

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

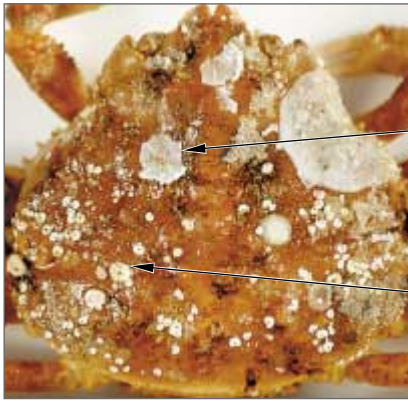
Figure 42. Symptoms of advanced bitter crab infection in Tanner crab: a. Ventral view of (above) healthy Tanner crab, and (below) external symptoms, i.e. opaque ivory coloration of the pereiopods. b. Dorsal view of (above) internal symptoms, i.e., milky coloration of hemolymph, and (below) healthy Tanner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



Barnacle scar



Tubeworm casing

45a. Calcareous epibionts; barnacle scar and tubeworm casing



Barnacle



Bryozoan

45b. Calcareous epibionts; barnacle and bryozoan



Leech cocoons

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 pereopods at the distal merus joint and secure pereopods 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, pereopods, 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 $\frac{3}{4}$ full.
- Remove a portion of the hepatopancreas, enough to fill the cryovial $\frac{3}{4}$ 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 $\frac{3}{4}$ 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 pereopod, 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.

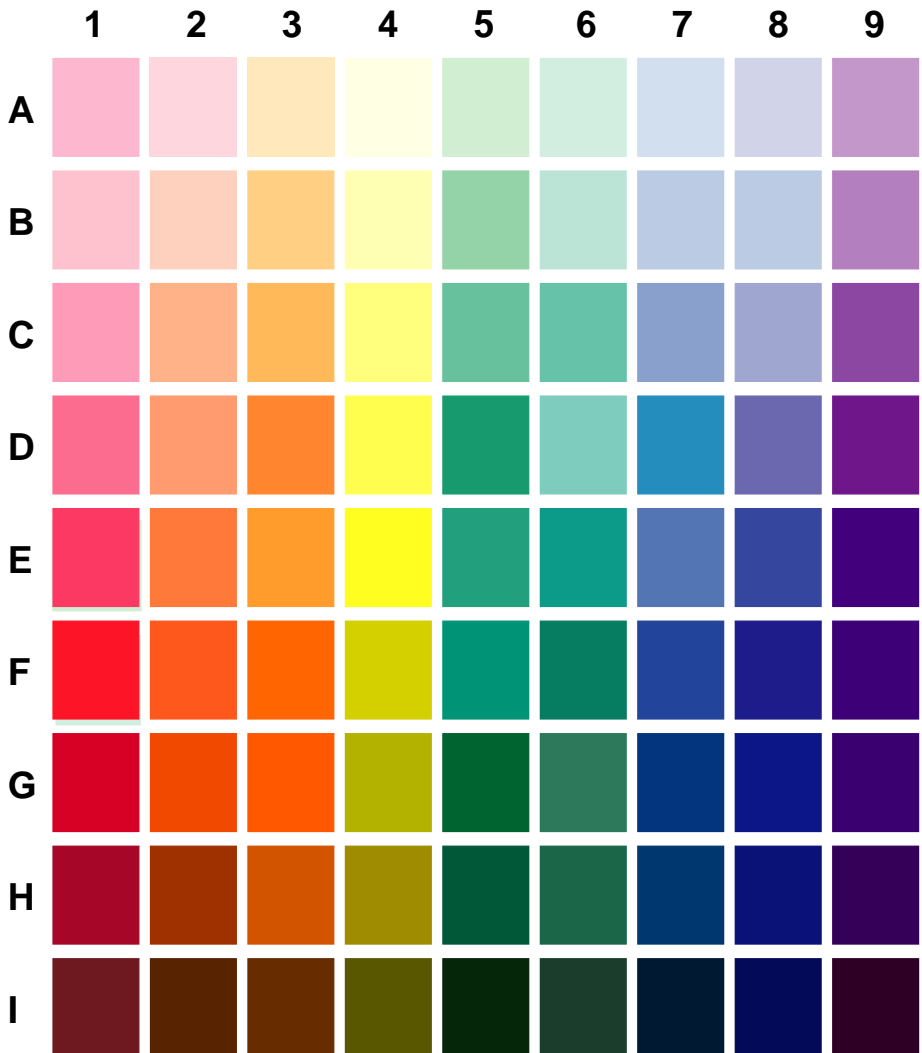
References

- 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.
- Hoening, 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. Decapoda 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.**



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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)

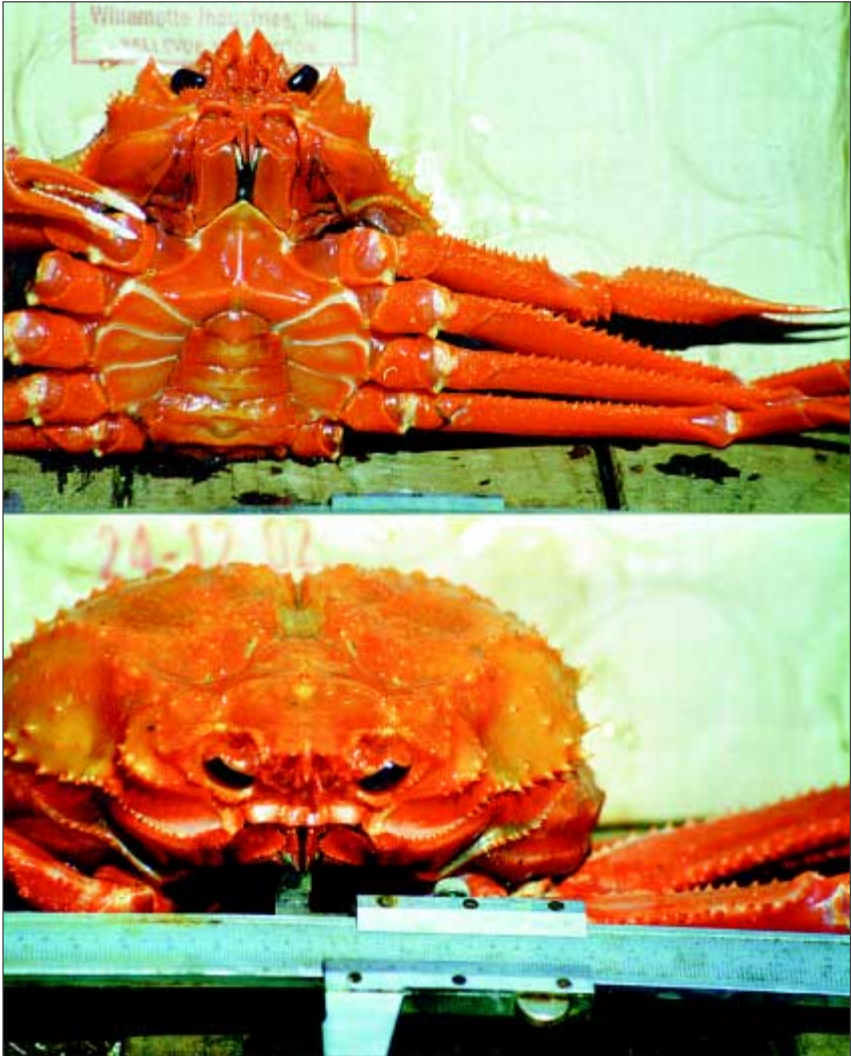


Figure A5. Ventral and frontal view of a molting grooved Tanner crab (for posterior view, see Fig. 30). (L.S. Jadamec)

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 pereopod 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 pereopod.

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 pereopods.
- 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 sometimes 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.
- Pereopods:** 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.

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