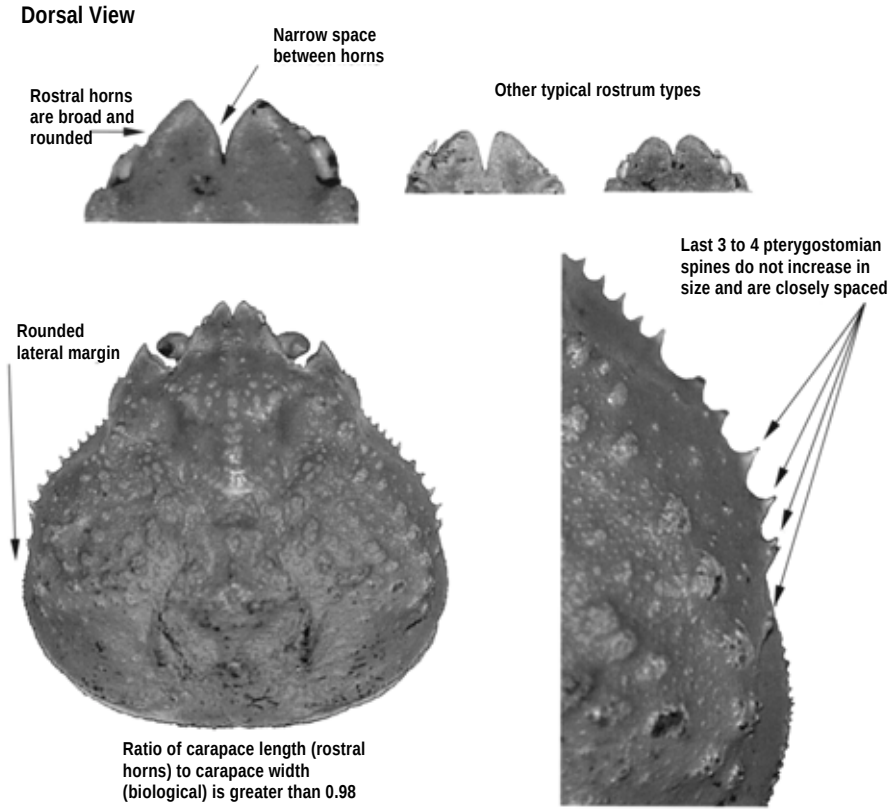


Figure 2. Frontal view showing the branchial region in comparison to the lateral margin of the carapace. (L.S. Jadamec)

2a. Ratio of carapace length (rostral horn) to carapace width (biological) is greater than 0.98; the carapace appears as wide as long. Last three to four pterygostomian spines do not increase in size and are closely spaced. Lateral margin of the carapace is slightly scalloped or smoothly rounded. Ventral margin of the epistomal plates is horizontal. Elevation of the frontal region is lower than the gastric region. Rostrum is horizontal to the frontal region, and the rostral horns are broad and rounded; there is a narrow space between the rostral horns. Both eyes are green in color (Fig. 3).

Snow Crab, *Chionoecetes opilio*

Distribution: Cold waters of the Sea of Japan east of the Korean Peninsula, the Sea of Okhotsk, and the Bering Sea north of the Alaska Peninsula (but not in the Aleutian Islands), and in the Beaufort Sea as far east as Cape Parry. In the northwest Atlantic, from Greenland south to Casco Bay, Maine. At depths from shallow to 450 m.



Note: Hybrids of Tanner and snow crab occur in the Bering Sea; refer to Field Identification of *Chionoecetes bairdi/opilio* Hybrids on page 6.

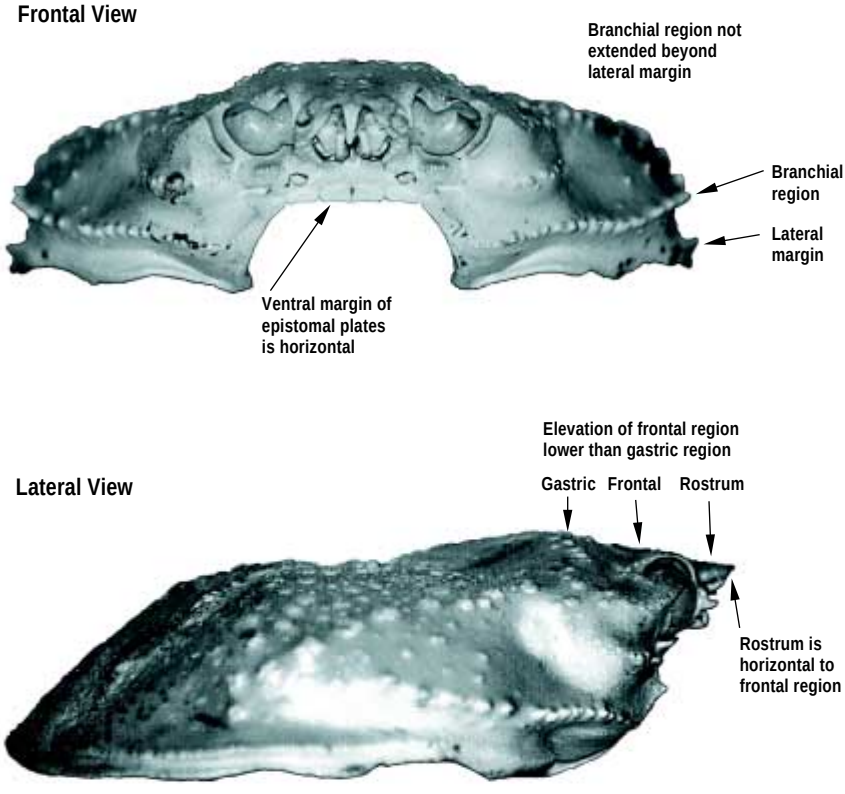


Figure 3. (Facing page and above) Mature male snow crab, and eye color: dorsal view of carapace with close-up images of the rostrum and pterygostomian spines, frontal view of the carapace, lateral view of the carapace, and eye color (an enlarged image of a snow crab eye). (L.S. Jadamec)

2b. Carapace length (rostral horn) to carapace width (biological) is less than 0.945; the carapace is wider than long. Last three to four pterygostomian spines increase in size posteriorly, and are widely spaced. Lateral margin of the carapace is moderately to deeply scalloped. Ventral margin of the epistomal plates is M-shaped. Elevation of the frontal region is greater than the gastric region. Rostrum projects upward from the frontal region and the rostral horns are narrow; there is a wide space between the rostral horns. Both eyes are red in color (Fig. 4).

Tanner Crab, *Chionoecetes bairdi*

Distribution: North Pacific Ocean from Oregon to Alaska, the Bering Sea, adjacent to the Aleutian Islands, and off Hokkaido in the Sea of Okhotsk. At depths from subtidal areas to 437 m.

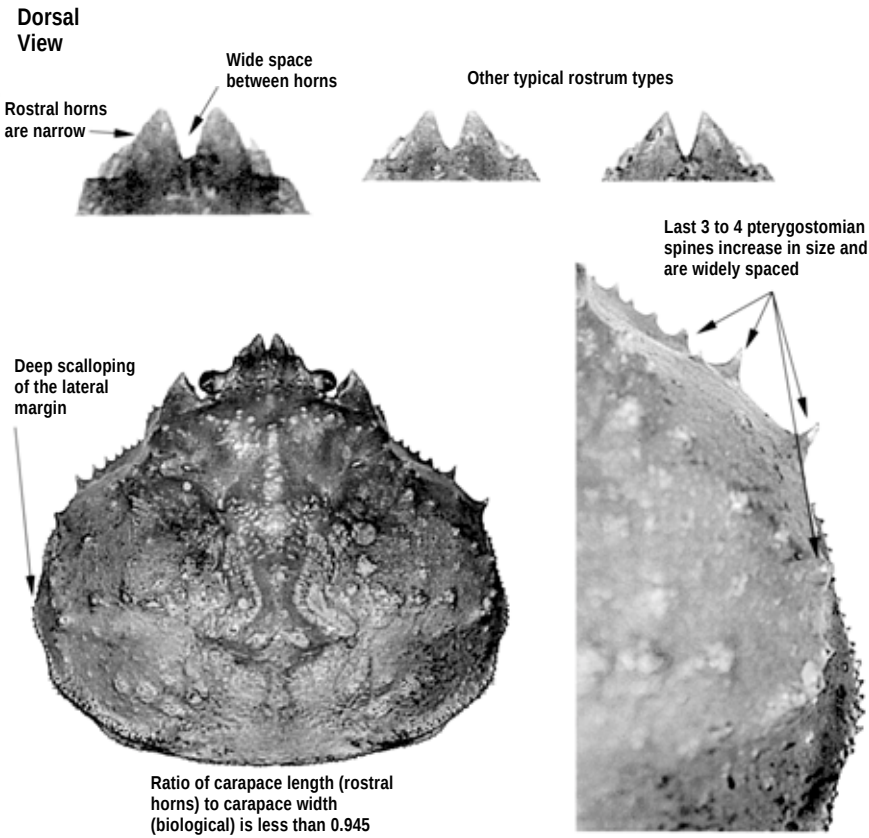
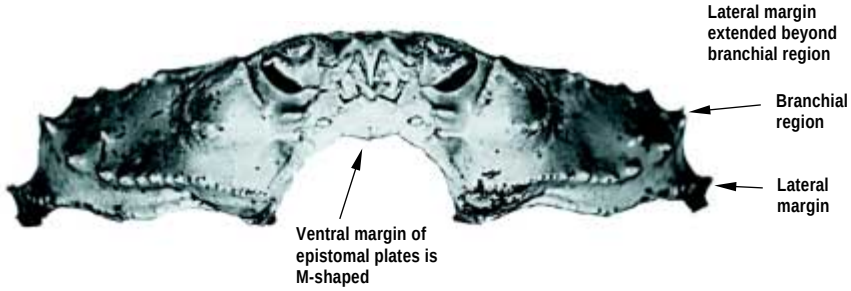
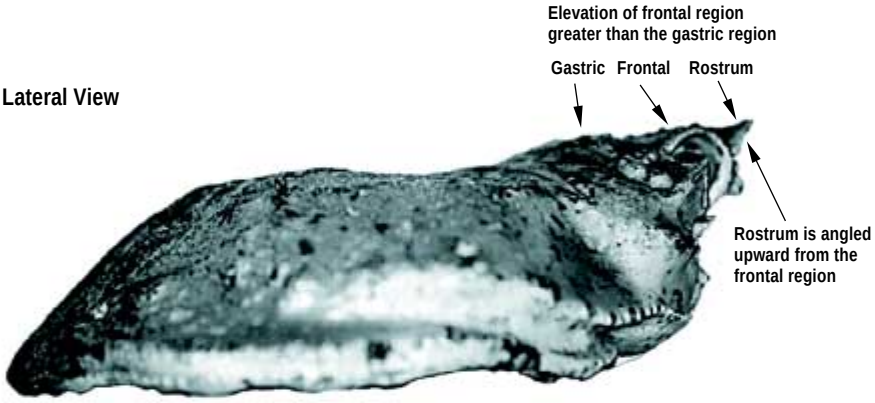


Figure 4. (Above and facing page) Mature male Tanner crab, and eye color: dorsal view of carapace with close-up images of the rostrum and pterygostomian spines, frontal view of the carapace, lateral view of the carapace, and eye color (an enlarged image of a Tanner crab eye). (L.S. Jadamec)

Frontal View



Lateral View



Eye Color

Both eyes are red in color

Figure 4. Tanner crab (Continued.)

Field Identification of *Chionoecetes bairdi/opilio* Hybrids

The *Chionoecetes bairdi/opilio* hybrid can be very difficult to distinguish from true Tanner and snow crab due to combined genetic information from the two parent species. Characteristics described here can be used to help identify hybrid crabs when significant differences exist from the parent species. However, they are not useful in identifying the whole range of hybrid phenotypes.

It is often possible to identify typical Tanner and snow crab characteristics in the same specimen, thus indicating hybridization. Hybrids typically exhibit characteristics intermediate between those of the parent species. Backcross hybrids or other hybrids that do not show a significant combination of characteristics from the parent species can be identified only with genetic analysis.

The three most obvious intermediate characteristics of a hybrid crab are (1) eye color (one red and one green eye, Fig. 5); (2) shape of the ventral margin of the epistomal plates (see Fig. 6 and 7 frontal view); and (3) the ratio of carapace length (rostral horn) to carapace width (biological) (between 0.945 and 0.98). However, the ratio of carapace length (rostral horn) to carapace width (biological) is unreliable when the specimen is less than 40 mm carapace width (Donaldson 1996).

Any of the following characteristics indicate hybridization:

- One red and one green eye or brown eyes, or
- Two red eyes plus snow crab characteristics, or
- Two green eyes plus Tanner crab characteristics, or
- Hybrid type epistomal margin (see Fig. 6 and 7), or
- Ratio of carapace length (rostral horn) to carapace width (biological) between 0.945 and 0.98, or
- Ratio of carapace length (rostral horn) to carapace width (biological) less than 0.945 (characteristic of Tanner crab) and snow crab epistome shape, or
- Ratio of carapace length (rostral horn) to carapace width (biological) greater than 0.98 (characteristic of snow crab) and Tanner crab epistome shape.

Chionoecetes bairdi/opilio Hybrid

Distribution: Bering Sea from subtidal waters to 450 m.

Eye color

Tanner crab  Snow crab 

Figure 5. Eye color (enlarged images of Tanner and snow crab eyes). (L.S. Jadamec)

Note: Avoid relying solely on a single characteristic when identifying hybrids in the field, particularly the rostrum in dorsal and lateral view.

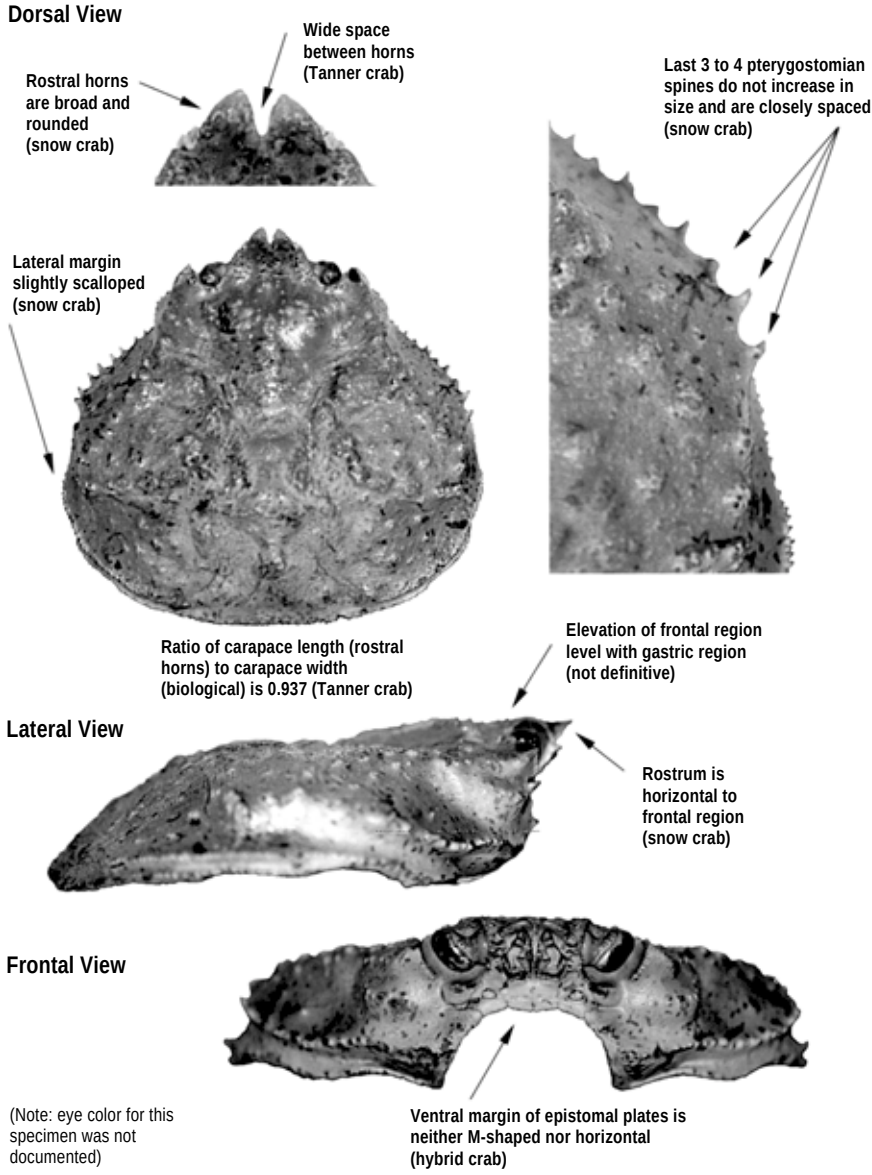


Figure 6. Genetically identified Chionoecetes bairdi/opilio *hybrid crab specimen: dorsal view of carapace with close-up images of the rostrum and pterygostomian spines, lateral view of the carapace, and frontal view of the carapace. (L.S. Jadamec)*

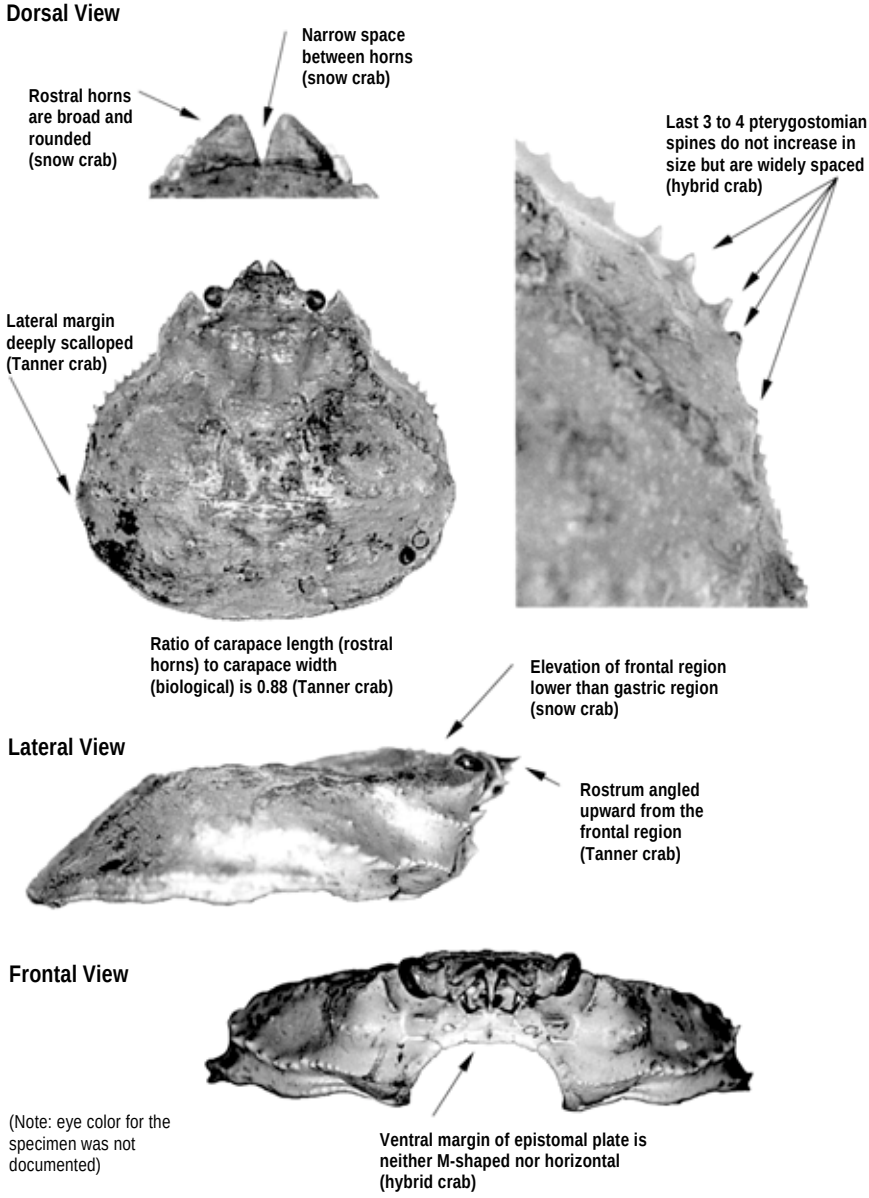


Figure 7. Genetically identified Chionoecetes bairdi/opilio *hybrid crab specimen: dorsal view of carapace with close-up images of the rostrum and pterygostomian spines, lateral view of the carapace, and frontal view of the carapace. (L.S. Jadamec)*

3a. Interspace between branchial regions shallow (Fig. 8) ..... **4a** (page 10)

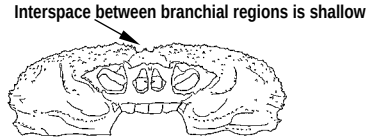


Figure 8. Triangle Tanner crab in frontal view. (L.S. Jadamec)

3b. Interspace between branchial regions is deep. The carapace is very spinous. Two small subequal spines are at the intersection of two dorsal branchial ridges (Fig. 9).

Grooved Tanner Crab, *Chionoecetes tanneri*

Distribution: Pacific Ocean off the California-Mexico border to the Bering Sea, primarily adjacent to the Aleutian Islands. At depths from 53 to 1,900 m.

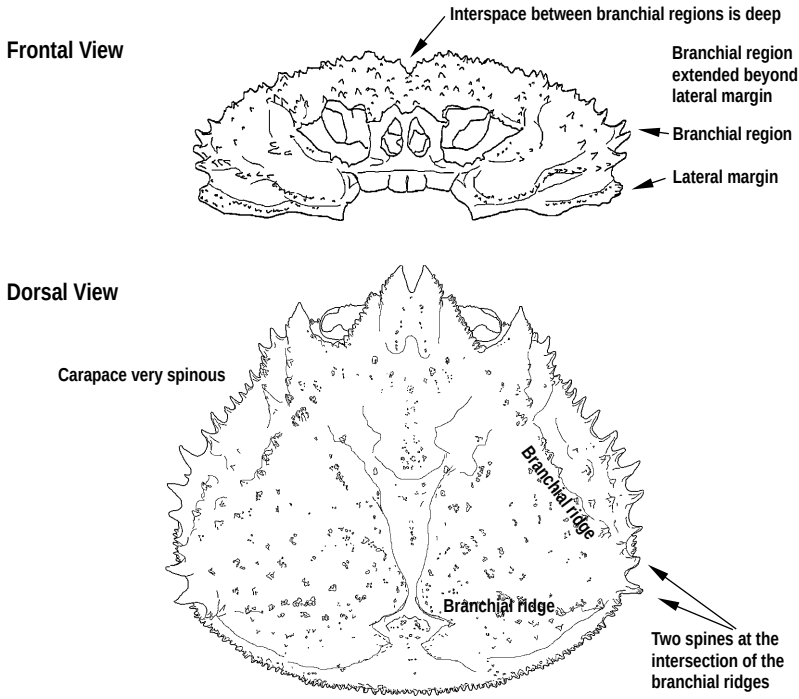


Figure 9. Grooved Tanner crab in frontal view and dorsal view. (L.S. Jadamec)

4a. The carapace is spinous with some tubercles. A single large spine is at the angle made by intersection of the two dorsal branchial ridges (Fig. 10).

Triangle Tanner Crab, *Chionoecetes angulatus*

Distribution: North Pacific from Oregon to Alaska, the Bering Sea, adjacent to the Aleutian Islands and Kamchatka Peninsula. At depths from 90 to 3,000 m.

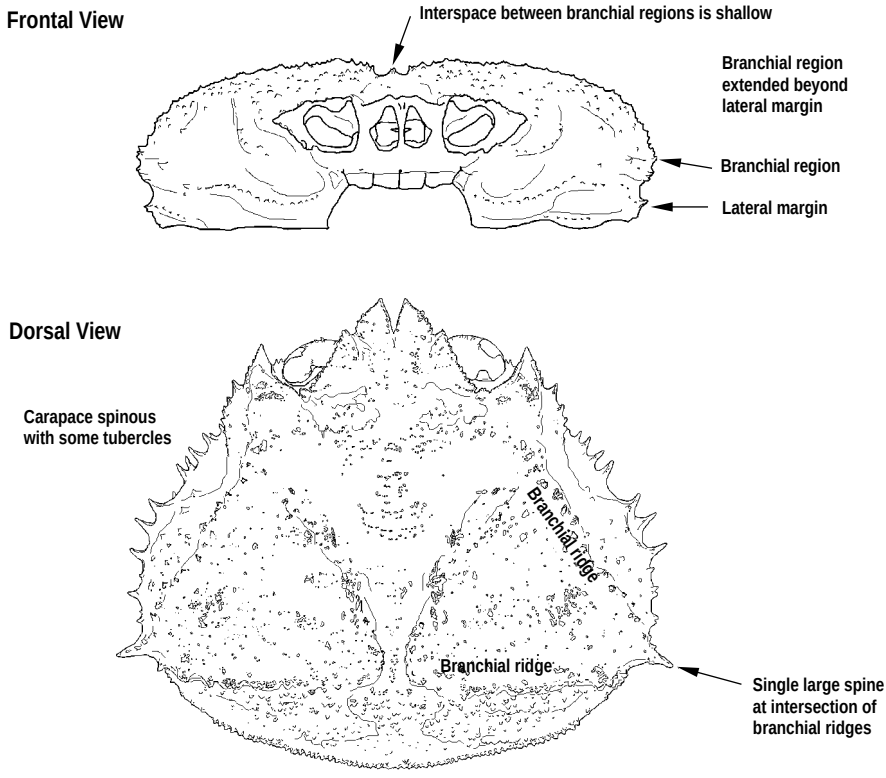


Figure 10. Triangle Tanner crab in frontal view and dorsal view. (L.S. Jadamec)

4b. The carapace is tuberculate to granulate with a few spines. A single small spine at angle made by intersection of the two dorsal branchial ridges (Fig. 11).

Beni-zuwai Crab, *Chionoecetes japonicus*

Distribution: Sea of Japan and Okhotsk Sea with greatest concentrations at 1,000 m.

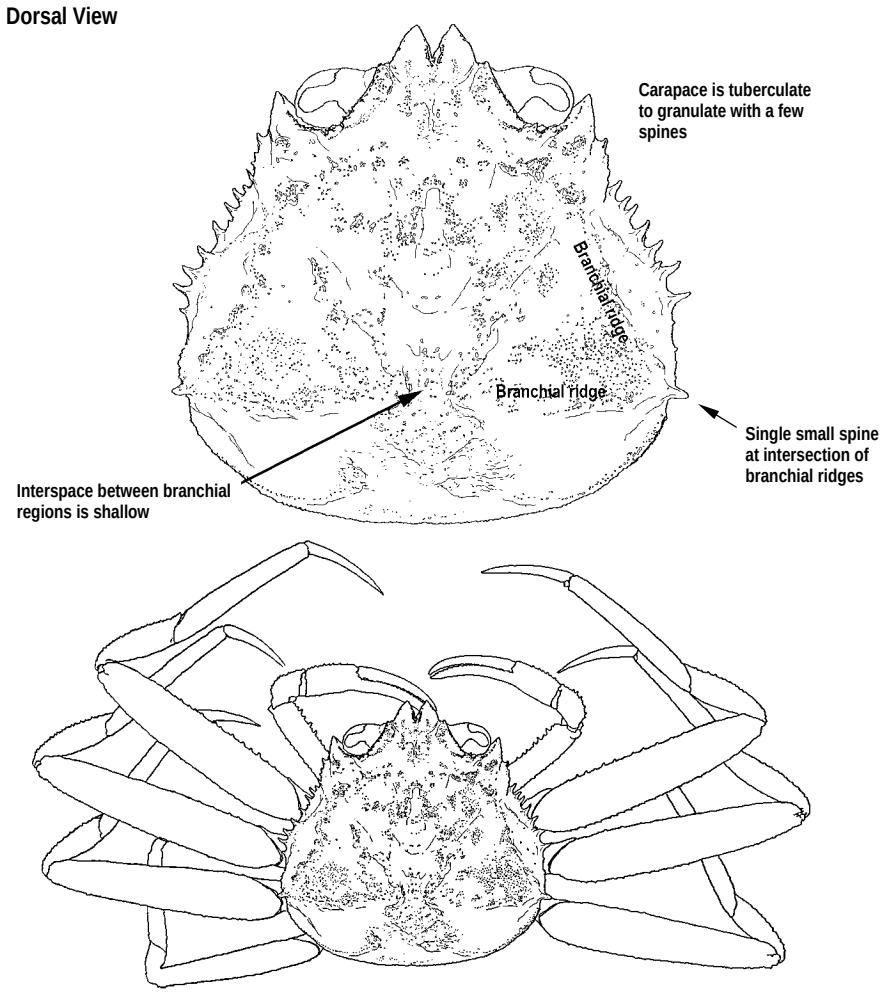


Figure 11. Beni-zuwai crab in dorsal view with a close-up of the carapace. (L.S. Jadamec)

2. Life History

The available information on the life history of *Chionoecetes* crabs is incomplete at best. What does exist is sometimes contradictory and area-specific. A general life history follows.

Chionoecetes embryos, which are about 0.5 to 1 mm in diameter, hatch from late winter through early summer and proceed through three planktonic stages. The prezoeae exit the egg mass beneath the female's abdomen and begin an upward migration in the water column. Laboratory studies indicate that prezoeae begin molting to the zoeae I stage in a matter of hours after hatching. The zoeae I molt to the zoeae II stage about one month later. The settling stage, referred to as the megalops, is achieved in one additional month. Megalops are about 6 to 7 mm in carapace length and are frequently found in surface waters. Estimates of megalops stage duration range from 1 to 10 months.

The megalops migrates to the ocean floor where it molts into the first instar at about 3.5 mm carapace width. The first instars are miniature versions of adults in appearance. During successive instars, many changes occur in size, relative dimensions of body parts, and habitat occupied. Duration of instar stages, or the intermolt period, increases with crab age. Estimates of growth per molt, in percent carapace width, range from 15 to 32% and decrease as crab size increases.

Female Tanner crabs are estimated to pass through 12 instars before they terminally molt at the 13th instar in about 5 years. Male Tanner crabs are estimated to mature in about 6 years with the largest males passing through as many as 18 instars (Donaldson et al. 1981). There is an ongoing, spirited debate concerning the existence of a terminal molt for males at morphometric maturity (Donaldson and Johnson 1988).

Bipartite breeding behavior has been described for both Tanner and snow crabs (Somerton 1982). Females capable of first sexual reproduction which have not previously spawned (termed pubescent) molt to maturity and spawn for the first time in shallow water with smaller males and earlier in the year (January to May). Females which have previously spawned once (termed primiparous) or more than once (termed multiparous) breed in deeper waters with larger males and later in the year (April to May). Multiparous Tanner females tend to form mating aggregations containing mounds or pods several meters high (Stevens et al. 1994). Large, old-shell males undertake seasonal migrations that bring them in contact with aggregated females.

Hatching and release of larvae occurs just prior to copulation and extrusion of the new clutch of embryos. Estimates for clutch size range from 24,000 to 318,000 eggs for Tanner crab in Prince William Sound (Hilsinger 1976), 20,000 to 140,000 eggs for snow crab off eastern Canada (Watson 1969), and 6,000 to 130,000 eggs for snow crab in Japanese waters (Ito 1963).

Reproductive behavior reported for Tanner and snow crabs is similar (Watson 1972, Adams 1982, Donaldson and Adams 1989). Adams described three phases of reproductive behavior. The precopulatory phase may last several weeks and involves detection of a receptive female by a male. Once he detects her, the male grasps the female at the base of the walking legs and holds her in front of himself, rostrum to rostrum, until the copulatory act.

If the female is pubescent, the male will continue to grasp and assist the female during her molt to maturity (terminal molt). After the female has completed her molt,

the male grasper releases the molted exoskeleton and immediately regrasps the soft-shell female. At this stage the female has the adult-shaped abdominal flap.

During the copulatory phase the male positions the female upside down and beneath himself, sternum to sternum, and transfers spermatophores into the female's gonopores. This phase may last less than one hour.

In the postcopulatory phase, the male continues to grasp the female, which is now upright, until the fertilized eggs or embryos are extruded and attached to the abdominal appendages, forming the egg (or embryo) mass. This occurs shortly after copulation. Grasping marks are left on the walking legs of females that are mated as primiparous and multiparous crabs. Grasping marks usually are not found on walking legs of a pubescent female because mating normally occurs when she is in a soft-shell condition.

Multiparous females are capable of fertilizing eggs in the absence of males by using sperm stored in their spermathecae from previous mating. Paul (1984) estimated that females could produce two fertilized clutches in succession using only stored sperm.

3. Distribution

Crabs of the genus *Chionoecetes* can be divided into two groups based on depth distribution. The shallower water (continental shelf) species are Tanner and snow crabs. The relatively deepwater (continental slope) species are the triangle Tanner crab, grooved Tanner crab, and Beni-zuwai crab.

Snow crabs have the widest distribution and are found in cold waters of the Japan Sea east of the Korean Peninsula, the Sea of Okhotsk, Bering Sea, and northwest Atlantic. According to results of National Marine Fisheries Service (NMFS) surveys, snow crabs are not found around the Aleutian Islands. They do not occur south of the Alaska Peninsula, but are found in the Beaufort Sea, occasionally as far east as Cape Parry (Squires 1969). In the northwest Atlantic they are reported from Greenland south to Casco Bay, Maine. Kon (1996) reported snow crabs at depths of 450 m in the Sea of Japan.

Tanner crabs are reported from subtidal areas to 437 m and occur in the Pacific Ocean from Oregon to Alaska, in the Bering Sea, and adjacent to the Aleutian Islands. Igarashi (1970) reported Tanner crabs off Hokkaido in the Sea of Okhotsk.

Triangle Tanner crabs occur in the North Pacific from Oregon to Alaska, the Bering Sea, adjacent to the Aleutian Islands, and the Kamchatka Peninsula. They are reported from depths of 90 to 3,000 m (Garth 1958). Recent Aleutian Islands and Bering Sea fisheries for this species have averaged 878 and 948 m depths respectively.

Grooved Tanner crabs have a southern boundary in the Pacific Ocean off the California-Mexico border. Their distribution extends northward into the North Pacific, primarily adjacent to the Aleutian Islands, and in the Bering Sea with a reported depth distribution of 53 to 1,900 m (Garth 1958).

Beni-zuwai is restricted to the Sea of Japan and Okhotsk Sea. Yosho and Hayashi (1994) reported that the greatest abundance of this species was found at 1,000 m. Figures 12a-c show geographic locations mentioned in this book.

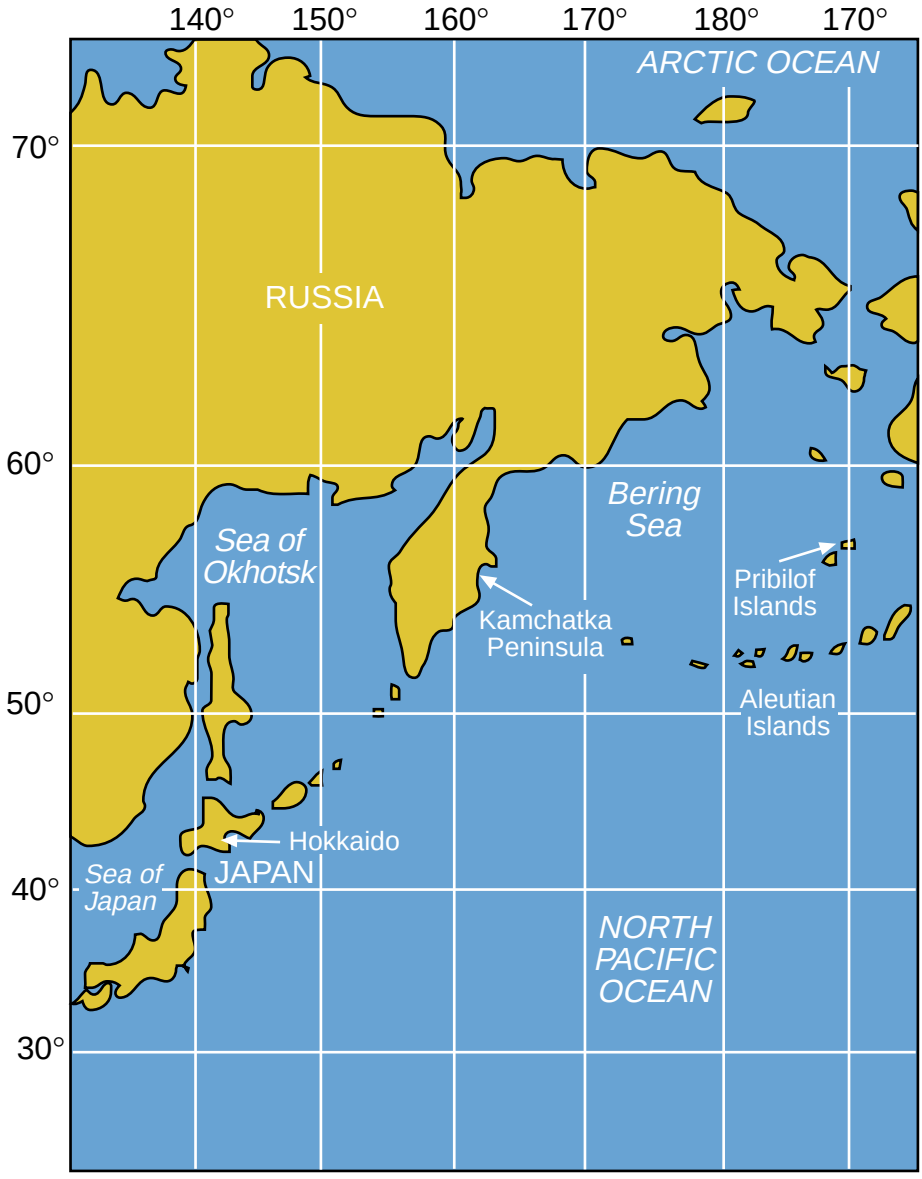


Figure 12a. Western North Pacific Ocean, with place names used to describe crab distribution in this book. (R. Quinones and D. Brenner)

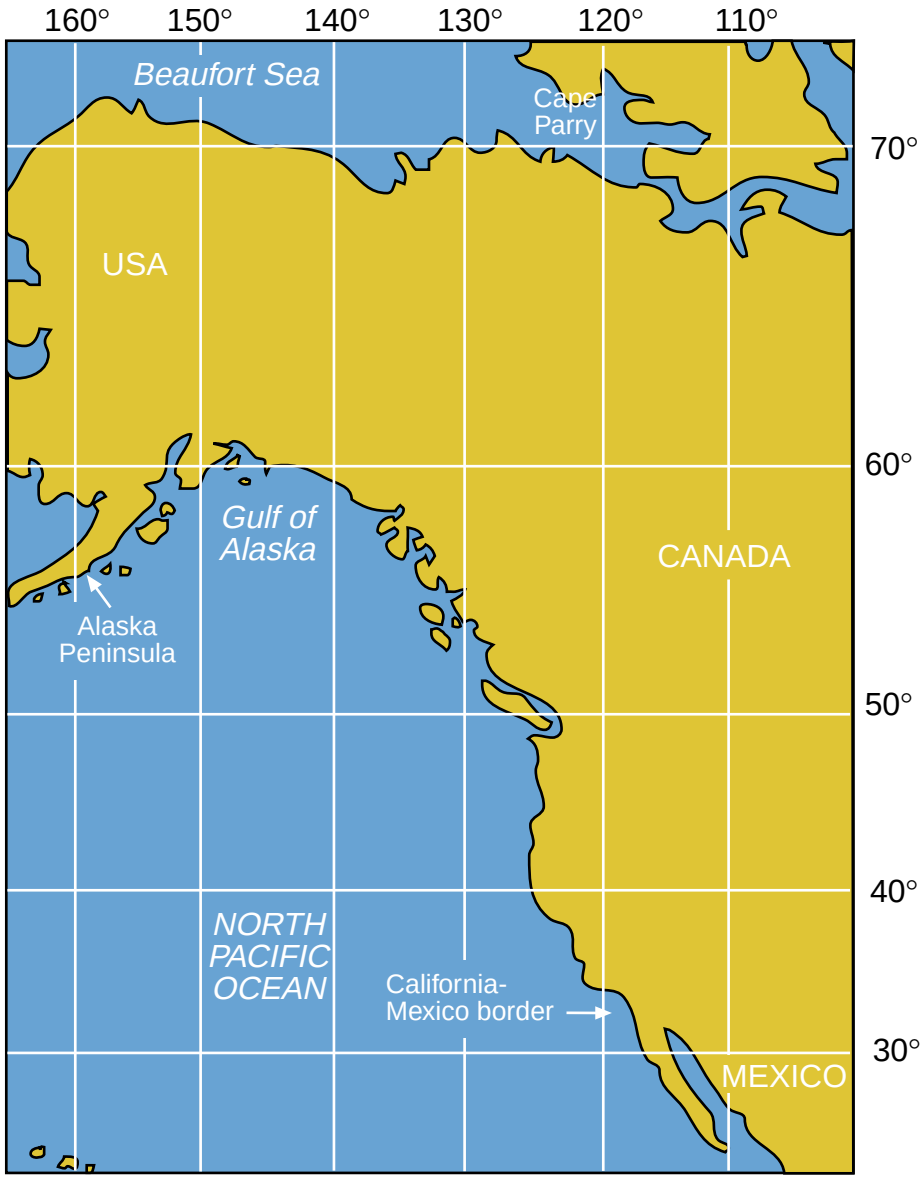


Figure 12b. Eastern North Pacific Ocean, with place names used to describe crab distribution in this book. (R. Quinones and D. Brenner)

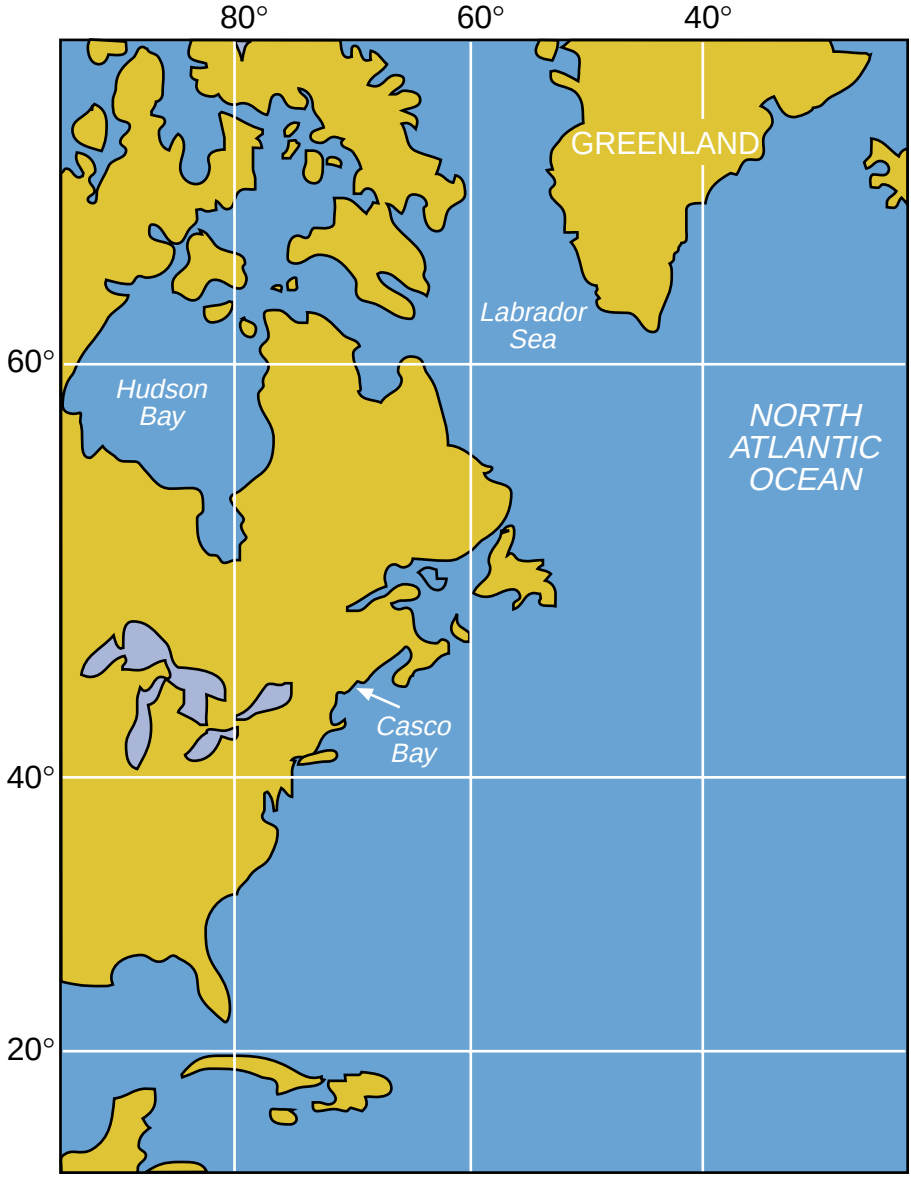


Figure 12c. Western North Atlantic Ocean, with place names used to describe crab distribution in this book. (R. Quinones and D. Brenner)

4. External Anatomy

Crab bodies are composed of a cephalothorax (fused head and thorax) and an abdomen. Dorsally and laterally, the covering of the cephalothorax is referred to as the carapace. Areas of the cephalothorax include frontal, gastric, branchial, and cardiac (Fig. 13). Mouthparts and antennae are located on the ventral side of the frontal region, while the ventral branchial region bears the locomotor appendages (pereiopods). The first pereiopods are modified as the chelipeds. The second through the fifth pereiopods are the walking legs (Fig. 14). The abdomen is composed of abdominal somites 1-6 plus the telson, which form the abdominal flap.

The shape of the abdominal flap can be used to determine the sex of the crab and the maturity status of females. Juvenile and adult males have a triangular shaped abdominal flap (Fig. 15a). Adult females have a circular abdominal flap that covers most of the ventral surface of the crab (Fig. 15b). Juvenile females have an abdominal flap that covers about two-thirds of the ventral surface (Fig. 15c). The abdominal flap of hermaphroditic individuals has a shape similar to juvenile females (Fig. 15d). Reproductive appendages including the pleopods (to which eggs are attached) of females and gonopods (sex organs of males) are located on the abdomen (Fig. 16a,b,c,d).

Determining the sex of very small crabs is difficult because the abdominal flap of the females may not be appreciably expanded. Sexing small crabs can also be accomplished by carefully lifting the abdominal flap and observing if gonopods are present (male) or absent (female). When sexing small crabs, a hand lens is recommended. As with juvenile females, hermaphroditic individuals are easily identified by checking under the abdominal flap and observing if gonopods (males), gonopores (females), and pleopods (females) are present (Fig. 16d).

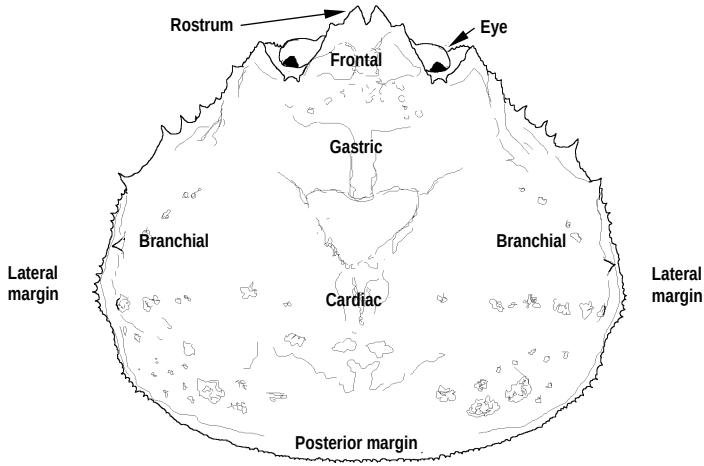


Figure 13. Major regions of the dorsal surface of a Chionoecetes *carapace. (L.S. Jadamec)*

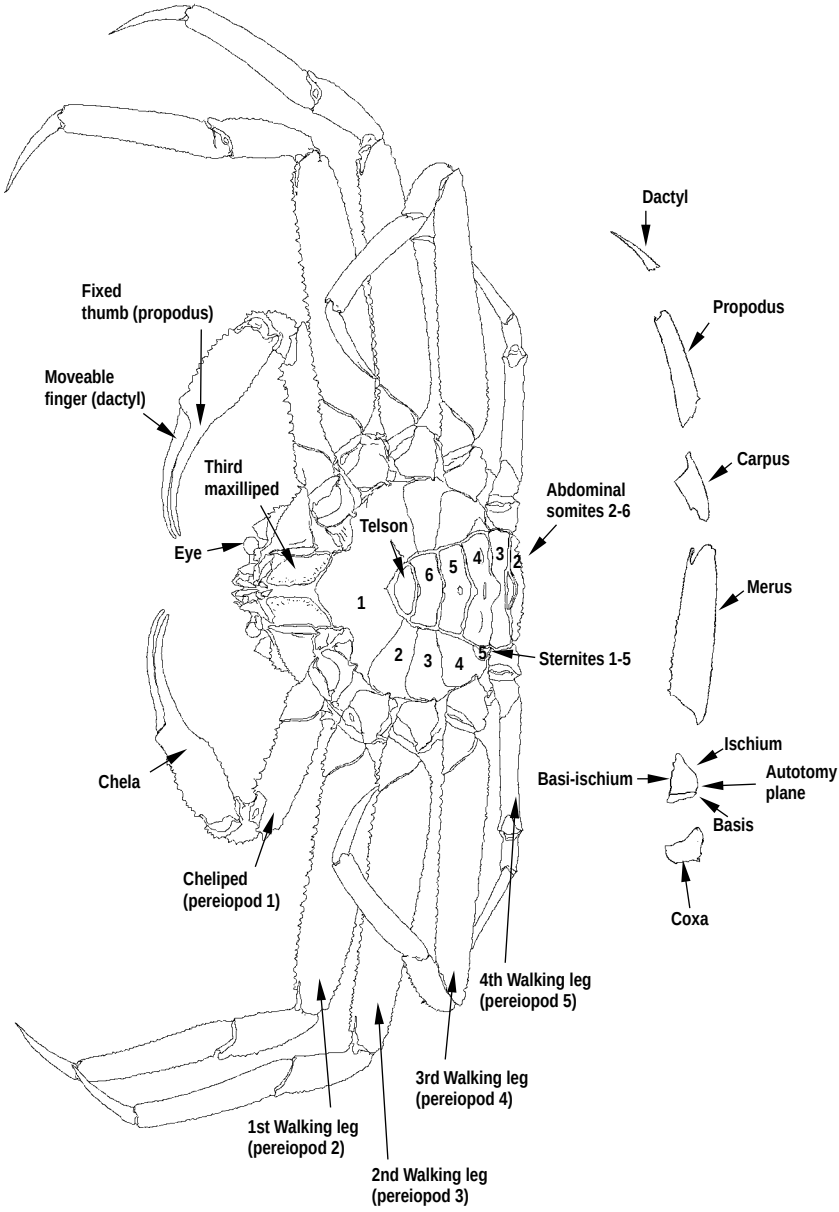
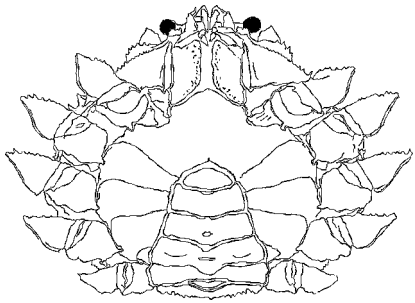
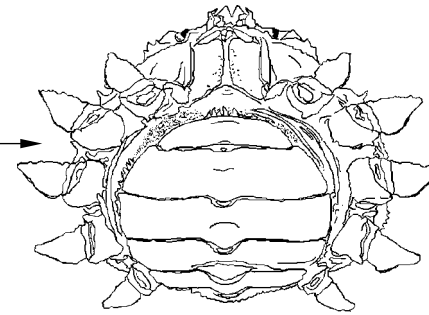


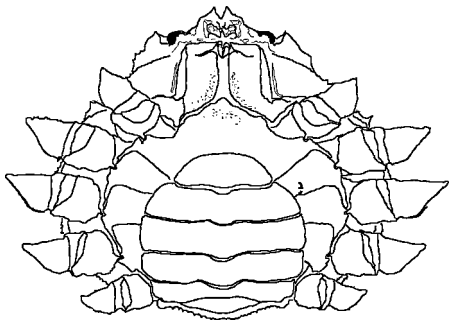
Figure 14. Ventral anatomy of a Chionoecetes *crab. (L.S. Jadamec)*



15a. Juvenile and mature male abdominal flaps are triangular in shape.

15b. Mature female crabs have a circular abdominal flap that covers most of the ventral surface.





15c. Juvenile female crabs have an abdominal flap that covers about $^{2}/_{3}$ of the ventral surface of the crab; fold back abdominal flap for sexing very small crabs.

15d. Hermaphroditic crabs have an abdominal flap similar in shape to juvenile females; fold back abdominal flap for identification.

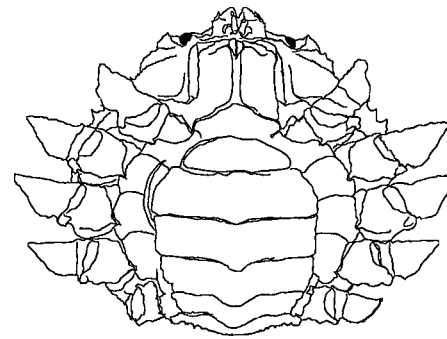


Figure 15. Ventral view of Chionoecetes *crabs (dorsal view of abdominal flap) identifying sex and maturity status: a. Juvenile or mature male. b. Mature female. c. Juvenile female. d. Hermaphrodite. (L.S. Jadamec)*

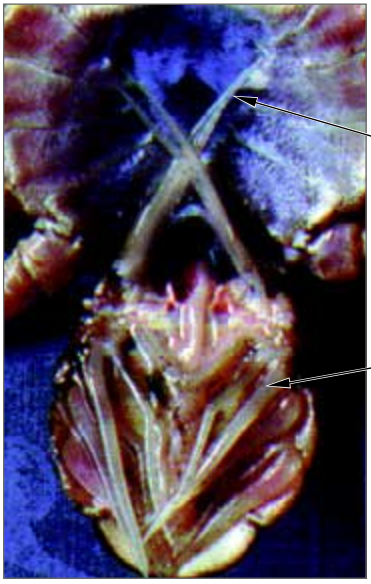
16a. Mature and juvenile male

Gonopods

Gonopores

Pleopods

16b. Mature female

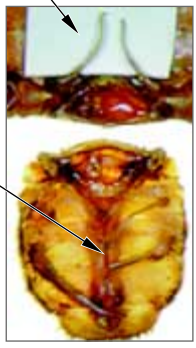


16c. Juvenile female

Gonopores

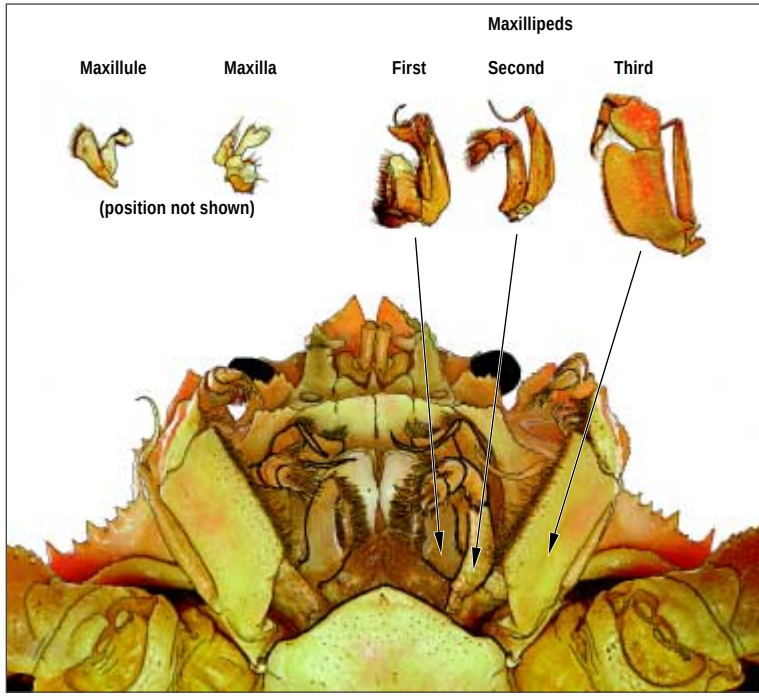
Gonopods

Pleopods

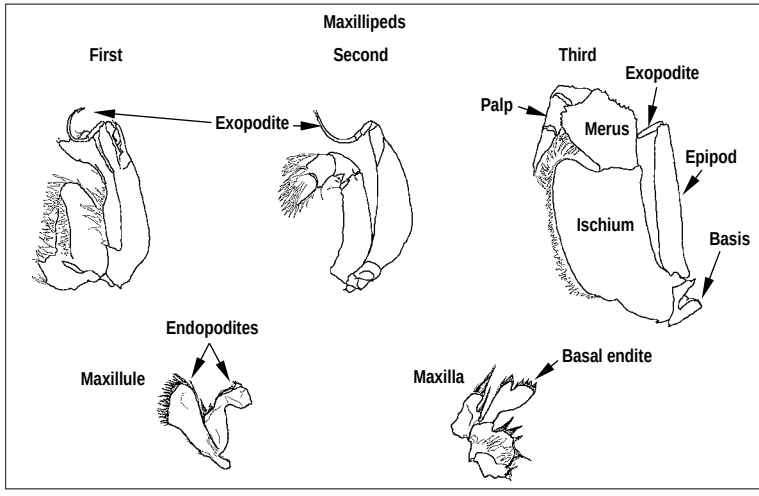


16d. Hermaphrodite

Figure 16. Ventral view of Chionoecetes *crabs with the abdominal flap open and reproductive appendages identified. (a. H. Pennington. b,d. L.S. Jadamec. c. E. Munk).*



17a



17b

Figure 17. Photograph and illustrations of the mouth parts of a Chionoecetes *crab: a. Photograph with the placement of the maxillipeds identified; maxillule and maxilla are located posterior and dorsal of the first maxilliped. b. Illustrations of the maxillipeds, maxillule, and maxilla with the major segments identified. (Photo H. Pennington, illustrations L.S. Jadamec)*

5. Internal Anatomy

Vas Deferens

The paired vas deferens are positioned in the dorsal cephalothorax below the level of the heart, and connect the testes (located to the anterior of the vas deferens and dorsally of the stomach) to the gonopods at the base of the 5th pereiopod. Vas deferens are filled with white, oval-shaped spermatophores. When mature, the vas deferens occupy much of the posterior quadrants of the body cavity, and spermatophores are apparent (Fig. 18a). In senescent males the vas deferens are much reduced in size (Fig. 18b).

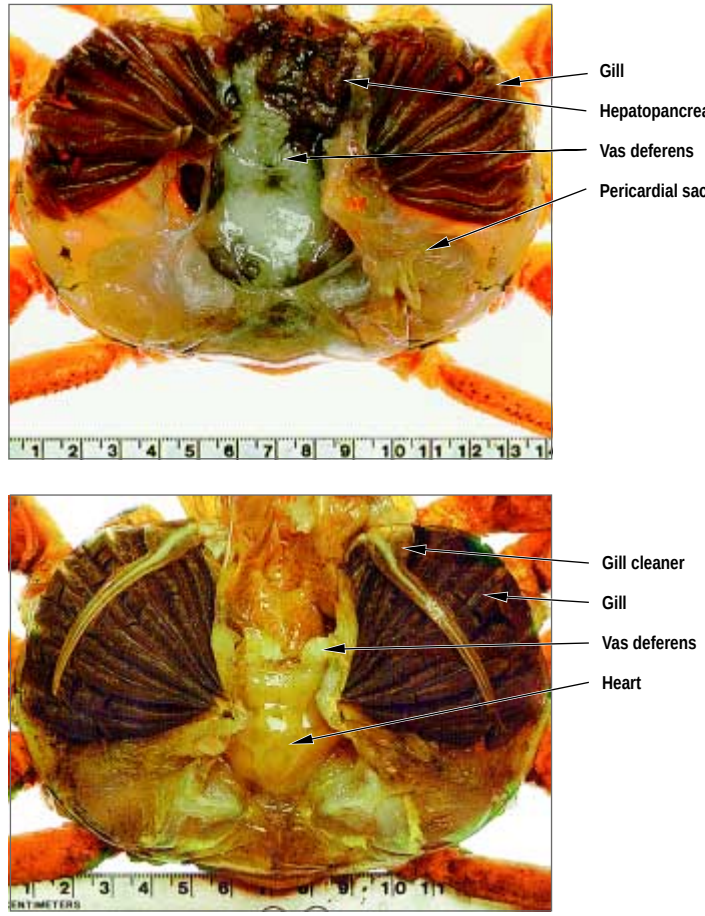
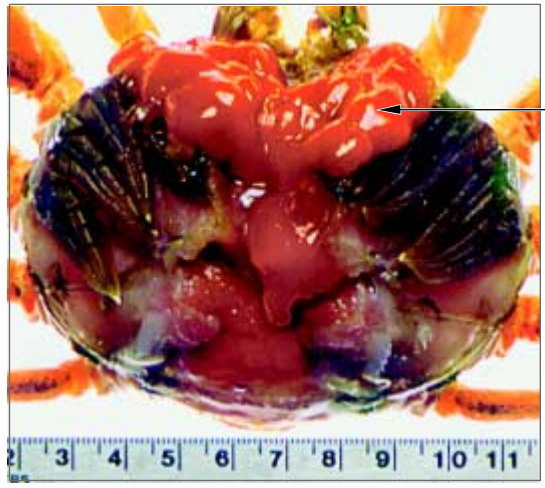


Figure 18. Dorsal view of adult male Chionoecetes *crab with the carapace removed: a. Full vas deferens typical of sexually mature males prior to mating. b. Atrophied vas deferens typical of senescent males. (H. Pennington)*

Ovary

Ovaries are positioned in the dorsal cephalothorax and are shaped as an elongated “H”. The right and left lobes are connected at the level of the heart. When mature, the posterior lobes extend into the abdomen and the anterior lobes extend to the level of the eyestalks. Paired white or translucent oviducts (tubes) leave the ovary at its ventral surface, pass ventrally through the cephalothorax, and lead to the gonopores (see Fig. 16b).

19a



19b

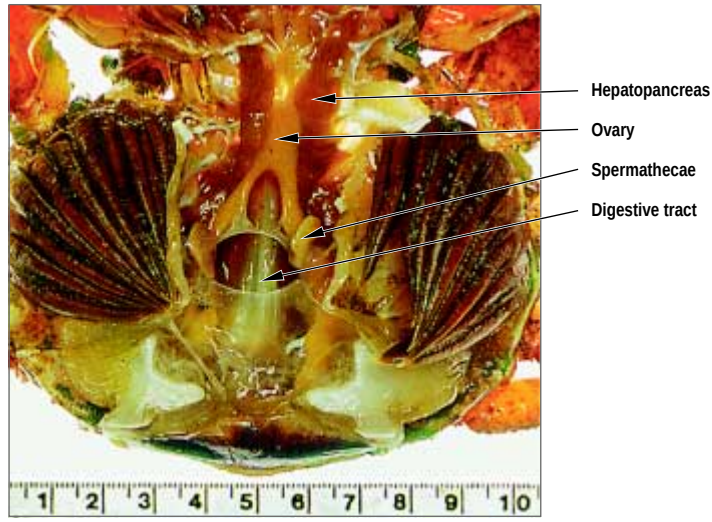


Figure 19. (This and facing page) Dorsal view of female Chionoecetes *crabs. a. An ovary after egg extrusion. b. A full ovary prior to egg extrusion. c. Very old-shell senescent crab. (a. E. Munk. b. D. Mercy. c. H. Pennington)*

Ovary Stages

In early development of a pubescent female's ovary and immediately after egg extrusion, the size of the ovary is much reduced relative to a fully developed, full ovary (Fig. 19a). The presence of developing oocytes imparts an orange color to the ovary. A fully developed ovary with oocytes can appear to occupy much of the body cavity (Fig. 19b) and is bright orange. Senescent female crabs are typically very old shell with atrophied ovaries (Fig. 19c).

Pubescent Ovary

Initially, the ovary is a white, thread-like structure that will increase in size as the ovary fills with white (undeveloped) oocytes. Once the ovary has become conspicuous, i.e., partially filled with oocytes, it will resemble an ovary (primiparous or multiparous) immediately after egg extrusion (see below).

Primiparous and Multiparous Ovary

Immediately after egg extrusion, the color and size of the ovary will range from white and much reduced (Fig. 19a) to dull orange and partially full depending on the quantity of oocytes remaining in the ovary. Prior to egg extrusion the ovary occupies much of the body cavity and has a bright orange color (Fig. 19b).

Senescent Ovary

This atrophied ovary is white-yellow or translucent and much reduced in size (Fig. 19c). It is no longer producing oocytes.

Spermathecae

Spermathecae are paired organs attached to the gonopore and oviduct. They are located medially on the right and left side under the ovary. In pubescent females the spermathecae are translucent and empty (not shown). In primiparous females the spermathecae are often partially full and white or translucent when empty (Fig. 20a,b). Primiparous female spermathecae are seldom full or turgid. Multiparous crab spermathecae are often full and turgid because sperm and ejaculate from successive matings may be present. They may also contain very little ejaculate if females have used stored sperm to fertilize clutches. Over time, multiparous crab spermathecae develop a dark band at the distal end (Fig. 20c,d). A senescent female's spermathecae appear empty without dark banding (Fig. 20e).

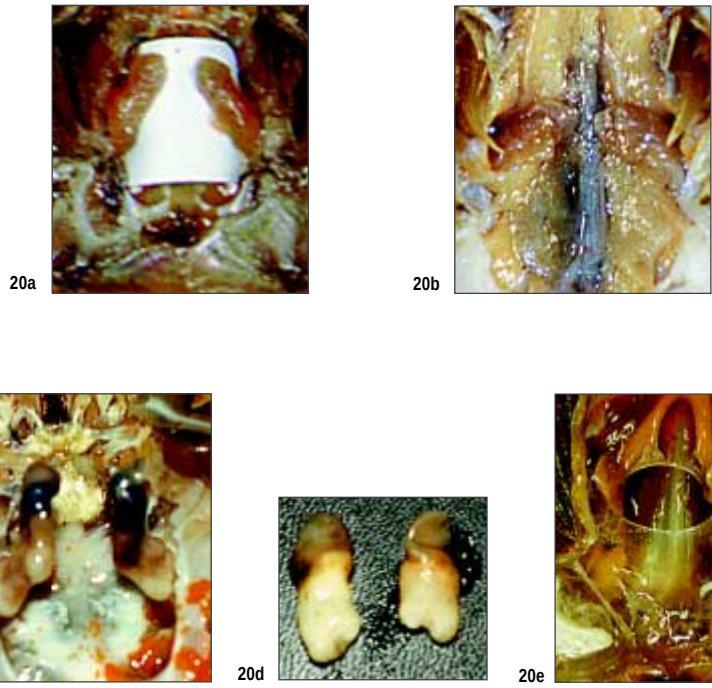


Figure 20. Spermathecae of female Chionoecetes *crab: a. Turgid spermathecae without dark banding. b. Partially full spermathecae without dark banding. c. Turgid spermathecae with dark banding. d. Removed spermathecae. e. Empty spermathecae without dark banding. (a. D. Mercy. b. L.S. Jadamec. c,d. W.E. Donaldson. e. H. Pennington)*

6. Morphometrics

A series of morphometric measurements in millimeters are routinely taken on *Chionoecetes* crabs. Measurements should be taken only on body parts that show no evidence of regeneration. To allow standardization of data collection, definitions are presented as referential standards in Figs. 21 through 26. Note: When using calipers, ensure that the measuring tips are ground down because they must fit between the lateral spines or between the rostral horns (personal communication, R.A. MacIntosh, NMFS).

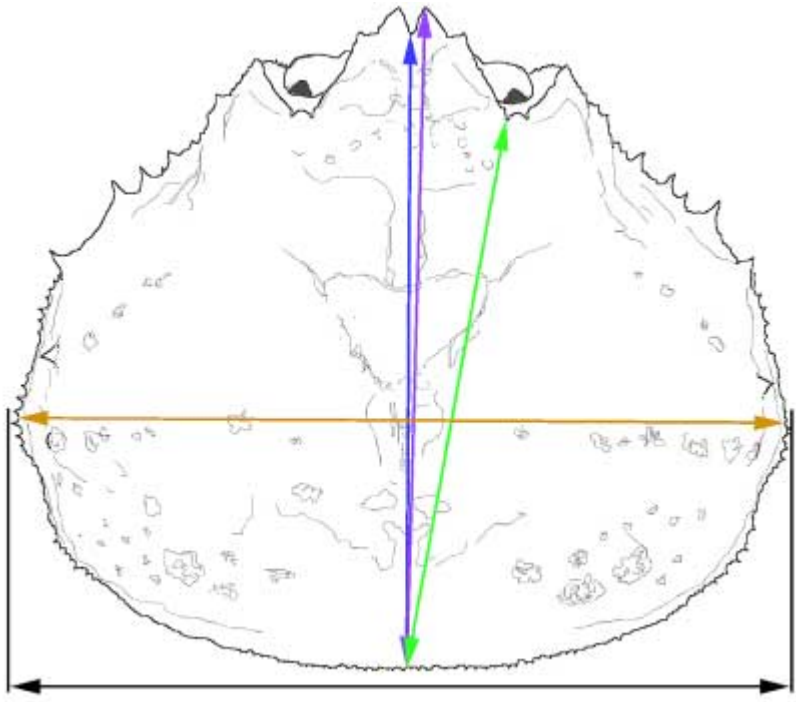


Figure 21. Dorsal view of a Chionoecetes *crab, showing the following measurements:*

Carapace width (legal): The greatest straight-line distance across the carapace at a right angle to a line midway between the eye to the midpoint of the posterior margin of the carapace, and shall include the spines.

Carapace width (biological): The greatest straight-line distance across the carapace of the lower lateral margin excluding spines. This measurement is made at a right angle to an imaginary line midway between the eyes to the midpoint of the posterior margin of the carapace.

Carapace length: From the notch between the rostral horns to the midpoint of the posterior margin of the carapace.

Carapace length (rostral horn): From the distal tip of the rostral horn to the midpoint of the posterior margin of the carapace.

Carapace length (eye orbit): From the rear of the eye orbit to the midpoint of the posterior margin of the carapace. (L.S. Jadamec)

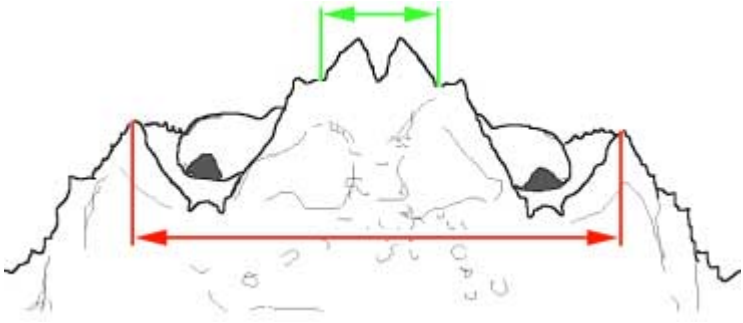


Figure 22. Dorsal view of the frontal region of a Chionoecetes *crab showing the following measurements:*

Rostral base width: Width between rostral horns measured at the rostrum base. (L.S. Jadamec)

Orbital spine width: Width between tips of orbital spines.

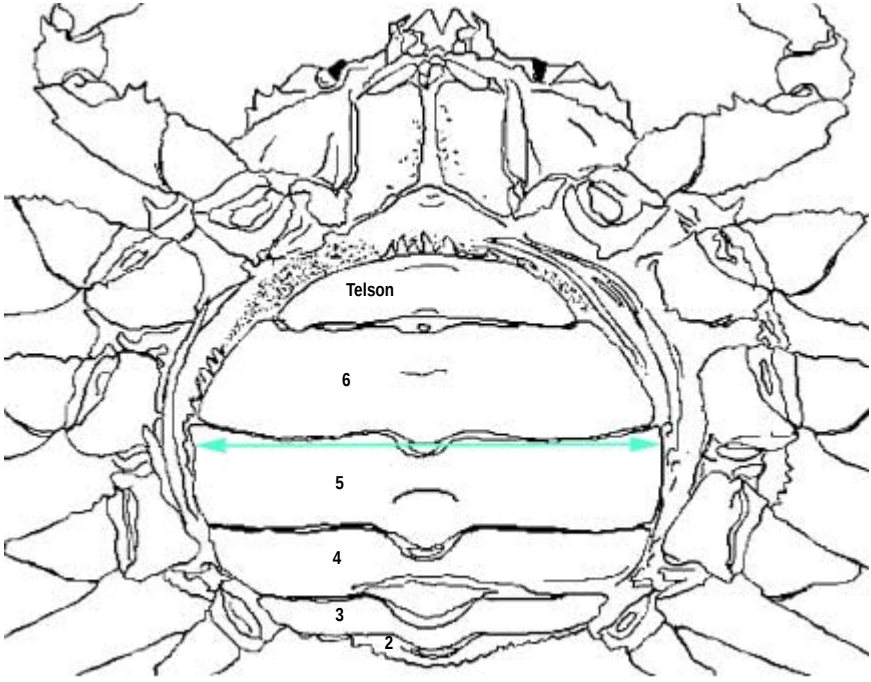


Figure 23. Ventral view of a female Chionoecetes *crab with the abdominal somites and telson identified showing abdomen width.*

Abdomen width: Greatest width across the fifth abdominal segment. (L.S. Jadamec)

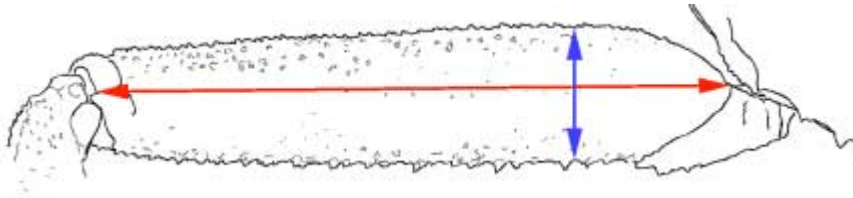


Figure 24. Lateral view of the right merus of a Chionoecetes *crab showing the following measurements:*

Merus length: Length of merus on first right walking leg.

Merus width: Greatest width of merus of first right walking leg excluding spines. (L.S. Jadamec)

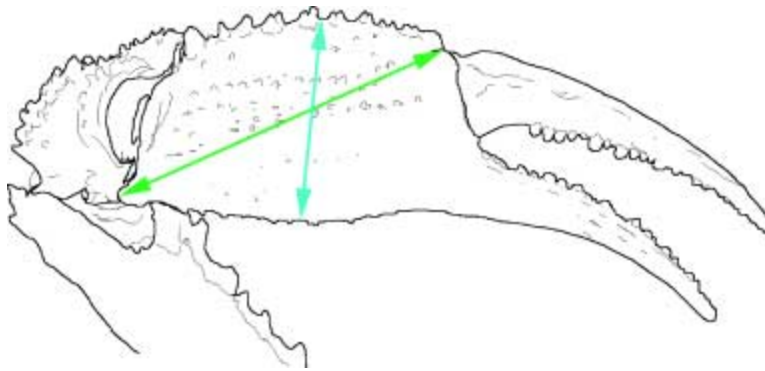


Figure 25. Lateral view of the right chela of a male Chionoecetes *crab showing the following measurements:*

Chela height: Greatest height measured on right chela excluding spines.

Chela length: Length measured diagonally on right chela. (L.S. Jadamec)

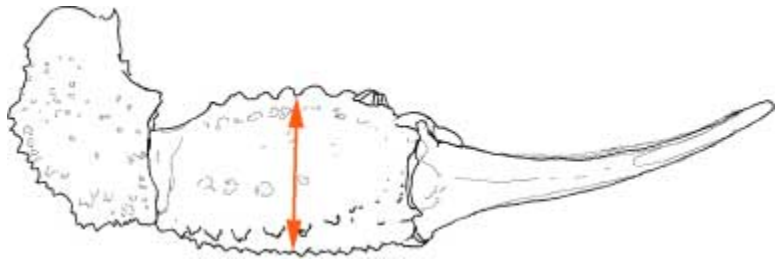


Figure 26. Dorsal view of the right chela of a male Chionoecetes *crab showing chela width.*

Chela width: Greatest width of right chela excluding spines. (L.S. Jadamec)

7. Egg Condition & Clutch Fullness

Egg condition and clutch fullness data collection parameters have been standardized for all *Chionoecetes* species. In practice, data collected varies with agency. For example, National Marine Fisheries Service (NMFS) researchers record egg color as a separate parameter, whereas Alaska Department of Fish and Game (ADF&G) observers record egg condition information which includes egg color ranges. This section describes the parameters of the databases.

Egg Condition

Developed eggs in the ovary are bright orange and remain so immediately after extrusion and attachment to the pleopods. Embryo development occurs in successive stages (see Hilsinger 1976), with the eyespots appearing at about the eighth month of development for multiparous crabs and at 11 months for primiparous crabs. Embryos begin to turn a darker orange progressing to a brown or purple color, as the dark eyespot and later the prezoeae become visible.

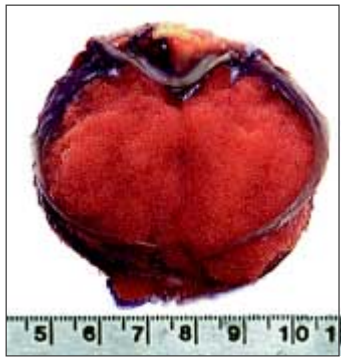
Embryo hatch occurs from April through June depending on location. Newly hatched larvae can be observed by placing a female with hatching embryos in a pail of seawater. Matted setae is the term used to describe the abdomen after egg hatch, containing dead eggs and empty egg cases. Matted setae are characterized by filamentous membranes and dead eggs which remain attached to the pleopods via the funiculi. Dead eggs in a clutch are opaque and lighter in color than the other eggs present. The color chart in Appendix 1 can be used to reference colors described here.

Egg Condition Categories (Fig. 27)

- No eggs present
- Orange, uneyed eggs present
- Dark orange or brown, eyed eggs present
- Hatching eggs
- Matted setae; dead eggs and empty egg cases

27a. No eggs

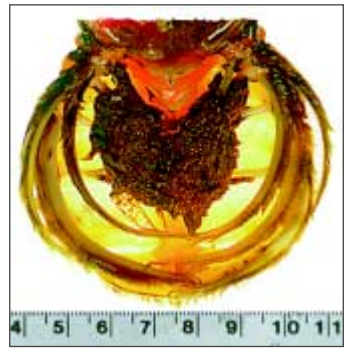
27b. Orange, uneyed eggs



27c. Dark orange, eyed eggs

27d. Brown, eyed eggs

27e. Hatching eggs



27f. Matted setae

Figure 27. Egg condition categories. (a,d,f. H. Pennington. b,e. L.S. Jadamec. c. D. Mercy).

Clutch Fullness

Clutch fullness is a subjective measurement used to indicate reproductive success (fecundity). The fullness of a clutch is described differently by different agencies. ADF&G observers record percentages to the nearest 20% (0, 20, 40, 60, 80, 100); ADF&G researchers record percentage ranges and pleopod condition (barren clean, barren matted, 0-29, 30-59, 60-89, 90-100)

NMFS researchers record a combination of fractions, ranges, and reproductive status (immature, mature with no eggs, trace to 1/8, 1/4, 1/2, 3/4, full)

Department of Fisheries and Oceans Canada (DFO) researchers (depending on region) record indices of fullness combined with egg condition, or take egg samples from primiparous and multiparous females and assess them quantitatively.

In this book, clutch fullness is described as fractions (0, trace, 1/4, 1/2, 3/4, full; Fig. 28). Egg and pleopod condition are described in the Egg Condition section. In addition, a full primiparous clutch is illustrated in Fig. 29.

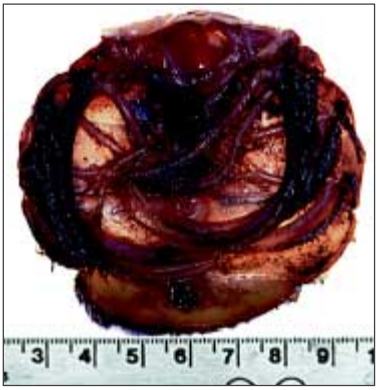
Clutch Fullness Categories (Fig. 28)

- No eggs
- Trace
- 1/4
- 1/2
- 3/4
- Full

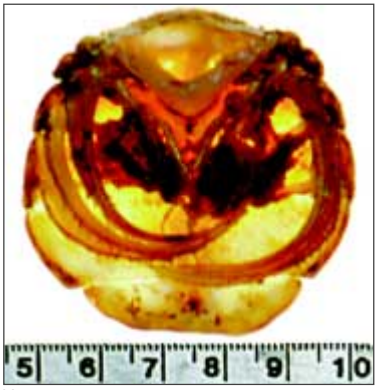
At a given carapace size, the mean fecundity of primiparous female Tanner crabs contain approximately 70% of the number of eggs of equal sized multiparous females (Somerton and Meyers 1983). Elner and Robichaud (1983), and Elner and Gass (1984) (in Elner and Beninger 1992) suggest that primiparous snow crab also have a reduced fecundity. Therefore, the full clutch of a primiparous female will appear 30% smaller than the full clutch of a similar size multiparous female. This is probably because the primiparous female has had to partition energy between somatic growth during the molt to maturity and egg production, or because of constraints of carapace size in pubescent females that have not yet molted to maturity (Somerton and Meyers 1983).

It is important to note that (with the exception of DFO Canada) no distinction is currently made between primiparous and multiparous females when sizing egg clutches in the field.

28a. No eggs



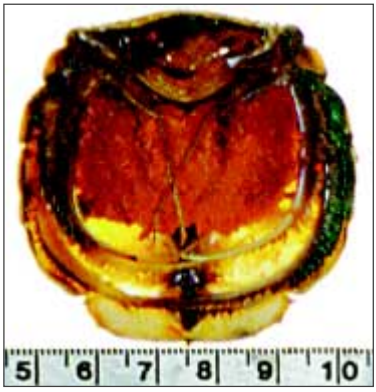
28b. No eggs



28c. Trace eggs

28d. Trace eggs

28e. 1/4 full

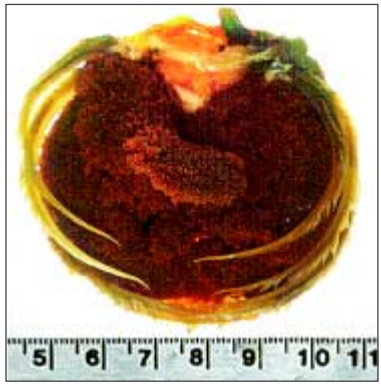


28f. 1/4 full

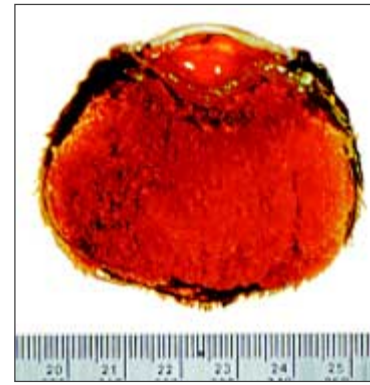
Figure 28. Clutch fullness categories commonly used in the field. a,b. No eggs present. c,d. Trace eggs present. e,f. 1/4 full. g,h. 1/2 full. i,j. 3/4 full. k. Primiparous (new-shell) female with a full clutch of eggs. l. Multiparous female with a full clutch of eggs. (a,b,d,e,i,k. H. Pennington. c,f,g,h,j,l. D. Mercy)

28g. 1/2 full

28h. 1/2 full



28i. 3/4 full



28j. 3/4 full

28k. Full (primiparous)

28l. Full (multiparous)

Figure 28. (Continued.)

8. Shell-Age Classification

Shell-age classification results in an approximation of time since the last molt. Consistent and accurate shell aging is difficult to achieve due to the subjectiveness of assessing crab shell conditions in situ. Molting history and habitat type cause crab shells to "age" at seemingly different rates. Also, there are natural differences between species of *Chionoecetes* over their geographic range. Before attempting to age shells, it would be helpful to review the available literature on molt season for the species and geographic area in question.

Shell aging of grooved Tanner, triangle Tanner, and Beni-zuwai crabs is difficult due to the lack of information available on their molting cycles, and therefore should be based on shell wear patterns. Hands-on experience while using the aging techniques will lead to more consistent and accurate shell aging. These categories and characteristics should be updated as more studies are conducted on the lesser-known species.

Shell-age classification and coding varies with agency. Table 1 shows shell-age classification presented in this book, and the classifications currently used by four agencies.

Table 1. Shell-age categories and codes presented in this book and currently used by NMFS; ADF&G research staff, survey staff, and shellfish observers; and DFO Canada.

This book	Premolt and molting	Soft-shell	Recently molted	New-shell	Old-shell	Very old-shell	Graveyard
NMFS	0	1	2[a]	2	3	4	5
ADF&G survey	Premolt 1-2[a]	0	1[a]	1	2	3	3[a]
	Molting 0						
ADF&G observers	Premolt 1-2[a]	0	9	1	2	3	3[a]
	Molting 0						
DFO Canada	Premolt 1-2[a]	9	1	2	6	3	4
	Molting 9						

[a] This category is not used by the agency. For example, ADF&G observers do not have a code for graveyard crabs; they code all graveyard crabs as 3 (very old-shell).

Premolt and Molting: Shells 6 Weeks Prior to Ecdysis up to and Including Ecdysis

Premolt crabs are preparing to molt and can be detected up to approximately 6 weeks before ecdysis as shown in studies using setal changes of the tips of the maxilliped exopodites (O'Halloran and O'Dor 1988), (see mouthparts, page 23).

The shell begins to decalcify 3 to 6 weeks prior to ecdysis. Decalcification of the shell will cause it to soften. The shell will change from very hard to soft; specifically the first abdominal somite and cheliped merus will change from very hard to soft, and the ecdysial suture will change from firmly closed to easily opened. The dactyl tip, when broken, will separate cleanly from the soft integument of the developing shell (Fig. 29).

In the process of molting, the carapace will be elevated at the ecdysial suture forming an opening, and the cephalothorax will be swollen and protruding from the ecdysial suture (Fig. 30). Note that a molting crab can be molting from an old or new shell.

Hoenig et al. (1994) showed that coloration of new-shell snow crabs was a useful indicator of molting. Based on studies of setal changes of the mouth parts, green carapace coloration indicated molting within 6 weeks (Fig. 31).

Figure 29. Dactyl tip removed from a new-shell Tanner crab. As a crab approaches a molt the soft integument will separate cleanly from the hard exoskeleton. (H. Pennington)

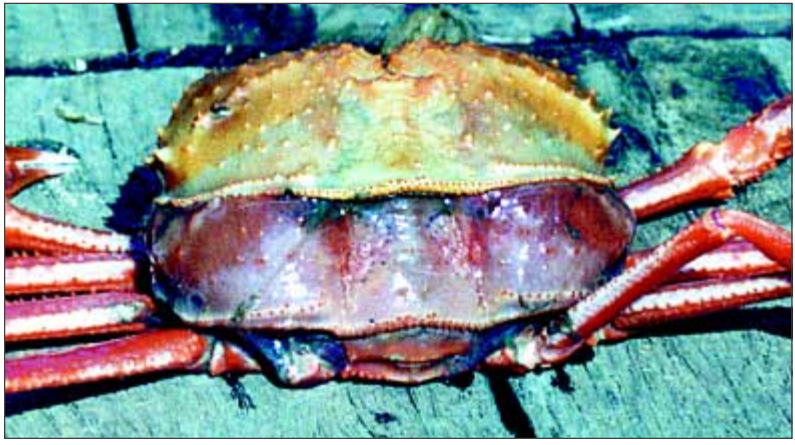


Figure 30. Posterior view of a molting grooved Tanner crab. (L.S. Jadamec)

Figure 31. Dorsal view of green snow crab (top) and red snow crab (bottom). (D. Taylor)

Soft-Shell: Shells 0 to 2 Weeks Post Ecdysis

Crabs of this shell age have just molted within the previous 2 week period. Shells are very soft and flaccid, and will lose their shape when out of water. The exoskeleton is similar in texture to wet leather or skin (Fig. 32). Handling will cause the shell to lose shape, making accurate morphometric measurements difficult. The duration of this shell condition is short. The exoskeleton begins to harden within 72 hours, allowing mobility, and is sufficiently hard within 2 weeks to be considered a recently molted animal. Soft-shell crabs are rarely encountered in pots because a true soft-shell crab cannot climb into a crab pot. When encountered in a pot, the shed carapace is frequently present.

Figure 32. Dorsal view of a soft-shell Tanner crab. (H. Pennington)

Recently Molted: Shells 2 to 8 Weeks Post Ecdysis

Recently molted crabs are in the process of fully calcifying (hardening) their exoskeleton, and crabs are fully mobile. They are brightly colored dorsally with large iridescent areas; the ventral surface is translucent. The exoskeleton is clean with no epibionts and typically no scratches or abrasions (Fig. 33). The dactyls and spines are sharp with no wear present. Recently molted crabs have a flexible exoskeleton that can be described as firm yet flexible. If the propodus of the chela can be easily indented with thumb pressure, or the merus of the second pereiopod bent without breaking and the crab meets the criteria above, then it is recently molted. Code 1 of DFO Canada includes crabs with firm inflexible claws that will break easily under thumb pressure. This condition can last for three months post ecdysis.

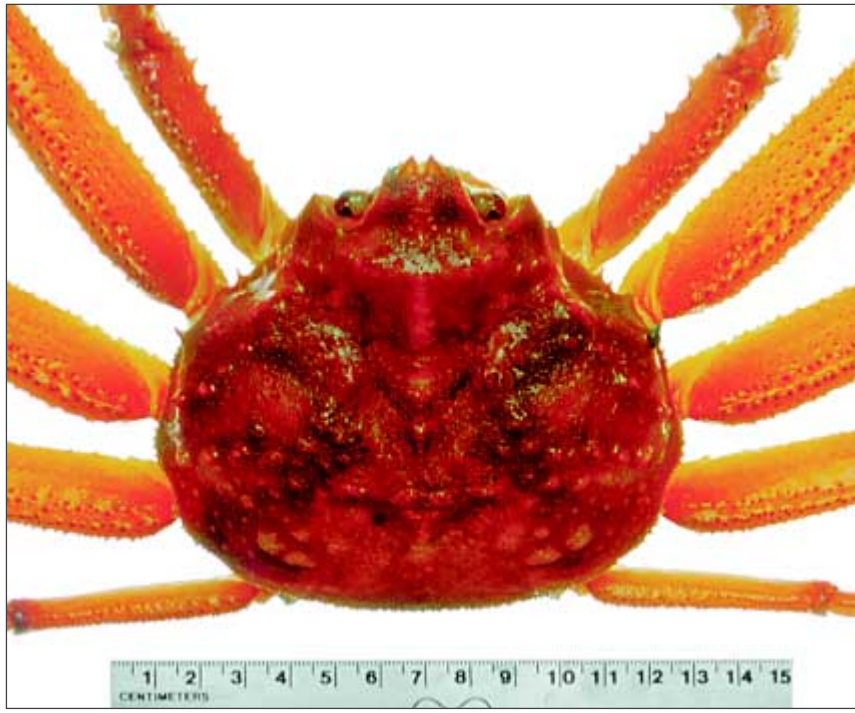


Figure 33. Dorsal view of a recently molted Tanner crab. (H. Pennington)

New-Shell: Shells 2-12 Months Post Ecdysis

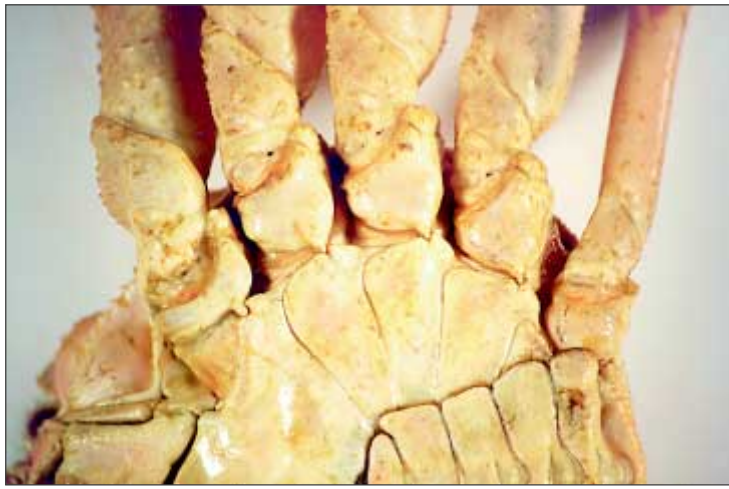
Carapace and chela are hard and cannot be indented by thumb pressure. Exoskeletal spines and dactyls are sharp but may show slight wear. Dorsally, the shell is brightly colored and iridescent. The crab usually appears clean with few barnacles or other epibionts (Fig. 34); leech cocoons often present. The ventral surface is not translucent, and will range from no discoloration to slight discoloration, with no scratching to limited scratching (Fig. 35). The meat content of the shell is low to maximum depending on the time since ecdysis. Adult females rarely have grasping marks on the meri.

Figure 34. Dorsal and ventral view of a new-shell female Tanner crab. (D. Mercy)

35a. New-shell dactyls (Fig 35e)

35b. "Late" new-shell dactyls (Fig. 35d)

35c Very old-shell dactyls (Fig. 38)



35d. "Late" new-shell snow crab

35e. New-shell snow crab

Figure 35. a-c. Dactyls from male crabs. d-e. Ventral view of a new-shell male snow crab. (L.S. Jadamec)

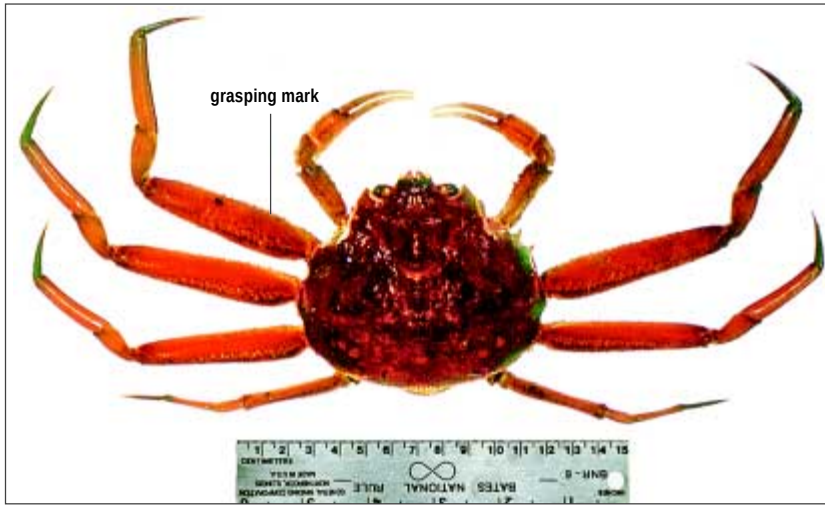
Old-Shell: Shells 13-24 Months Post Ecdysis

Old-shell crabs (or skip molts) are characterized as having a darker coloration, significant scratching, wear, and abrasions (Fig. 36). Carapace and chela are hard and cannot be indented by thumb pressure. Dactyls are worn and typically dull at the tips. Spines show wear with rounded or worn tips. Barnacles and other epibionts are usually present. The types and severity of epibiotic encrustation varies with geographic area and depth.

The dorsal surface is discolored, i.e., is fading and no longer bright. The ventral surface is discolored by wear and typically appears yellowish-brown to dark brown in shallow water species. The ventral surface of deep water species appears discolored by significant wear; for grooved Tanner crabs the ventral surface coloration is dull orange, and for triangle Tanner crabs the ventral coloration is dull pink.

The meat content is at maximum. Adult females that have been mated a second time usually show grasping marks on the meri (Fig. 37). Adult females that have not been mated a second time will not show grasping marks.

Figure 36. Ventral view of an old-shell male Tanner crab. (D. Mercy)



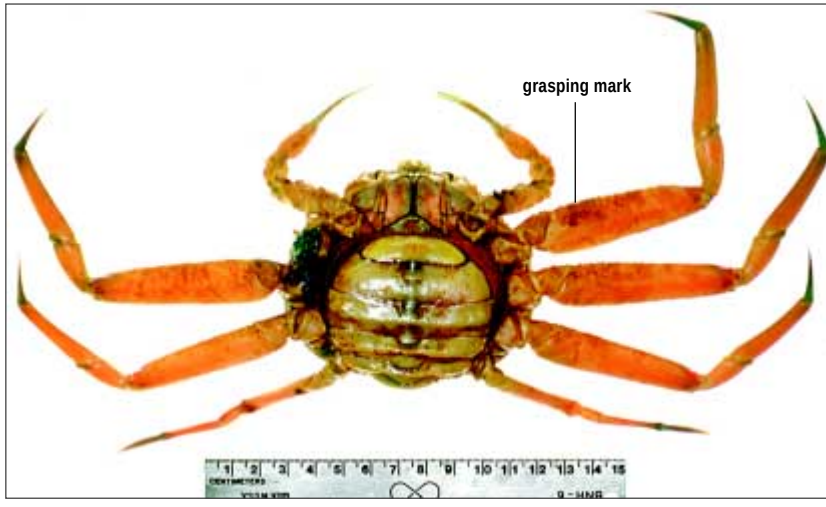


Figure 37. Dorsal and ventral view of an old-shell female Tanner crab. (D. Mercy)

Very Old-Shell: Shells 24-36 Months Post Ecdysis

The difference between old- and very old-shell crab is a function of the extent of wear and epibiotic fouling. The carapace is hard. Epibionts, including barnacles, are always present (Fig. 38). Dorsal and ventral surfaces are discolored as follows: in shallow water species, yellow-brown dorsally and dark brown with black areas ventrally; in deepwater species, dull orange dorsally and discolored by multiple scratches and abrasions ventrally.

For grooved Tanner crabs, the ventral coloration is dark orange (Fig. 39); in triangle Tanner crabs the ventral coloration is dark pink. Spines dorsally and ventrally are heavily worn; dactyls are heavily worn. The meat content is maximum to medium. Adult females have abdomens that appear heavily worn and abraded. Female crabs that have been mated more that two times frequently have multiple grasping marks on the merus (Fig. 40).

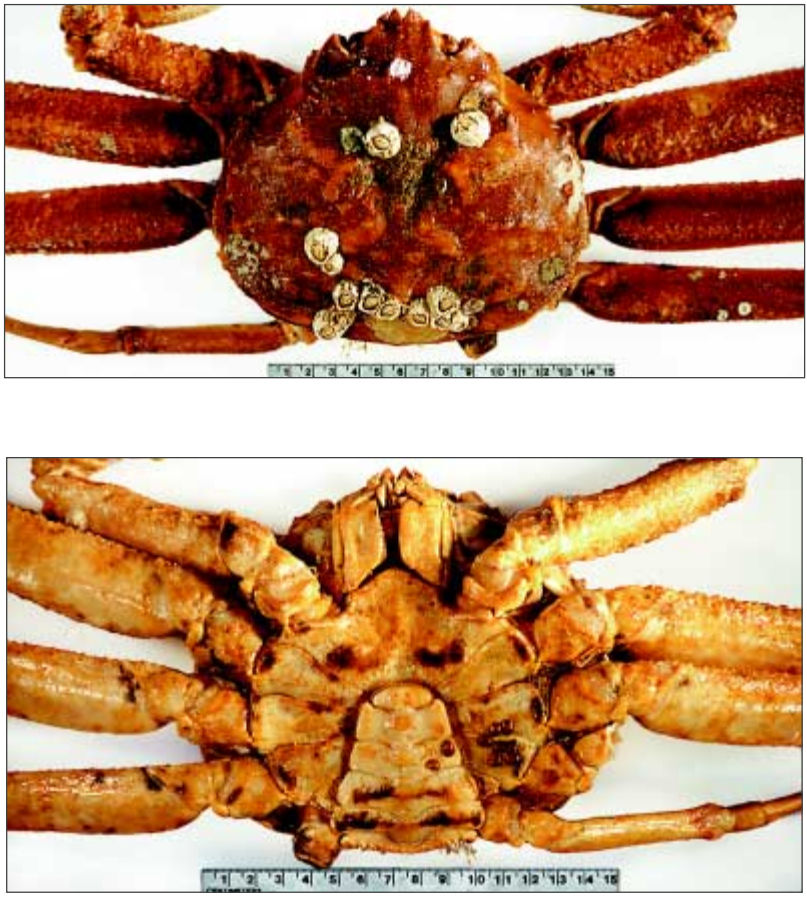


Figure 38. Dorsal and ventral view of a very old-shell male Tanner crab. (L.S. Jadamec)

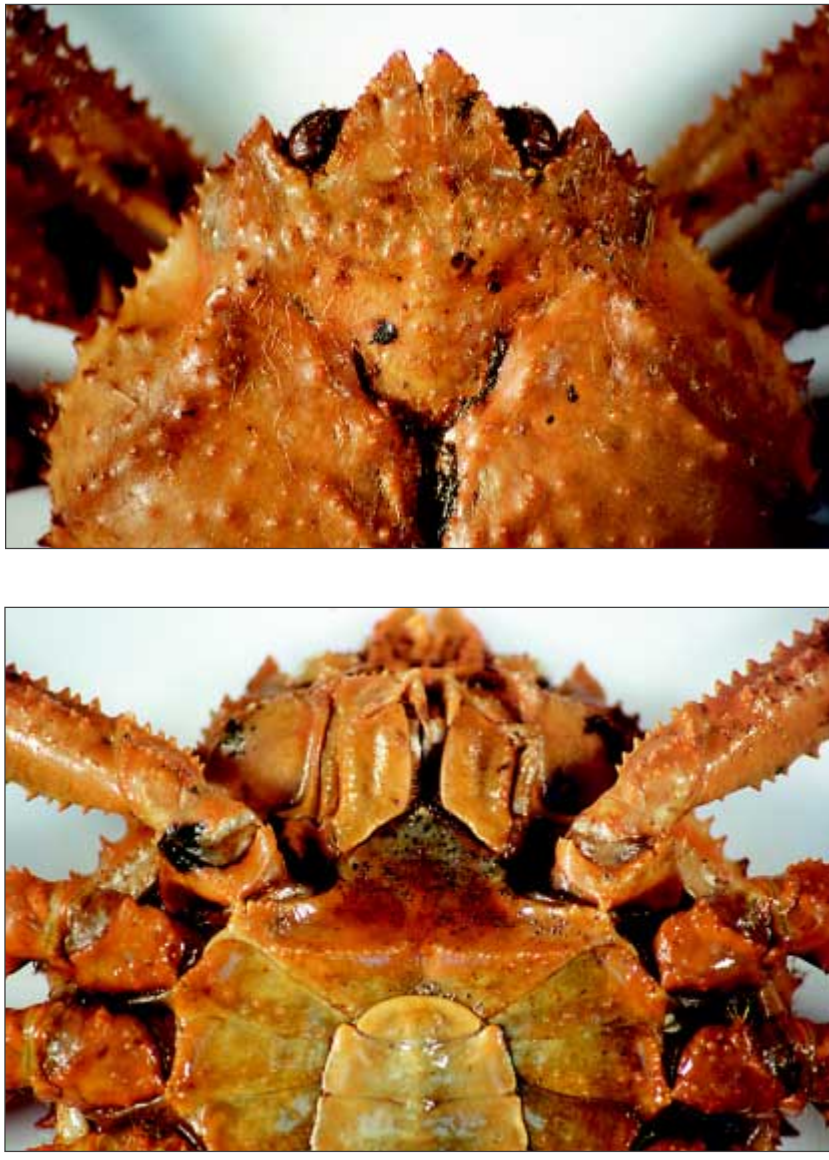


Figure 39. Dorsal and ventral view of a very old-shell male grooved Tanner crab. (L.S. Jadamec)

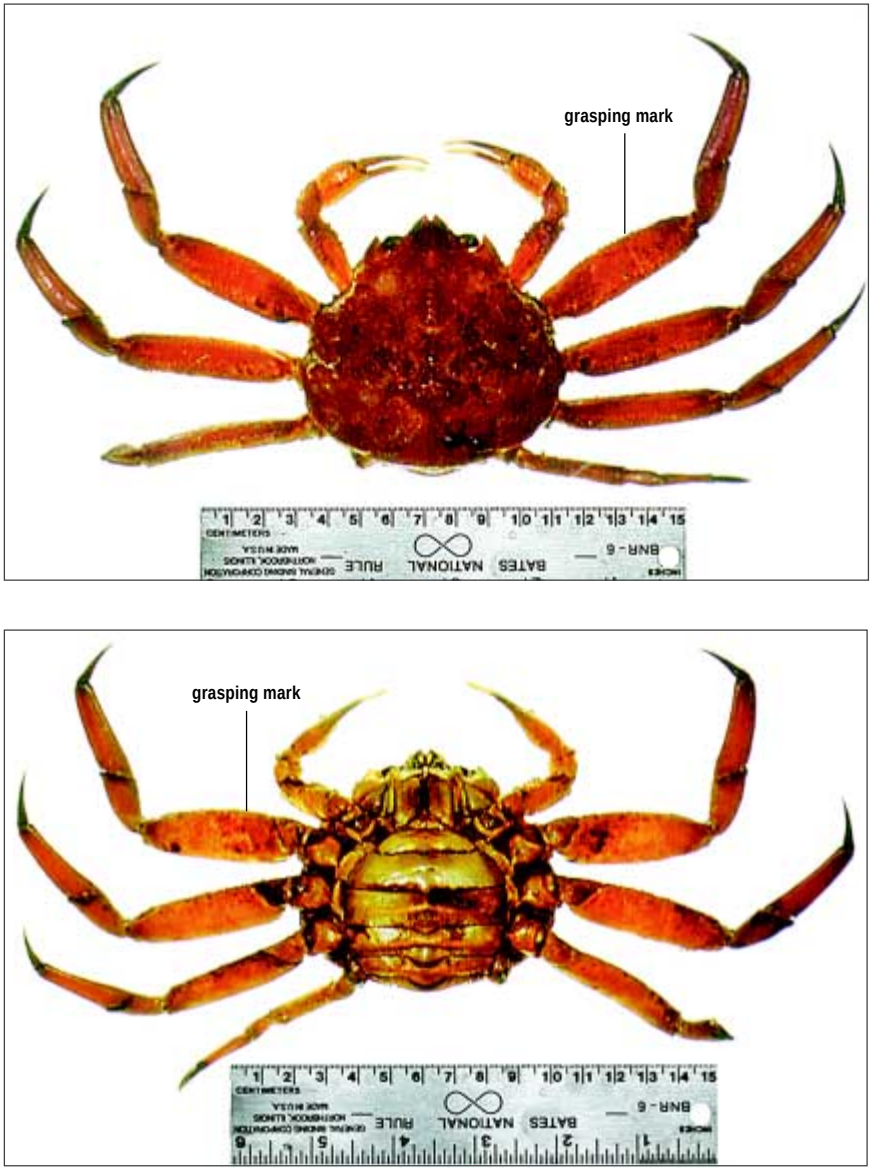


Figure 40. Dorsal and ventral view of a very old-shell female Tanner crab. (D. Mercy)

Graveyard: Shells More Than 36 Months Post Ecdysis

Graveyard crabs are characterized by shells that have become soft and spongy because of decay. Decay is noted at the joints. Spines and dactyls are heavily worn and often worn through. Epibionts are always present, typically with a heavy covering of barnacles, bryozoans, worm casings, and hydroids. The shell appears brown to black dorsally and ventrally because of wear and decay (Fig. 41). The meat content is medium to minimum. Female crabs that have been mated more than two times frequently have multiple grasping marks on the merus. Graveyard crabs are usually listless upon capture.

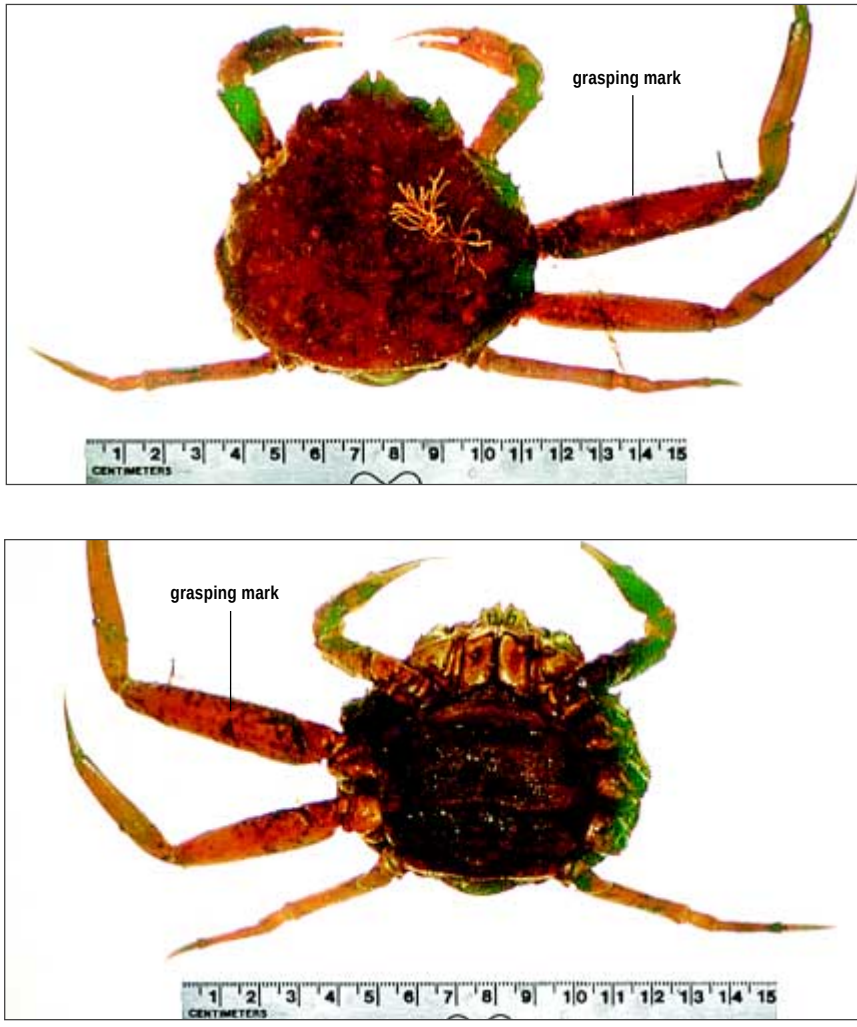


Figure 41. Dorsal and ventral view of a graveyard female Tanner crab. (D. Mercy)

Table 2. Shell-age categories and characteristics for *Chionoecetes.*

Shell condition	Carapace-claw rigidity	Spine and dactyl wear	Epibionts	Scratches and abrasions	Shell iridescence	Color	Meat content	Grasping marks on females
Premolt and molting	Flexible to soft	Varies, see new- or old-shell	Varies, see new- or old-shell	Varies, see new- or old-shell	Varies, see new- or old-shell	May fade with decalcification	Minimum	None
Soft-shell	Soft, flaccid	None	None	None	None	Bright	Minimum	None
Recently molted	Firm but flexible	None	None	None	Large areas	Bright dorsally and ventrally	Low	None
New-shell	Hard and rigid	Slight to moderate; spines sharp	Limited, small barnacles, few leech cocoons	Limited on ventral surface	Large to small areas	Bright dorsally and ventrally to limited discolored	Low to maximum	Rarely
Old-shell	Hard and rigid	Significant wear, spines and dactyls dull	Almost always present; barnacles and other epibionts	Multiple on ventral surface and sometimes dorsal	Small areas to none	Dorsal surface is fading, not bright; ventral surface is discolored	Maximum	Sometimes
Very old-shell	Hard to firm but flexible	Significant to heavy wear on spines and dactyls	Always present; barnacles, many leech cocoons, and other epibionts	Heavy	None	Dorsal surface is discolored and dark; ventral surface is brown with black mottling	Maximum to medium	Sometimes multiple
Graveyard	Spongy and flexible	Heavy wear on spines and dactyls	Always present; barnacles, many leech cocoons, and other epibionts	Heavy	None	Dorsal and ventral surface dark brown to black	Medium to minimum	Sometimes multiple

9. Diseases & Epibionts

Diseases

The diseases and parasites of *Chionoecetes* crabs are poorly understood. Three conditions that are routinely sampled for in Alaska waters are bitter crab (also sampled for in the North Atlantic Ocean), black mat, and "torch."

The exoskeleton condition commonly referred to as "pepper crab" is reported from the deepwater fisheries for *Chionoecetes.* The etiology of this condition has not been determined, but it is reported to be similar in appearance to a black mat infection but dispersed in discrete grains as opposed to the nondiscrete blotches of true black mat.

Bitter Crab

Bitter crab is lethal to the infected crab and is caused by a non-motile single celled protistan blood parasite *Hematodinium* sp. Crabs with the advanced vegetative stage of this disease can be recognized by the exaggerated ivory coloration to the shell. Upon dissection, infected crabs have milky-appearing tissues and hemolymph (Fig. 42). Cooked crabmeat with this disease is chalky with a bitter aspirin-like aftertaste. Recognition of early vegetative stages requires that crab hemolymph smears be examined microscopically.

Black Mat

Black mat is a systemic fungal infection caused by *Trichomaris invadens.* This fungus is grossly recognized by the black, tar-like appearance of the spore-producing bodies on the shell of an infected crab (Fig. 43). The fungus is lethal to the crab.

"Torch"

Baross et al. (1978) described shell disease for grooved Tanner crab off the coast of Oregon caused by bacteria (*Photobacterium* sp.) resulting in exoskeletal lesions. A similar shell disease has been reported for the deepwater *Chionoecetes* in Alaska; however, whether the affliction in Alaska crabs is the same reported by Baross et al. has not been verified.

Exoskeleton lesions are frequently observed on deepwater *Chionoecetes* resulting from the invasion of chitin-digesting bacteria. The disease according to Baross et al. (1978) is characterized by progressive softening and pitting of the chitinous exoskeleton accompanied by blackening of the necrotic region (Fig. 44).

Epibionts

Dick et al. 1998, identified 39 taxa of organisms on the shell and in the branchial cavity of male Tanner crab. Crab shell age was found to be a significant factor in determining the number of species of epibionts on crabs. The number of epibionts increased with an increasing shell age. Figure 45 shows some of the more common epibionts of Tanner crab.

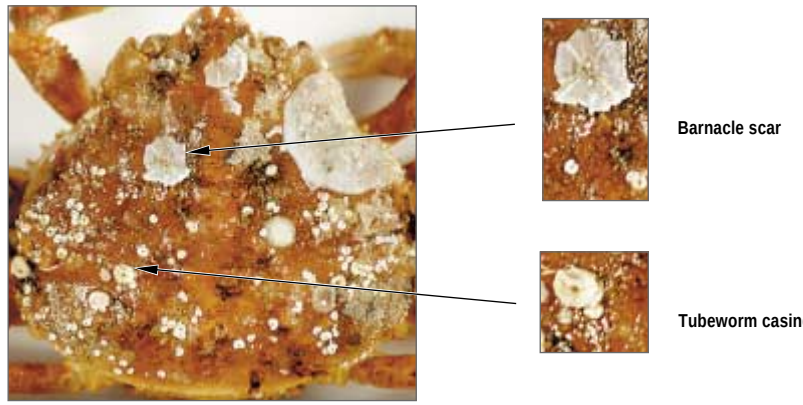
42a

42b

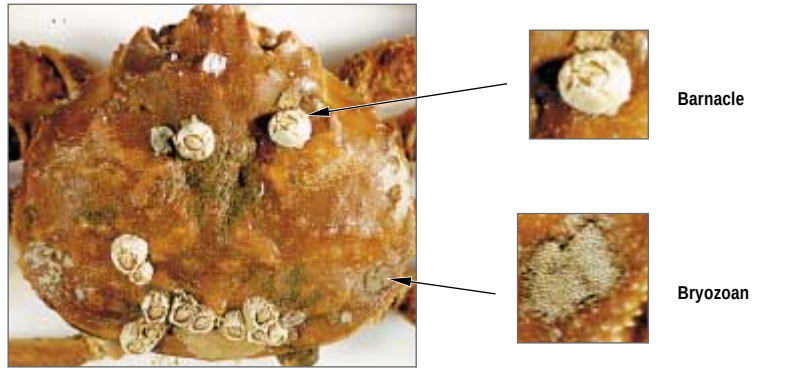
Figure 42. Symptoms of advanced bitter crab infection in Tanner crab: a. Ventral view of (above) healthy Tanner crab, and (below) external symptoms, i.e. opaque ivory coloration of the pereiopods. b. Dorsal view of (above) internal symptoms, i.e., milky coloration of hemolymph, and (below) healthy Tanner crab. (W.E. Donaldson)

Figure 43. Dorsal view of a Tanner crab with heavy encrustation of black mat on the carapace and light covering of black mat on the proximal segments of the 4th and 5th pereiopods. (H. Pennington)

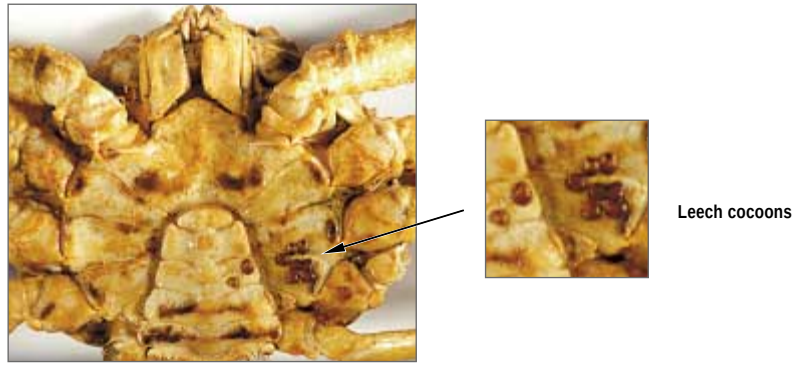
Figure 44. Ventral view of a grooved Tanner crab with black (and softened) discolorations that match the description of exoskeletal lesions caused by chitinoclastic bacteria. This condition is sometimes referred to as "torch" because the shell appears to have been burned by a welder's torch. (L.S. Jadamec)



45a. Calcareous epibionts; barnacle scar and tubeworm casing



45b. Calcareous epibionts; barnacle and bryozoan



45c. Leech cocoons

Figure 45. Epibionts commonly encountered on Chionoecetes. *(L.S. Jadamec)*

10. How to Collect Specimens

Field biologists are often called upon to collect specimens of and from *Chionoecetes* crabs. Among the specimens collected are whole live crab, whole frozen crab, dried carapaces (dorsal covering of cephalothorax), tissues for genetic study, and hemolymph for bitter crab detection.

All specimens collected are documented with information on location of capture (latitude, longitude, depth, date, and collector), species, sex, shell age, carapace width (biological), specimen (tissue) type, and other information as requested by the head investigator.

The methods presented here are the standard collection methods used at the time of this publication.

Whole Live Crab

- For best results, collect the specimens directly from point of capture and handle them with care. Avoid injured or damaged specimens.
- Record the necessary biological information from the specimen.
- Place the specimen in a burlap bag with an information label written in pencil on waterproof paper.
- Seal the bag with a zip tie and carefully sink the bag in the live tank of the vessel.
- Transporting or shipping live crab: live crab specimens can be maintained for approximately four days out of the water by these procedures.
- Handle specimens with care.
- Place crab upside down in an insulated or noninsulated, ventilated container.
- Line the container with wet burlap or other similar seawater-soaked material. Cover crabs with similar material. If the specimens are in burlap bags, do not rebag them.
- When transporting or storing live crabs in noncirculated seawater, be aware that the smaller the volume of water, the faster the depletion of dissolved oxygen.
- To keep the specimens cool, place ice packs or sea ice under the crab or store the box in a refrigerated area. Do not freeze the crab. The use of seaweed is not recommended for storage or transportation for more than 24 hours; it will biodegrade and generate heat in the process.
- Return crabs to chilled re-circulated seawater as soon as possible. When returning the crab to water, the air under the carapace should be evacuated by holding the crab upside down, under water until the air bubbles cease. Then turn the crab right side up and allow it to sink to the bottom of the tank.

Whole Frozen Crab

- For best results, collect specimens directly from point of capture, and handle with care. Injured or damaged crab may be acceptable; refer to instructions from the head investigator.
- Fold pereiopods at the distal merus joint and secure pereiopods together by wrapping the crab in pallet wrap or plastic wrap. Include shed legs with the specimen. A label stating capture location should accompany the specimen and be wrapped between layers of pallet wrap or plastic wrap, not directly against the specimen.
- Quick-freeze the specimen in vitro with a blast or brine freezer. If only standard freezer equipment is available, place wrapped or banded crab in the freezer in the open, and store in the freezer in a box once it is frozen.
- Do not allow the specimens to thaw, and avoid direct handling of the frozen specimens. Frozen specimens should be regarded as very fragile.

Carapace Dried

"Late" new-shell, premolt and molting shell-age crabs are recommended for this type of collection because the carapace has begun to naturally separate from the epithelium and will require little or no cleaning (see Fig. 31). Conversely, recently molted and early new-shell crabs are the most labor intensive to collect. Old-shell crabs have variable shell characteristics because of the unknown molting cycle. To estimate the ease with which a carapace may be collected, lift the posterior margin of the carapace at the ecdysial suture. If the carapace is firmly attached and cannot be raised, assume that the carapace is firmly attached to the epithelium and will require extensive cleaning.

- For best results, collect crabs directly from the point of capture, and make sure specimens have no carapace damage.
- Collect carapace specimens from live crabs only.
- Clean mud and detritus from the carapace surface. It is not necessary to remove epibionts; they fall off on their own when the carapace has dried. Insert a knife at the ecdysial suture and bisect the connective tissue located to the left and right of the cardiac region.
- Raise the carapace at the ecdysial suture 15° to 20°. Twist the carapace left and then right to break the shell connections in the frontal region. You should be able to feel them pop or snap.
- Once it is free, lift the carapace all the way off, twisting it free of the frontal connective tissues. Be careful not to fracture the epistomal margin.
- Break the teeth free by over-extending them in the open position; use a rotating motion in their natural direction of movement and then force them past their normal stopping point.

- Scrape the connective tissue from the perimeter of the cardiac and frontal regions where it is found in discrete patches firmly stuck to the shell.
- Flush the carapace with seawater. Scraping with the flat end of angled forceps will free most of the epithelium from the shell.
- Finish cleaning the epithelium from the shell with a toothbrush. For best results use a hard bristle toothbrush. Recommended modifications to the brush include heating the brush shaft near the head and bending it back slightly (10°); removing every other bristle cluster with a pair of needle nose pliers. Be sure to clean the margin of the shell and the frontal region. Properly cleaned shells are free of odor when dried and do not have dried blackened tissue remaining.
- Rinse the carapace with fresh water or seawater to remove residual hemolymph.
- Dry carapaces in a warm dry room (i.e., engine room if available) in a box or other open container, and protect them from damage. Dried carapaces are fragile and should be handled with care.

Tissue Collections for Genetic Study

There are two methods for collection of tissues from crabs for electrophoretic studies. Each involves a different storage medium and different tissue collections. Liquid nitrogen is used to store the heart, hepatopancreas, and muscle tissue. Ethanol storage involves the collection of entire egg clutches, pereiopods, and spermathecae.

Liquid Nitrogen Tissue Collections

- The head investigator will provide instructions for recording, storage, and safety, along with all storage materials and other supplies.
- Tissues are to be dissected in vitro, kept cool, and stored in liquid nitrogen promptly. Therefore, preparations should be made to facilitate collection of tissues, including the necessary clean work space, the space for temporarily storing cryovials on ice, and the appropriate number of crab specimens queued up. Collect all necessary information from the set of crab specimens and label the vials before dissection.
- Remove the carapace by either bisecting the connective tissue with a clean knife as described above for carapace collection, or by prying open the frontal portion of the carapace at the epistomal margin with your thumb. If the carapace is also to be collected, care must be used not to damage the epistomal margin. It should be noted that carapace cleaning should begin within 20 minutes of the crab's expiration to prevent shell discoloration. Tissue collections for genetic study require immediate attention, so store carapaces in seawater once they are removed until they can be properly cleaned. They may be identified for labeling later based on their morphometric measurements.

- Remove the heart with forceps and a scalpel. Be careful not to contaminate the heart with hepatopancreas fluid. Set the heart aside or place it directly into the appropriate vial. If necessary, cut the heart into pieces that will fit into the vial. The vial should be no more than 3/4 full.
- Remove a portion of the hepatopancreas, enough to fill the cryovial 3/4 full. Be careful not to contaminate the hepatopancreas with the digestive tract, reproductive organs, or other organs.
- Remove muscle tissue from the merus segment of the largest pereiopod present. There are several options for gaining access to the muscle tissue. One option is to break the merus just proximal to its distal end, then pull the muscle tissue out of the segment. To get enough tissue to fill the cryovial 3/4 full, it may be necessary to remove the muscle tissue from more than one pereiopod or segment. Be careful not to contaminate the muscle tissue with epithelium, tendons, or fluids from the body cavity.
- Once all tissues have been stored in the appropriate vials and set on ice, clean the work area, and dissect the next specimen.

Ethanol Tissue Collections

- The head investigator will supply instructions for data, storage, and safety, along with all the necessary supplies.
- Tissues are to be collected in vitro and placed in ethanol directly. Specimens are stored in 100% ethanol at a ratio of 1:4, i.e., 1 g of specimen to 4 ml of ethanol. After 24 hours, the ethanol is replaced with fresh ethanol at the same ratio.
- Record information from the specimen and prepare a collection station.
- Remove the second pereiopod at the autotomy plane. To remove the pereiopod, either suspend the specimen by the pereiopod until autotomy takes place, or induce autotomy by applying pressure with a stout pointed object at the aperture on the ventral surface of the autotomy plane.
- If the specimen is female, remove the spermathecae. To remove the spermathecae, hold the crab at an angle and pick away the internal organs from the anterior portion of the body cavity to free them. Then flush the body cavity with water. The spermathecae will remain; they are located to the left and right of the center of the abdominal cavity (see Spermathecae, page 28).
- Grasp the base of the spermathecae with forceps and bisect them between the forceps and the gonopore.
- If the female is bearing a clutch of eggs, remove the clutch by bisecting the abdominal flap between the second and third abdominal somite.

Mounting Hemolymph on Slides

- The head investigator will supply biological data requirements, slide coding instructions, and all necessary equipment.
- For detection of bitter crab disease, the hemolymph is examined under a microscope. Hemolymph samples are taken at sea, mounted on slides, dried, stored, and returned to the head investigator for analysis.
- Label the frosted side of the slide with the appropriate specimen code in pencil.
- For crabs larger than 30 mm carapace width (biological), (1) cut or break off half of the dactyl of the 5th pereiopod, and allow two drops of hemolymph to fall free and catch the third drop on the slide near the end of the slide, or (2) extract a large drop of hemolymph with a disposable syringe from the articulating membrane between the dactyl and propodus of the chela, and place a drop of hemolymph on the slide near the end of the slide. For crabs smaller than 30 mm carapace width, pinch off a leg at the merus segment and allow two drops of hemolymph to fall free and catch the third drop on the slide near the end of the slide.
- Position a second slide on edge in the center of the slide containing the hemolymph, angled slightly toward the drop, and draw it toward the drop until it comes in contact with the drop. Then draw the drop toward the center of the slide with a slow smooth motion.
- Let excess hemolymph run off the slide, and blot the edge of the slide dry if necessary.
- Place the slide in a warm dry area until the slide has dried, then store the slide in a slide box. Two slides may be stored in each slot if the dried hemolymph is facing outward.
- Check slides periodically for fuzziness. If the slides become fuzzy, they have been contaminated with fungi and will require further drying. Fungi impede slide reading and can be prevented with proper drying.
- To ship slides, tape slide box shut and shake lightly to make sure there is no excessive rattling.

References

Adams, A.E. 1982. The mating behavior of *Chionoecetes bairdi.* In: B. Melteff (ed.), Proceedings of the International Symposium on the Genus *Chionoecetes.* University of Alaska Sea Grant, AK-SG-82-10, Fairbanks, pp. 233-272.

American Fisheries Society. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: Decapod crustaceans. American Fisheries Society Special Publication 17.

Baross, J.A., P.A. Tester, and R.Y. Morita. 1978. Incidence, microscopy, and etiology of exoskeleton lesions in the Tanner crab, *Chionoecetes tanneri.* J. Fish. Res. Board Can. 35:1141-1149.

Derjugin, K.M., and S. Kobjakowa. 1935. Zur Dekapodenfauna des Japonischen Meeres. Zool. Anz. Bd. 112:141-147.

Dick, M.H., W.E. Donaldson, and I. Vining. 1998. Epibionts of the Tanner crab *Chionoecetes bairdi* in the region of Kodiak Island, Alaska. J. Crus. Bio. 18(3):147-156.

Donaldson, W.E. 1996. Development of an expert computer vision-based crab classification system. In: High latitude crabs: Biology, management, and economics. University of Alaska Sea Grant, AK-SG 96-02, Fairbanks, pp. 99-113.

Donaldson, W.E., and A.E. Adams. 1989. Ethogram of behavior with emphasis on mating for the Tanner crab *Chionoecetes bairdi* Rathbun. J. Crus. Bio. 9(1):37-53.

Donaldson, W.E., and B.A. Johnson. 1988. Some remarks on "Functional maturity and terminal molt of male snow crab, *Chionoecetes opilio*" by Conan and Comeau. Can. J. Fish. Aquat. Sci. 45:1499-1501.

Donaldson, W.E., R.T. Cooney, and J.R. Hilsinger. 1981. Growth, age and size at maturity of Tanner crab, *Chionoecetes bairdi* M.J. Rathbun, in the Northern Gulf of Alaska (Decapoda, Brachyura). Crustaceana 40(3):286-302.

Elner, R.W., and P.G. Beninger. 1992. The reproductive biology of snow crab, *Chionoecetes opilio*: A synthesis of recent contributions. Am. Zoo. 32:524-533.

Fabricius, O. 1788. Beskrivelse over den store Gronlandske krabbe. Nye samling selskab skr. K. Danske Vidensk. Selsk. 3:181-190, 1 pl.

Garth, J.S. 1958. Brachyura of the Pacific Coast of America. Oxyrhyncha. Allan Hancock Pacific Expedition, Tech. Rpt. 21. 854 pp.

Hilsinger, J.R. 1976. Aspects of the reproductive biology of female snow crabs, *Chionoecetes bairdi,* from Prince William Sound and the adjacent Gulf of Alaska. Marine Sci. Comm. 2(3&4):201-225.

Hoenig, J.M., E.G. Dawe, and P.G. O'Keefe. 1994. Molt indicators and growth per molt for male snow crabs *(Chionoecetes opilio).* J. Crus. Bio. 14(2):273-279.

Igarashi, T. 1970. A list of marine decapod crustaceans from Hokkaido, deposited at the Fisheries Museum, Faculty of Fisheries, Hokkaido University. III. Brachyura. Fish. Mus. Fac. Fish., Hokkaido Univ. 13:1-18.

Ito, K. 1963. A few studies on the ripeness of eggs of zuwai-gani, *Chionoecetes opilio.* Bull. Japan Sea Region Fish. Res. Lab. 11:65-76.

Kon, T. 1996. Overview of Tanner crab fisheries around the Japanese Archipelago. In: High latitude crabs: Biology, management, and economics. University of Alaska Sea Grant, AK-SG 96-02, Fairbanks, pp. 13-24.

Krøyer, H. 1838. Conspectus Crustaceorum Groenlandiae. Naturhist. Tidsskr. 2:249-261.

O'Halloran, M.J., and R.K. O'Dor. 1988. Molt cycle of male snow crabs, *Chionoecetes opilio*, from observations of external features, setal changes, and feeding behavior. J. Crus. Bio. 8(2):164-176.

Paul, A.J. 1984. Mating frequency and viability of stored sperm in the Tanner crab *Chionoecetes bairdi* (Decapoda, Majidae). J. Crus. Bio. 4:205-211.

Rathbun, M.J. 1893. Catalogue of the crabs of the family Majidae in the U.S. National Museum. Proc. U.S. Natl. Mus. 16:63-103, pls. 3-8.

Rathbun, M.J. 1924. New species and subspecies of spider crabs. Proc. U.S. Natl. Mus. 64:1-5.

Rathbun, M.J. 1932. Preliminary descriptions of new species of Japanese crabs. Proc. Biol. Soc. Wash. 45:29-38.

Sakai, T. 1976. Crabs of Japan and adjacent seas. Kodansha LTD, 12-21 Otowa 2-chrome, Bunkyo-ku, Tokyo 112, Japan.

Somerton, D.A. 1982. Bipartite breeding: A hypothesis of the reproductive pattern in Tanner crabs. In: B. Melteff (ed.), Proceedings of the International symposium on the genus *Chionoecetes*. University of Alaska Sea Grant, AK-SG-82-10, Fairbanks, pp. 283-288.

Somerton, D.A., and W.S. Meyers. 1983. Fecundity differences between primiparous and multiparous female Alaskan Tanner crab *(Chionoecetes bairdi).* J. Crus. Bio. 3(2):183-186.

Squires, H.J. 1969. Decopoda Crustacea of the Beaufort Sea and arctic waters eastward to Cambridge Bay, 1960-65 J. Fish. Res. Board Can. 26(7):1899-1918.

Stevens, B.G., J.A. Haaga, and W.E. Donaldson. 1994. Aggregative mating of Tanner crabs, *Chionoecetes bairdi*. Can. J. Fish. Aquat. Sci. 51:1273-1280.

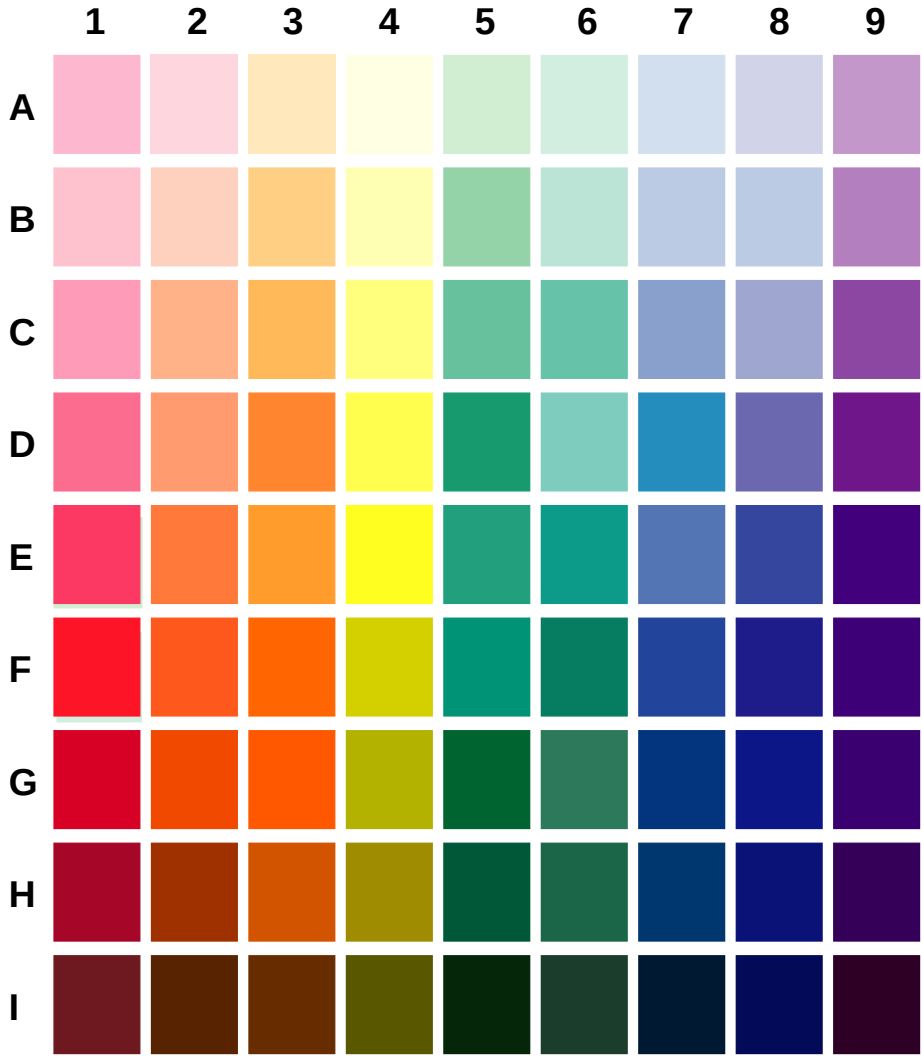
Watson, J. 1969. Biological investigations on the spider crab *Chionoecetes opilio.* Can. Fish. Rep. 13:24-47.

Watson, J. 1972. Mating behavior in the spider crab, *Chionoecetes opilio.* J. Fish. Res. Board Can. 29:447-449.

Yosho, I., and I. Hayashi. 1994. The bathymetric distribution of *Chionoecetes opilio* and *C. japonicus* (Majidae: Brachyura) in the western and northern areas of the Sea of Japan. Bull. Japan Sea Nat. Res. Inst. 44:59-71.

Appendix 1. Color Chart

This color chart can serve as a standard reference for collection and analysis of data. A person collecting data should match crab color to a color on the chart and record the color code. Field biologists who are taking data at sea can document eye color, for example. This refers to printed and bound book only. DO NOT USE PDF VERSION FOR COLOR MATCHING.



	1	2	3	4	5	6	7	8	9
A	C = 0 M = 27 Y = 6 K = 0	C = 0 M = 15 Y = 6 K = 0	C = 0 M = 9 Y = 23 K = 0	C = 0 M = 0 Y = 11 K = 0	C = 18 M = 0 Y = 15 K = 0	C = 18 M = 0 Y = 9 K = 0	C = 18 M = 6 Y = 0 K = 0	C = 18 M = 11 Y = 0 K = 0	C = 23 M = 34 Y = 0 K = 0
B	C = 0 M = 23 Y = 9 K = 0	C = 0 M = 18 Y = 18 K = 0	C = 0 M = 18 Y = 43 K = 0	C = 0 M = 0 Y = 30 K = 0	C = 43 M = 0 Y = 30 K = 0	C = 27 M = 0 Y = 11 K = 0	C = 27 M = 11 Y = 0 K = 0	C = 27 M = 11 Y = 0 K = 0	C = 30 M = 43 Y = 0 K = 0
C	C = 0 M = 38 Y = 11 K = 0	C = 0 M = 30 Y = 38 K = 0	C = 0 M = 27 Y = 60 K = 0	C = 0 M = 0 Y = 51 K = 0	C = 60 M = 0 Y = 34 K = 0	C = 60 M = 0 Y = 27 K = 0	C = 47 M = 23 Y = 0 K = 0	C = 38 M = 23 Y = 0 K = 0	C = 47 M = 65 Y = 0 K = 0
D	C = 0 M = 56 Y = 23 K = 0	C = 0 M = 38 Y = 47 K = 0	C = 0 M = 47 Y = 76 K = 0	C = 0 M = 0 Y = 69 K = 0	C = 91 M = 0 Y = 60 K = 0	C = 51 M = 0 Y = 18 K = 0	C = 87 M = 18 Y = 0 K = 0	C = 60 M = 47 Y = 0 K = 0	C = 60 M = 87 Y = 0 K = 0
E	C = 0 M = 76 Y = 38 K = 0	C = 0 M = 51 Y = 69 K = 0	C = 0 M = 38 Y = 79 K = 0	C = 0 M = 0 Y = 87 K = 0	C = 87 M = 0 Y = 51 K = 0	C = 94 M = 0 Y = 43 K = 0	C = 69 M = 38 Y = 0 K = 0	C = 83 M = 60 Y = 0 K = 0	C = 79 M = 100 Y = 0 K = 0
F	C = 0 M = 91 Y = 72 K = 0	C = 0 M = 65 Y = 83 K = 0	C = 0 M = 60 Y = 100 K = 0	C = 0 M = 0 Y = 100 K = 18	C = 100 M = 0 Y = 56 K = 0	C = 94 M = 0 Y = 56 K = 18	C = 91 M = 60 Y = 0 K = 0	C = 94 M = 83 Y = 0 K = 0	C = 79 M = 100 Y = 0 K = 6
G	C = 0 M = 100 Y = 65 K = 15	C = 0 M = 69 Y =100 K = 6	C = 0 M = 65 Y = 100 K = 0	C = 0 M = 0 Y = 100 K = 30	C = 100 M = 0 Y = 91 K = 27	C = 76 M = 0 Y = 47 K = 30	C = 100 M = 60 Y = 0 K = 18	C = 100 M = 87 Y = 0 K = 0	C = 79 M = 100 Y = 0 K = 11
H	C = 0 M = 91 Y = 56 K = 34	C = 0 M = 69 Y = 100 K = 38	C = 0 M = 60 Y = 100 K = 18	C = 0 M = 11 Y = 100 K = 38	C = 100 M = 0 Y = 76 K = 38	C = 83 M = 0 Y = 56 K = 38	C = 100 M = 51 Y = 0 K = 30	C = 100 M = 87 Y = 0 K = 11	C = 76 M = 100 Y = 0 K = 30
I	C = 0 M = 76 Y = 56 K = 56	C = 0 M = 60 Y = 87 K = 65	C = 0 M = 56 Y = 100 K = 60	C = 0 M = 0 Y = 100 K = 65	C = 79 M = 0 Y = 87 K = 76	C = 69 M = 0 Y = 51 K = 65	C = 100 M = 47 Y = 0 K = 69	C = 100 M = 87 Y = 0 K = 34	C = 83 M = 100 Y = 69 K = 0

This chart is for use by printers and publishers who want to reproduce the colors on the color chart. Numbers represent the screen tint values of cyan, magenta, yellow, and black inks for 4-color process on an offset printing press.

Appendix 2. Supplemental Photos

Figure A1. Podding Tanner crabs. (W.E. Donaldson)

Figure A2. Grasping pair of Tanner crabs with the female in the process of molting to maturity (primiparous molt). (W.E. Donaldson)

Figure A3. Grasping pair of Tanner crabs with the female in the process of molting to maturity (primiparous molt). (W.E. Donaldson)

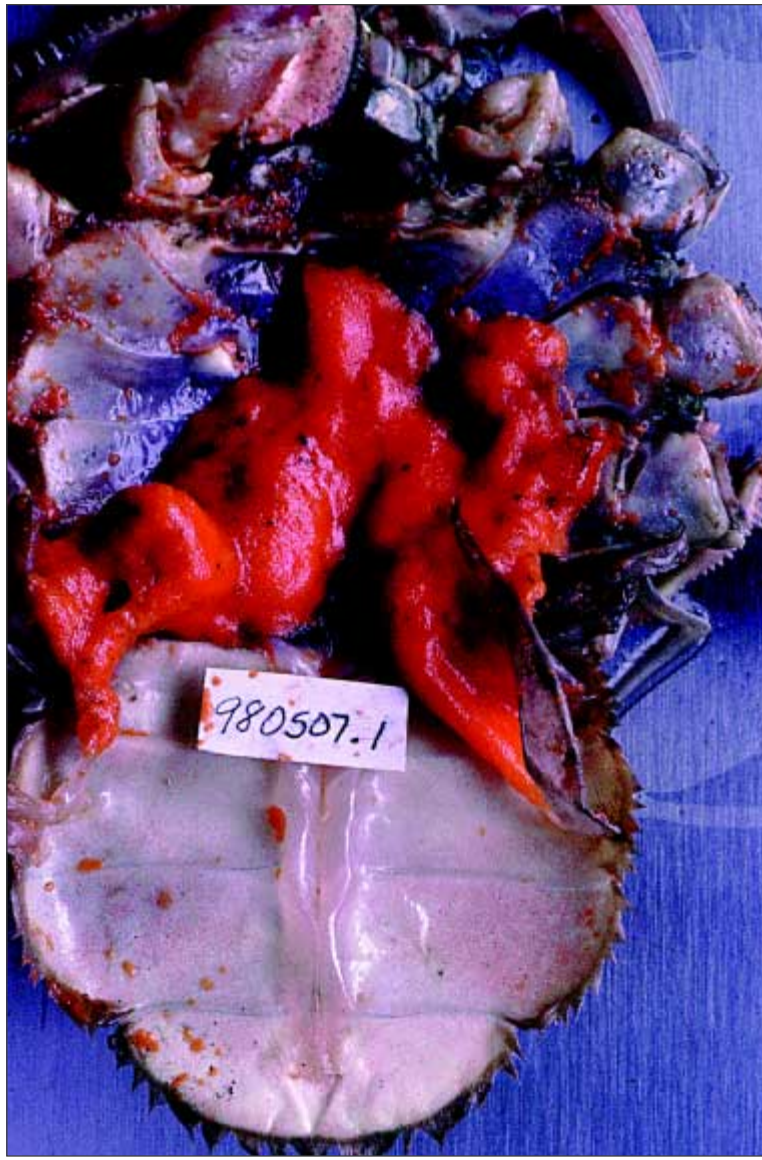


Figure A4. "Soupy" clutch of eggs, immediately after egg extrusion. This is a clutch condition that lasts for hours. (E. Munk)

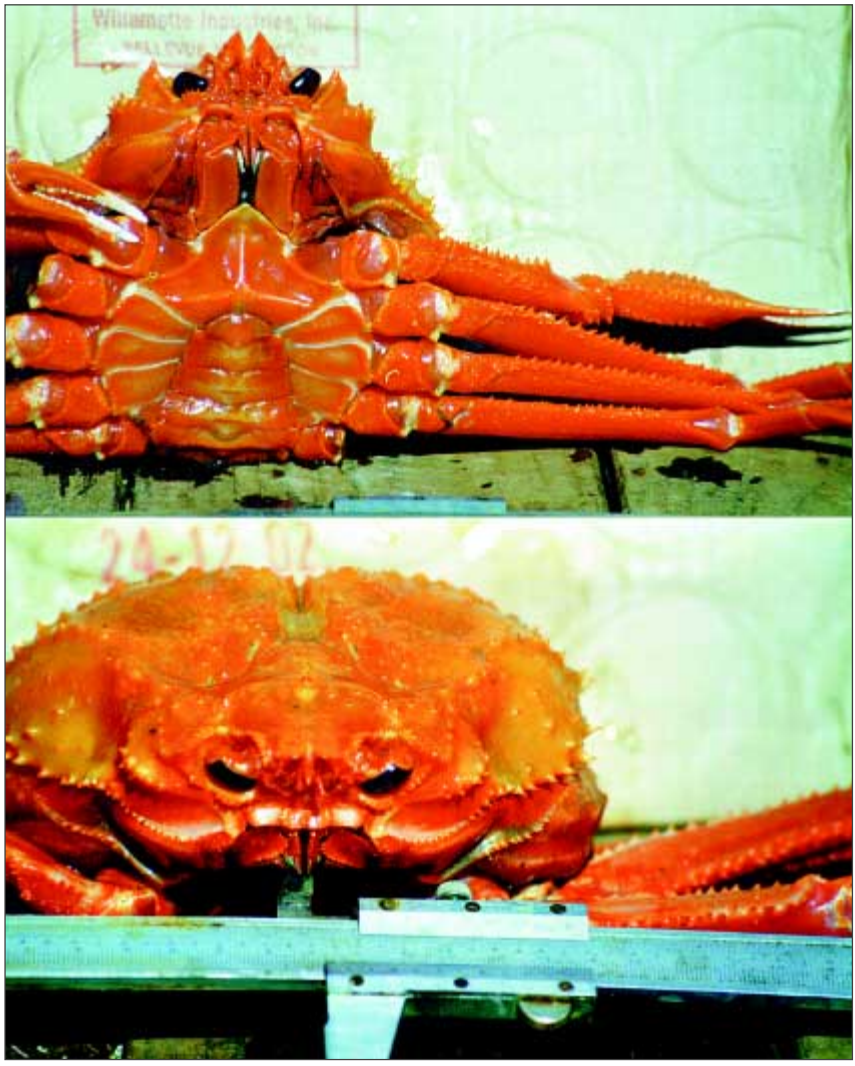


Figure A5. Ventral and frontal view of a molting grooved Tanner crab (for posterior view, see Fig. 30). (L.S. Jadamec)

Glossary

Abdominal flap: Formed by the abdomen which is folded under the thorax. In females, the abdomen is modified into a brood pouch to hold eggs.

Antenna: Anterior jointed sensory appendage with one flagellum.

Antennule: Anterior jointed sensory appendage with two flagella.

Autotomy: Self amputation or shedding of damaged or trapped legs.

Bitter crab: Disease lethal to crabs, caused by a single celled protistan blood parasite (*Hematodinium* sp.). Advanced stages cause the carapace to appear pink and impart a milky appearance to inner organs and blood.

Black mat: A systemic fungus *(Trichomaris invadens)* with spore-producing bodies which impart a tar-like appearance on the shell of an infected crab.

Brachyura: Taxonomic infraorder of crabs with short tail or abdomen folding beneath the cephalothorax; considered to be the "true" crabs. The first pair of legs are claws and the other four pairs are walking legs. (From Greek brachys = short, oura = tail.)

Calcareous: Composed of calcium carbonate.

Carapace: The dorsal covering of the cephalothorax, divided into frontal, gastric, branchial, and cardiac regions.

Carapace length: From the notch between the rostral horns to the midpoint of the posterior margin of the carapace (page 29).

Carapace length (rostral horn): From the distal tip of the rostral horn to the midpoint of the posterior margin of the carapace (page 29).

Carapace width (biological): The greatest straight-line distance across the carapace of the lower lateral margin, excluding spines (page 29).

Carapace width (legal): The greatest straight-line distance across the carapace at a right angle to a line midway between the eye to the midpoint of the posterior margin of the carapace, including the spines (page 29).

Carpus: The "wrist" of a crustacean limb; the third segment in from the dactyl end.

Cephalothorax: Fused head and tail.

Chela (plural = chelae): The pincer or claw terminating pereiopod one.

Cheliped: A modified leg that contains the pincers or claws.

Chionoecetes: Taxonomic genus of crabs. (From Greek chion = snow.)

Chitin: A characteristic organic component of the arthropod exoskeleton.

Chitinoclastic: Chitin-destroying (as in chitinoclastic bacteria).

Clutch: The cluster of eggs extruded by the female and located under the abdomen.

Dactyl: The terminal segment of a pereiopod.

Decapod: Any crustacean of the order Decapoda, having five pairs of thoracic legs. Decapods include crabs, lobsters, and shrimp. (From Greek deca = 10, poda = feet.)

Dorsal: Referring to the back or upper surface of the body.

Ecdysis: Shedding or casting off the exoskeleton.

Egg: A fertilized ovum consisting of an embryo surrounded by nutrient material with a protective covering.

Epibionts: Animal and plant material of other species attached to a host species.

Epithelium: Inner lining of the shell and covering of the muscle tissue.

Epistome: A region of the anterior portion of the crab commonly referred to as "the teeth."

Exoskeleton: External skeleton of crustaceans composed mostly of chitin.

Gonopods: Male sexual organs located under the abdominal flap.

Gonopores: Sperm receptacles of females located between the sternites of the second and third pereiopods.

Grasping marks: Scratches or abrasions left on the merus segment of the walking legs of females by males during mating (usually on the first but somtimes also on the second walking legs).

Graveyard: A shell-age classification greater than 36 months post ecdysis characterized by a soft spongy shell, a result of decay.

Hemolymph: The fluid in the body cavity and tissues that functions as blood.

Hepatopancreas: Digestive gland which secretes digestive fluid.

Instar: A stage of postembryonic growth between molts.

Maxilliped: A thoracic appendage that functions as a mouth part.

Megalops: The final larval form of a decapod; swims by using its pleopods.

Merus (plural = meri): The fourth segment from the dactyl end of the crustacean limb, usually the longest of the segments.

Molting: Shedding of the shell, with the succession of a new shell.

Morphometrics: The science of measuring forms and structures of plants and animals.

Multiparous female crab: A female which has produced more than one clutch of eggs and embryos.

New-shell: A crab with a shell that is approximately 2-12 months post ecdysis, with sharp dactyli, few or no scratches, and little or no growth or epifauna.

Necrotic: Dead tissue caused by a pathological condition.

Old-shell: A crab that has a shell approximately 13-24 months post ecdysis, characterized as having a darker coloration and significant scratching, wear, and abrasions as compared to a new shell.

Oocyte: A maturing ovarian germ cell.

Ovum (plural = ova): A mature but unfertilized ovarian germ cell.

Ovary: The female gonad, in which develop ova and hormones that regulate female secondary sex characteristics.

Pereiopods: Chelae and walking legs 1-4.

Pleopod: Paired appendages associated with the abdomen, used by crabs for brooding eggs.

Primiparous female: A female that has produced only one clutch of eggs and embryos.

Propodus: The next-to-last segment of a crustacean appendage; forms the hand of the clawed appendage.

Pterygostomian: Row of spines on either side of a brachyuran crab extending from the mouth to the branchial region.

Pubescent female: In this book, a pubescent female is defined as one capable of first sexual reproduction or having offspring. Pubescent females have full ovaries and will molt to maturity at their next molt, OR they have completed the molt to maturity but have not produced their first eggs and embryos.

Recently molted: A crab that has a shell approximately 2-8 weeks post ecdysis. Exoskeletons are thin and flexible as opposed to flaccid.

Rostrum: A forward elongation of the carapace between the eyes.

Senescent: Growing old, aging. Senescent crabs have atrophied sex organs and very old shells.

Setae: Bristle-like structures.

Shell: Outer chitinous covering of a crab.

Shell age: An estimate of the elapsed time since the last molt.

Soft-shell: A crab that is newly molted, 0-2 weeks post ecdysis. Shells are very soft and may lose their shape when out of water.

Somites: Longitudinal series of parts into which the body is divided.

Spermathecae: Paired organs in the female for storage of sperm and seminal fluids.

Spermatophores: Capsules containing numbers of spermatozoa produced by the male.

Sternite: Ventral portion of the exoskeleton covering a segment of the thorax.

Telson: The terminal segment of the abdomen; bears the anus.

Thorax: In crustaceans, the middle portion of the body between the head and the abdomen.

Tubercles: Rounded bumps or projections.

Vas deferens: A tubular organ for spermatophore transfer and storage which also secretes seminal fluid.

Ventral: Referring to the underside of the body.

Very old-shell: A crab that has a shell greater than 24 months to and including 36 months post ecdysis. The difference between old-shell, very old-shell, and graveyard crabs is a function of the extent of wear and fouling present.

Walking legs: Pereiopods 2-5.

Zoea (plural = zoeae): Larval stage of a crustacean prior to the megalops stage.

Index

N

O

P

Q

R

S

T

V

W

Z