

# **CIMT** Center for Integrated Marine Technologies

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A research unit of the Central and Northern California Ocean Observing System (CeNCOOS)

Euphausiids, or krill, are shrimp-like planktonic crustaceans found throughout the earth's oceans. The term euphausiid comes from the greek roots eu = "true", phane = "to show," and ousia = "substance or essence." The term captures the sentiment "to show one true inner substance" and krill are named as a consequence of their ability to bioluminesce or produce chemical light with specialized organs called photophores, allowing us to see their true inner light. Krill form a key link between primary producers and higher level consumers in oceanic foodwebs worldwide. Most marine species are only one or two steps away from krill, that is to say they are either prey to krill or predators of krill.

There are currently 82 described species of krill and, while they can be found in almost all marine habitats, krill are especially abundant in cool, productive waters. Most species of krill are capable of directly feeding upon phytoplankton, the unicellular salad of the sea, and as such they are able to directly tap into the base of the food web. Krill in turn make this energy available to a wide variety of predators including other zooplankton, fish, seabirds, and mammals. This includes the blue whale, which is the largest animal to have ever lived on this planet, and which feeds almost exclusively on krill.

#### Three common Monterey Bay krill species



Actual size: 2.6 centimeters (1.02 inches)

Actual size: 3.5 centimeters (1.38 inches)



- Distribution: Found throughout the North Pacific and along the west coast from Alaska to Baja California.
- Monterey Bay Distribution: Most abundant species in the bay, largely restricted to the deeper waters associated with the Monterey Submarine Canyon.
- Omnivore feeding principally on phytoplankton.
- Lifespan: 2 years.
- Reproduction: Reproduces year round, although highly seasonal, peaking mainly in spring and summer. Free spawning. From eggs to mature adults in 4 months.

#### Thysanoessa spinifers

- Distribution: Mainly a nearshore (neritic) species associated with the cool productive waters of the Northeast Pacific, ranging from Alaska to Baja California, and largely restricted to the waters of the outer continental shelf and slope.
- Monterey Bay Distribution: Seasonally abundant and typically found in and around the edges of the Monterey Submarine Canyon, and inshore on the continental shelf ~75 meters in depth.
- Omnivore feeding principally on phytoplankton.
- Reproduction: Highly seasonal, peaking in spring/early summer.
  Free spawning. From eggs to mature adults in 4 months.

#### Nematoscelis difficilis

- Distribution: Oceanic species associated with the waters of the North Pacific Drift and California Current.
- Monterey Bay Distribution: Typically found in deeper outer waters of the bay and are most abundant when oceanic waters impinge upon the coast, or during the winter months when the California Undercurrent surfaces.
- Primarily carnivorous, but does feed on phytoplankton.
- Reproduction: Unknown in Central California though gravid females are present year round. From eggs to juveniles in 1-2 months; time to adult is unknown.



# atural History

Both *E. pacifica* and *T. spinifera* are omnivores, feeding both on phytoplankton and zooplankton prey, which are filtered from the water through the use of their setose (hairy) thoracic appendages. *N. difficilis* is predominantly a carnivore and utilizes it's elongated second thoracic appendage to skewer zooplankton prey, but it does also feed on phytoplankton.

All three species of krill undergo daily vertical migrations, seeking the refuge of the dim deeper waters during the day and rising to the surface waters at night to feed. *T. spinifera* has the shallowest migration with a maximum daytime depth of 250-200 meters (m), while both *E. pacifica* and *N. difficilis* are capable of much greater daily migrations extending down to as much as 500 m but more typically to around 300m.

Both *E. pacifica* and *T. spinifera* are free spawning species, which means that females release fertilized eggs directly into the water column where they complete their development. In contrast, *N. difficilis* is a brooder, which means the females retain the fertilized eggs in an external sac and release live larvae. The first larval stage for all three species is known as a nauplius, which is a poor swimmer and largely restricted to the surface waters.

The next larval stages and first feeding phase is known as the calyptopis and typically contains three stages. (Here the thoracic appendages develop as well as other features such as the compound eyes and antennas). The calyptopis is a stronger swimmer than the nauplius but is still largely restricted to the surface layer of the ocean. The final phase is known as the furcilia and may have anywhere from 4 to 7 stages depending on the species and the environment. During the furcilia stage, larvae develop the abdominal appendages and become progressive better swimmers capable of increasingly deeper daily migrations. The entire larval duration varies by species and environmental conditions but may take from 1 to 2 months.

Shown Below: Day and evening migration of krill in their various stages of development. © Erin Hunter

Chitinous exoskeleton made of 3 parts: head, thorax, & abdomen



### easonal/Inter-annual patterns

Peak recruitment of juvenile krill in Monterey Bay typically occurs in the spring and early summer and is associated with high levels of phytoplankton productivity. If conditions are good, krill rapidly grow and become mature in 3 to 4 months. During productive years when upwelling is sustained into the fall, this can lead to large numbers of adult krill between July and September, which attract a variety of krill predators including blue and humpback whales.

On longer timescales, krill are influenced by such interannual events as El Niño/La Niña and the Pacific Decadal Oscillation. Krill abundance is higher in cooler, more productive conditions and declines in warmer, lower productive environments. *T. spinifera* is most sensitive to such oscillations in marine climates and essentially underwent a local extinction in Monterey Bay during the 1997/98 El Niño event, but returned in force during the strong subsequent 1999 La Niña event.

## You could say that krill are the important "energy" middle men between phytoplankton and other larger predators.



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