Neotrypaea californiensis

The ghost shrimp

Phylum: Arthropoda, Crustacea
Class: Malacostraca
Order: Decapoda
Section: Anomura, Paguroidea
Family: Callinassidae

Taxonomy: *Neotrypaea californiensis* was described as a member of the genus *Callianassa* 1854 by Dana and remained there until an analysis by Manning and Felder (1991) resulted in the three NE pacific *Callianassa* species moving to the new genus *Neotrypaea*. Tudge et al. (2000) later analyzed 93 characters of adult morphology and found the genus *Neotrypaea* to be non-monophyletic and Sakai (1999) synonymized *Neotrypaea* and *Callianassa*. The monophyly of *Neotrypaea* is still supported by some authors (e.g. Campos et al. 2009) and we follow the most current local intertidal guides, which use *N. californiensis* (Kuris et al. 2007). For complete list of synonymies see Sakai (2005).

Description

Size: Males up to 115 mm and females to 120 mm in length (Barnard et al. 1980; Puls 2001; Wicksten 2011).

Color: Can be white to cream with patches of pinkish red or orange on the abdomen and appendages (see Plate 19, Kozloff 1993; Wicksten 2011). The illustrated specimen (from Coos Bay) is pale pink with light orange abdomen.

General Morphology: The body of decapod crustaceans can be divided into the **cephalothorax** (fused head and thorax) and **abdomen**. They have a large plate-like carapace dorsally, beneath which are five pairs of thoracic appendages (see **chelipeds** and **pereopods**) and three pairs of maxillipeds (see **mouthparts**). The abdomen and associated appendages are outstretched and shrimp-like in Callianassidae (Stevens 1928; Kuris et al. 2007).

Cephalothorax:

Eyes: Eyestalks flattened and with acute tips. Pigmented corneas are mid-dorsal within eyestalk (Fig. 2) (Wicksten 2011). Eyes triangular and with diverging tip (Campos et al. 2009).

Antennae: Antennal angles rounded and naked and antennal peduncle shorter than antennular peduncle (Campos et al. 2009).

Mouthparts: The mouth of decapod crustaceans comprises six pairs of appendages including one pair of mandibles (on either side of the mouth), two pairs of maxillae and three pairs of maxillipeds. The maxillae and maxillipeds attach posterior to the mouth and extend to cover the mandibles (Ruppert et al. 2004). The third maxilliped in *N. californiensis* is operculiform, with widened merus extending beyond articulation with carpus and ischium (Manning and Felder 1991; Campos et al. 2009; Wicksten 2011).

Carapace: Smooth and with lateral grooves (Wicksten 2011).

Rostrum: Not prominent, rounded and with small blunt tooth (Wicksten 2011) (Fig. 2).

Teeth:

Pereopods: Second pereopod flattened, chelate (Fig. 3) and with row of setae along posterior margin (Campos et al. 2009). Third to fifth pereopods are predominantly used in walking (MacGinitie 1934). Third pereopod with triangular carpus and round, small dactyl. Fourth and fifth pereopods are slender (Wicksten 2011).

Chelipeds: First chelipeds are chelate and unequal (Fig. 1). The large cheliped is broad, serrate and with an obvious gap in dactyls. The merus has a conspicuous ventral lobe, the carpus is almost square and longer than the palm, and with laterally incurved dorsal margin (Campos et al. 2009). The dactyl has a recurved hook distally (Wicksten 2011) (Fig. 1). Propodi are of nearly equal length (McGinitie 1934). Second chelipeds are both chelate with propodi and dactyls near equal in width (Figs. 1, 3). Female and immature individuals have hand longer than carpus (Wicksten 2011).

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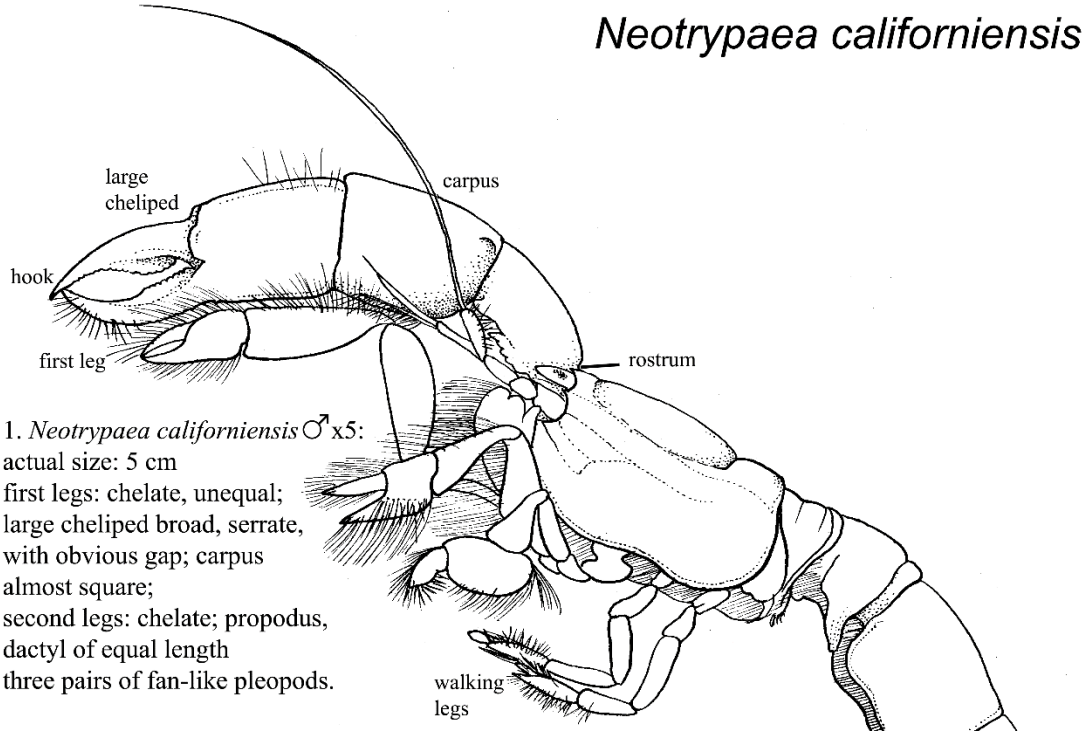
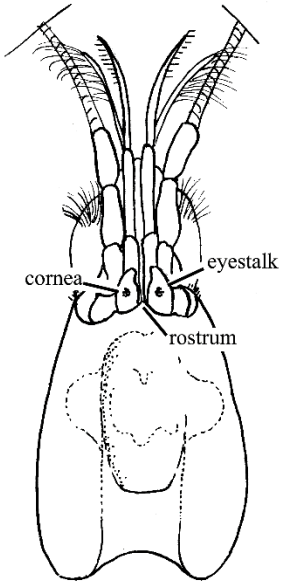
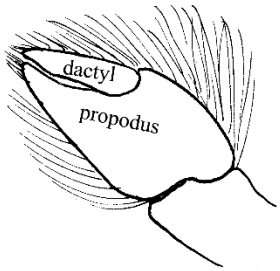
Neotrypaea californiensis



1. *Neotrypaea californiensis* ♂ x5:
actual size: 5 cm
first legs: chelate, unequal;
large cheliped broad, serrate,
with obvious gap; carpus
almost square;
second legs: chelate; propodus,
dactyl of equal length
three pairs of fan-like pleopods.



2. Head (dorsal view):
eyestalks flattened, acute,
pigmented, divergent;
corneas dorsal
rostrum: small, blunt.



3. Second pereopod:
dactyl (top) closes to
propodus without a gap;
dactyl, propodus same
width.

Abdomen (Pleon): Abdomen elongate (longer than cephalothorax), not reflexed but extended, symmetrical and externally segmented. It bears three pairs of fan-like pleopods (Fig. 1). First and second pleopods are vestigal and absent in males. Third to fifth are leaf-like (Fig. 1). In females, the first pleopods are uniramous and the second are biramous (Wicksten 2011).
Telson & Uropods: Telson nearly rectangular, forming a well-developed fan-shape with uropods, which are equal in length to the telson (Fig. 1). Telson composed of two dorsal ribs and posterior marginal tooth. Exopod (outer ramus) also with dorsal ribs.
Sexual Dimorphism: Pleopod (see **Abdomen (Pleon)**) and cheliped (see **Chelipeds**) morphology differs between males and females. Females are also commonly seen with conspicuous bright orange egg masses attached to their pleopods.

Callianassidae-specific character

Burrow: *Neotrypaea californiensis* build and inhabit large, sloppy and permanent burrows with branching side tunnels (Y-shape, Jensen 1995; Puls 2001). Individuals dig tirelessly, turning over acres of northwest oyster beds (Ricketts and Calvin 1971, see **Behavior**). Burrows can be to 0.76–1.00 m deep (MacGinitie 1934; MacGinitie and MacGinitie 1949). They burrow using their first to third legs, aided by mouthparts (MacGinitie 1934; Kozloff 1993) and begin digging backward before turning and removing excess loose sediment from the burrow to the surface (see MacGinitie 1934 for figure).

Possible Misidentifications

Thalassinidea is a former infraorder containing Callianassidae and Upogebiidae and, although shown to be non-monophyletic (Sakai 2004), most mud and ghost shrimps are often referred to collectively as thalassinids.

Upogebiidae is described in Williams (1986) and Campos et al. 2009 and, locally, consists of a single species, *Upogebia pugettensis*, the blue mud shrimp, often co-occurs with *N. californiensis*. *Upogebia pugettensis* is easy to recognize because it is larger and its color (bluish and never red or pink) is strikingly different. Its burrows are also more firm and substantial. The most noticeable morphological difference between the species is the first pair of legs: both of which are small, sub-chelate and equal in *U. pugettensis*. Furthermore, its rostrum is hairy and has a laterally compressed and slender tip of the short fixed finger of the chela (Wicksten 2011).

Characteristics defining the Callianassidae are described in Sakai 1999 and and Campos et al. 2009. There are three species locally, *Neotrypaea californiensis*, *N. gigas* and *N. buffari* (Kuris et al. 2007). *Neotrypaea californiensis* can be distinguished from the other two species by the lack of a prominent rostrum (present in *N. gigas*) and eyestalks that are acute and diverging tips of the eyestalks (rather than short, blunt and not diverging in *N. biffari*) (see Campos et al. 2009). *Neotrypaea gigas* is larger (to 125–150 mm) than the other two, and relatively rare in sandy sublittoral habitats. Its rostrum is sharp, with prominent medial tooth (which*N. californiensis* does not possess), and its first chela closes without a gap. It is more common in its southern distribution, south of Point Conception (Barnard et al. 1980; Kuris et al. 2007; Wicksten 2011). *Neotrypaea gigas* and *N. californiensis* also differ in the morphology of the second pereopod: In *N. californiensis* the propodus and dactyl are of equal length and in *N. gigas*, the propodus is curved and wider than the dactyl (Kuris et al. 2007). Recent examination of these two species using morphological and molecular data suggests that the key characters for differentiating species is the length of eyestalks and shape of the distal outer edges (Pernet et al. 2010).

Ecological Information

Range: Type region is California, with proposed locality San Francisco or Monterey Bay (Wicksten 2011), but type material has been lost. Known range includes Alaska to Tiajuana River, California and Point Abreojos, Baja California, Mexico (Campos et al. 2009)
Local Distribution: Distribution in many Oregon estuaries including Coos Bay, Alsea River (Gaumer et al. 1973b), Nestucca estuary (Gaumer et al. 1973a), Netarts Bay (Gaumer et al. 1974), Umpqua estuary

(Umpqua Estuary 1978), Tillamook Bay (Gaumer 1973b) and Yaquina Bay (Gaumer et al. 1974).
Habitat: Mud or sand. Individuals can survive anoxia for nearly six days (Garth and Abbott 1980). In adaptation to living in an environment that is relatively low in oxygen, *N. californiensis* and *U. pugettensis* exhibit low metabolic rates and can both survive periods of anoxia. *Upogebia pugettensis* has a higher metabolic rate and *N. californiensis* is able to survive longer during periods of anoxia (Thompson and Pritchard 1969a; Zebe 1982).
Salinity: Collected at salinities of 30. An osmotic conformer, lower lethal limit 8.75–10.5 (Thompson and Pritchard 1969b) and the upper limit is 43.75 (Barnard et al. 1980).
Temperature:
Tidal Level: High intertidal. Collected at medium high and upper to mid-intertidal zones (0.0–1.2 m, Ricketts and Calvin 1971).
Associates: The blue mud shrimp, *Upogebia pugettensis*, is found overlapping the range of *N. californiensis*, though it is generally lower intertidally and in muddier sediments. Common commensals in ghost shrimp burrows include a polynoid worm *Hesperonoe*, pinnotherid crabs (*Scleroplax glanulata*), copepods (*Hemicyclops, Clausidium*), the shrimp *Betaeus harrimani*, the bopyrid isopod *lone cornuta*, the goby *Clevelandia*, the echiuroid worm *Urechis caupo*, and the clam *Cryptomya californica* (MacGinitie 1934; Kuris et al. 2007; Campos 2009; Wicksten 2011).
Abundance: Common in Oregon's estuarine mudflats. In Wallapa Bay, Washington, the density of *N. californiensis* (up to 450 shrimp per m^2) was always higher than that of the other locally occurring ghost shrimp, *U. pugettensis* (up to 100 shrimp per m^2) Dumbauld et al. 1996).

Life-History Information

Reproduction: Continuously reproductive in central California, especially June and July (MacGinitie 1934; Ricketts and Calvin 1971). A breeding season in late spring and summer is known to occur in Yaquina Bay, Oregon (Puls 2001). *Neotrypaea californiensis* reach sexual maturity at 2 years and produce 3,900 eggs while *U. pugettensis* produces 7,100 (Dumbauld et al. 1996). Individuals ovigerous from April through August (Willapa Bay, Washington, Dumbauld et al. 1996).
Larva: Larval development in *N. californiensis* proceeds via several zoea (five total) and, a final, megalopa stage, each marked by a molt (Puls 2001). *Neotrypaea californiensis* zoea have rostrum longer than antennules (compare to *Upogebia pugettensis*), abdominal segments with dorsal and/or lateral spines and telson that is broad and flat with medial tooth at posterior (see paguroid zoeae Fig. 53.2, Harvey et al. 2014: Fig. 11, McCrow 1972; Puls 2001). Larval size (measured from tip of rostrum to tip of telson) proceeds from 2.8–3.6 mm (Zoea I) to 6.8–7.5 mm (Zoea V) (Puls 2001). Megalopae are shrimp-like in morphology with long pereopods, resembling the adult. First and second pereopods chelate or subchelate (Puls 2001). Larvae are flushed into open ocean by tides, where they spend most of larval period in the plankton and exchange between neighboring bays is common (McCrow 1972; Johnson and Gonor 1982). Larvae recruit back to the estuary to settle from August to October (Willapa Bay, Washington, Dumbalud et al. 1996) and preferentially settle on mud substrate (rather than shell, Feldman et al. 1997).
Juvenile: Sexual dimorphism and maturation in claw size occurs at 2 years of age, when individuals are 9–10 mm carapace length (Dumbauld et al. 1996).
Longevity:
Growth Rate: Growth occurs in conjunction with molting where the exoskeleton is shed and replaced. Post-molt individuals will have soft shells as the cuticle gradually hardens (Ruppert et al. 2004). The growth rate for *N. californiensis* is approximately 2–3 mm (carapace length) per year (Dumbauld et al. 1996).
Food: Detritivore, obtains food by ingesting mud as it burrows the top (richest) layer (MacGinitie 1934; MacGinitie and MacGinitie 1949) and also filter feeds by pumping water through burrow (Powell 1974).
Predators: Adults are used by humans for fish bait and individuals avoid predation by retreating to burrow. Juveniles and larvae are eaten in the plankton (e.g. by fish). Adults are also eaten by bottom feeding fish. Green and

white sturgeon collected from Willapa Bay, Washington and the Columbia River estuary had *N. californiensis* within their guts (Dumbauld et al. 2008). Foraging gray whales in British Columbia (Clayoquot Sound) also ingest adult benthic *N. californiensis* (Dunham and Duffus 2001).

Behavior: Ghost shrimp species (e.g. *Neotrypaea*, *Upogebia*) are known to be ecosystem engineers with the ability to regulate and change community (macro and microbial communities) structure by burrowing and deposit feeding (Dumbauld and Wyllie-Echeverria 2003; Bertics and Ziebis 2009). Their presence and behavior effects biogeochemical composition including sediment grain size, nutrient exchange and organic composition. Bioturbation (Kristensen et al. 2012) turns over and re-suspends sediment, which can increase erosion and sediment instability, having a negative effect on algae and seagrasses that require light for photosynthesis (e.g. *Zostera*, Dumbauld and Wyllie-Echeverria 2003) and suspension feeders (e.g. oysters, Dumbauld et al. 1996; Feldman et al. 2000). All sediment to 76 cm deep is turned over completely in 240 days (MacGinitie 1934). In turn, seagrasses tend to solidify sediment and are not suitable habitats for ghost shrimp species (Berkenbusch et al. 2007). Outside of their burrows, *N. californiensis* specimens are fragile and lay rather helpless on the sediment surface (Kozloff 1993). They can swim for short distances and move quickly backwards by flapping the fan-like posterior (MacGinitie 1934).

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