# Unusual gray whale *Eschrichtius robustus* feeding in the summer of 2005 off the central Oregon Coast

Carrie L. Newell[1] and Timothy J. Cowles[1]

Received 9 June 2006; revised 26 October 2006; accepted 31 October 2006; published 30 November 2006.

[1] The climate of the North Pacific underwent an unusual event in the summer of 2005 with a very late spring transition. This event had profound effects on both resident gray whales (*Eschrichtius robustus*) and their food source, mysids, off Depoe Bay, Oregon. Near bottom swarms of gray whales' major prey item, *Holmesimysis sculpta*, were sparse until August, a marked contrast to normal years when mysid swarms are abundant all summer. A large percentage of mysid females had empty brood pouches in 2005 while in 2003 and 2004 all observed females had full brood pouches. Gray whales spent little time foraging and spent fewer days in residence than in earlier years. The 2005 resident whales also showed signs of poor body condition, reflecting a nutritional deficit. **Citation:** Newell, C. L., and T. J. Cowles (2006), Unusual gray whale *Eschrichtius robustus* feeding in the summer of 2005 off the central Oregon Coast, *Geophys. Res. Lett.*, *33*, L22S11, doi:10.1029/2006GL027189.

## 1. Introduction

[2] The California Current System had unseasonably warm sea surface temperatures (SSTs) in early summer of 2005 [*Kosro et al.*, 2006; *Pierce et al.*, 2006], and the subsequent effects manifested themselves through all trophic levels [*Thomas and Brickley*, 2006; *Brodeur et al.*, 2006]. Ecosystem production and structure was affected by this climate abnormality. Upper trophic levels were especially responsive to these anomalous oceanographic conditions, with unprecedented reproductive failures of a planktivorous seabird, the Cassin's auklet, *Ptychoramphus aleuticus*, off northern California [*Sydeman et al.*, 2006]. Biomass of euphausiids was also reduced off central California compared to previous years [*Sydeman et al.*, 2006]. As will be described below, ecosystem responses observed off the central Oregon coast included substantial decreases in near-shore biomass of mysids (*Holmesimysis sculpta*) and reduced foraging, residency time, and poor body condition of resident gray whales (*Eschrichtius robustus*). In this paper we examine the impact of anomalous atmospheric conditions and delayed upwelling in late spring/early summer on gray whale foraging behavior, most likely as a consequence of reduced availability of mysids to the whales.

[3] Gray whales and other baleen whales rely on dense concentrations of prey in order to obtain their daily caloric requirements and they typically forage only in areas of above-average prey abundance [*Murison and Gaskin*, 1989; *Dunham and Duffus*, 2001, 2002]. Gray whales migrate from breeding grounds in Baja California to high latitude feeding areas in the Bering and Chukchi Seas, and they harvest their annual energy requirement in four to six months of feeding [*Highsmith and Coyle*, 1992]. In the Arctic, they feed primarily on benthic amphipods which can reach concentrations of 10,000 individuals per square meter [*Feder*, 1981]. Over the last 20 years, about 250 gray whales have abbreviated this northern migratory route and have taken up summer residency in various areas along the Northwest coast [*Calambokidis et al.*, 2002]. Along the central Oregon coast, mysids are the primary prey of gray whales with porcelain crab larvae an occasional minor component of the diet. These items have been confirmed as prey by analysis of whale feces and observations of whale feeding behavior [*Newell*, 2005].

[4] Mysids form hyperbenthic swarms along the coast, attaining considerable biomass. These swarms may attain sufficient biomass in April or May for gray whales to consume the quantity of food per day (approximately $10^3$ kg) which adults require [*Nerini*, 1984]. Swarms disappear from the shallow nearshore habitat in October or November, possibly due to predation pressure from the gray whales, or due to population migration to deeper depths.

## 2. Methods

[5] We have documented 19 different locations along the central Oregon coast between Lincoln City and Seal Rock where gray whales repeatedly forage. These locations have been surveyed since 2000 (Figure 1), and all possess recurring hyperbenthic swarms of mysids (*H. sculpta*) near the 10 m isobath. Each mysid swarm location was characterized by the abundance of kelp, type of benthic substrate and water depth. Repeat sampling visits to swarm locations confirmed that mysid swarms recurred annually at most of these sites, based on plankton tows, underwater video observations, and in situ observations using SCUBA. This paper focuses on three distinct swarm locations between Government Point and North Point, a distance of 3.5 km (Figure 1), which were sampled repeatedly between April and November in 2003, 2004, and 2005. These feeding sites ranged from 4 m to 14 m in water depth, located approximately 0.4 km from shore and were over a basalt substrate. We characterized mysid swarms by collecting samples with a 0.5 m diameter, 70-*u*m mesh plankton net, and by using SCUBA surveys to obtain dimensions of swarms as well as spatial separation of individual mysids in the swarm. Underwater video observations and echosounder patterns (fish finder) complemented the net and SCUBA sampling in and around mysid swarms. Swarm thickness at each sampling location was estimated from echosounder traces and video observations. We confirmed the swarm dimensions estimated by the echosounder with monthly SCUBA obser-

[1]College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon, USA.


0094-8276/06/2006GL027189


**Figure 1.** Study area with locations of mysid swarms noted numerically from Lincoln City to Seal Rock, Oregon. Inset shows mysid swarms at Government Point, the condos, and North Point (3.52 km), focus of the transects.

vations, weather permitting. Since gray whales occasionally were observed skim feeding at the sea surface, we conducted additional net sampling to capture the crab larvae occupying the surface layer. These collections were done by towing the plankton net horizontally through the upper 2 m of water for a known distance.

[6] Plankton samples from mysid swarms were preserved in 70% ethanol. Samples typically contained 20 to 500 mysids, which were identified and measured using a dissecting microscope which had 20× eyepieces and an ocular micrometer. Male mysids were identified by elongated fourth pleopods, while the presence of oostegites defined a female. If the specimen possessed neither, it was counted as a juvenile. The brood pouches of gravid females were dissected and the eggs or juveniles were counted.

[7] We did not sample temperature or chlorophyll directly, but relied upon temperature information from moored sensors operated by the PISCO program (http://www.piscoweb.org) and from the long-term mooring 10 nm west of Newport OR [see *Kosro et al.*, 2006]. Surface chlorophyll estimates were made available by Dr. A. Thomas [see *Thomas and Brickley*, 2006]. Our interpretation of mysid and whale behavior is linked to physical conditions and surface chlorophyll conditions evaluated in the papers by *Kosro et al.* [2006], *Pierce et al.* [2006], *Hickey et al.* [2006], and *Thomas and Brickley* [2006].

## 3. Resident Whales

[8] Some gray whales leave the northern migration route from Baja California to Alaska and feed along the Oregon coast from May through October. We identify gray whales as residents if they: 1) return to one of the prey habitats around Depoe Bay or Newport in succeeding years, 2) spend a minimum of two days in a known feeding locality, and 3) exhibit feeding behavior. Resident gray whales were observed daily during six summer field seasons (2000–2005) off central Oregon from observations made on fishing boats or Zodiacs when weather and sea conditions permitted.

[9] Each gray whale was photographed to provide a photo library for subsequent identification of individual whales. The dorsal hump on a gray whale has characteristics unique to each individual, so both the right and left sides of each whale were photographed using a 300 mm lens. On each sighting, the whales' location (based on GPS) and behavior were noted and additional photographs were taken to determine body condition.

[10] Two visible features of the whale body form permit us to assess body condition. Good body condition was assumed if the region from the blowholes to the upper back (distance of 2–3 m) was linear and the scapula was not a visible protuberance under the blubber layer (Figures 2a and 2b). In contrast, whales with poor body condition possessed a depression behind the blowholes or upper back and a pronounced protuberance of the scapula (Figures 2c, 2d, and 2e). We note that such pronounced depression of the back profile is not seen during swimming movements of whales with good body condition.

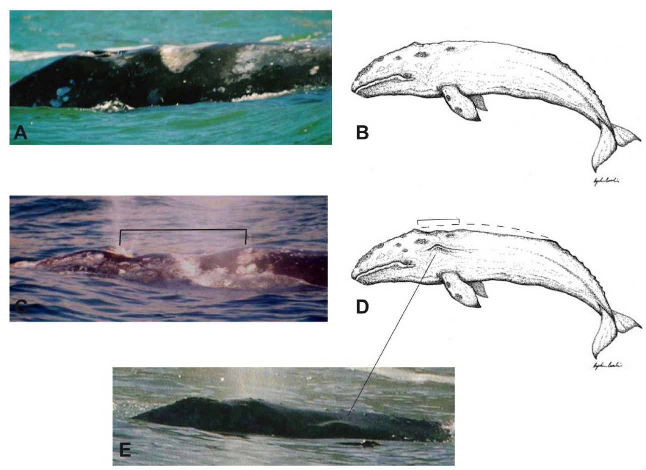


**Figure 2.** (a) Long time resident Whale # 22 in good condition in 2004 as seen by the fullness in the area behind the blowholes exhibiting a straight line. (b) The drawing illustrates a gray whale in good body condition by noting the robustness of the area behind the blowholes and no appearance of the scapula. (Drawing by Ayesha Guzali). (c) Long time resident Whale # 22 in poor condition in 2003 as defined by the depressions behind the blowholes. A similar photograph of whale #22 was taken in 2005 (not shown). (d) The drawing illustrates the full extent of poor body condition. The bracketed areas in Figure 2c and Figure 2d show the depressions behind the blowholes. (Drawing by Ayesha Guzali). (e) Resident Whale #16 in Poor Condition in 2005 as seen by the protuberance of the scapula by the back. Note in Figure 2d the scapula as seen from a whole body profile. The line between 2e and 2d points to the scapula protuberance.

**Table 1.** Interannual Comparison of Whale Behavior and Mysid Reproduction in 2003, 2004, and 2005 off the Central Oregon Coast[a]

| | 2003 | 2004 | 2005 |
|---|---|---|---|
| *Resident Whales* | | | |
| Observing Hours | 276 | 342 | 228 |
| Days Observing | 46 | 57 | 38 |
| Number of Resident Whales | 29 | 40 | 15 |
| Percent of Time of Whales in Residency, % | 83 | 88 | 20 |
| Percent of Time in Mysid Feeding, % | 81 | 86 | 19 |
| Percent of Whales in Poor Condition, % | 21 | 0 | 80 |
| *Mysids* | | | |
| Mean Number of Eggs/Female in May (n = 52) | 27 (5.48) | 19 (4.32) | 22 (4.34) |
| Mean Number of Juveniles/Female in May (n = 85) | 12 (2.74) | 15 (1.29) | 19 (1.58) |
| Mean Number of Eggs/Female in August (n = 67) | 31 (4.32) | 33 (1.59) | 0 |
| Mean Number of Juveniles/Female in August (n = 75) | 12 (1.3) | 20 (2.16) | 0 |

[a]Reproductive data on mysids reported as mean (std deviation).

## 4. Feeding Modes

[11] Resident gray whales exhibit two distinct feeding behaviors off the Oregon coast. While feeding on benthic swarms of mysids, the whales roll onto their right side with the left tail fluke sticking above the water surface. This is the most common feeding behavior displayed by the resident gray whales in this area. We documented the presence of mysids during this whale behavior, using opportunistic and systematic plankton tows, SCUBA surveys, echogram traces, and underwater video. This "mysid feeding mode" was also confirmed through analysis of whale feces. During the second, much less common feeding mode, the whales swim at the surface with the mouth slightly agape. This "skim feeding mode" collected crab larvae, which was confirmed with plankton net tows.

## 5. Results

[12] Using the criteria mentioned above, 33 gray whales have been identified as residents during the summer field season (May–October) from Lincoln City to Seal Rock, Oregon between 2000 and 2005 [*Newell*, 2005]. Of these 33 whales, 28 (85%) have returned during the last three years (2003–2005). Two calves from 2004 did not return and three other resident adult whales were last seen in the area in 2002. In 2005, only 15 gray whales were observed in the study area compared to 40 in 2004 and 29 in 2003.

[13] Whales were observed for approximately six hours per day from 38–56 days per field season. Mysid feeding was the primary feeding mode observed, with over 80% of the feeding time spent in this feeding mode in 2003 and 2004. In contrast, less than 20% of the feeding time was spent in this feeding mode in 2005 (Table 1). A secondary feeding mode, skim feeding on porcelain crab larvae, accounted for less than 2% of the feeding time in all years.

[14] In 2003 and 2004, most of the whales seen exhibited mysid feeding behavior (n = 29–40) and an average of one month residency. Less than 20% of the resident gray whales passed through the area without feeding. In 2005, however, 80% of the resident whales passed through the area without displaying feeding behavior (Table 1). Only three resident whales were observed feeding on mysid swarms from late May through early August in 2005. Most of the returning resident gray whales swam slowly through previously productive areas two to three different times during the field season, but did not stop to feed. As will be described below, mysid biomass was extremely low from June to early August in the same areas where abundance was high in 2003 and 2004 (Figure 3). It wasn't until mid August that several whales began maintaining residence in the different feeding localities around Depoe Bay. By late August 2005, mysid swarm biomass approached levels of abundance seen in 2003 (Figure 3).

[15] The body condition of resident whales varied considerably between 2003, 2004, and 2005. In 2003, 20% of the resident whales entered the area in poor condition, with both the scapula showing and depressions behind the blowhole (Figures 2c, 2d, and 2e). In 2004, no whales were in poor condition (see Figures 2a and 2b). In striking contrast, 80% of the whales entering the study area in 2005 were judged to be in poor body condition (Table 1).

[16] Prey availability for gray whales was unusually low in early summer 2005, as indicated by mysid swarm thickness along a line from Government Point to North Point (see Figure 1 inset). From June to August 2003 and in August 2005, mysid swarms were 2 m thick, based on echogram traces. During 2004, mysid swarms were nearly 5 m thick in this area. In contrast, in June 2005, mysids were found only at Government Point in a small swarm only 0.3 m thick (Figure 3). The thickness of mysid swarms along this line in June 2005 was significantly less than

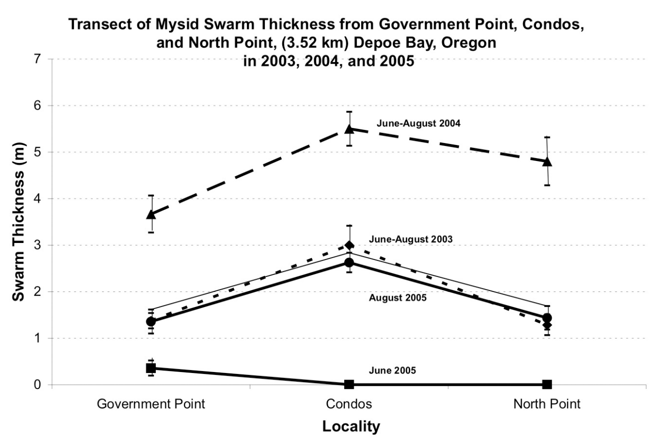


**Figure 3.** Mean mysid swarm thickness in 2003, 2004, and 2005 along a transect line from Government Point to North Point, Depoe Bay, Oregon. Error bars represent ±1 std dev.

found in either 2003 or 2004 (t-test, $p < 0.001$). The swarm thickness in August 2005 had recovered to levels statistically indistinguishable from those in 2003.

[17] Gray whales exhibited characteristic mysid feeding behavior throughout June, July and August in 2003 and 2004 along this survey line. In June and July 2005, however, no resident whales were seen foraging at North Point and only one whale was seen foraging at the Condos and Government Point in July of 2005.

[18] Between 2000–2004, the only species of mysid found along this portion of the Oregon coast was *Holmesimysis sculpta.* Examination of preserved samples from 2000–2004 (June to September) has revealed that *H. sculpta* females carry 20–30 eggs or10–20 juveniles in the brood pouch (Table 1). Those same 2000–2004 samples showed that all females had brood pouches containing eggs or juveniles. In early May 2005, *H. sculpta* females had eggs and young in their brood pouches, but by August all collected females had empty brood pouches. This reproductive pattern was a significant departure from the patterns observed between 2000–2004.

## 6. Discussion

[19] The California Current system in 2005 displayed several unusual conditions, including delayed upwelling and reduced surface chlorophyll concentration [*Thomas and Brickley*, 2006], elevated sea surface temperatures [*Kosro et al.*, 2006; *Pierce et al.*, 2006], depressed productivity through July [*Brodeur et al.*, 2006] and complex ecosystem responses [*Sydeman et al.*, 2006]. Our results indicate that the predator/prey interaction between gray whales and mysids also responded to this large scale phenomenon.

[20] Nearshore Oregon coastal waters, from 2 m to 15 m water depth, possess spatially distinct swarms of mysids. Our results show that mysids were less abundant in early summer 2005 than in previous summers, and that the late summer reproductive condition of the female probably reflected food limitation in early summer. As discussed by *Schwing et al.* [2006], both the timing and the intensity of seasonal upwelling are critical factors in ecosystem productivity. Our data suggest that mysid biomass was linked to the delayed onset of upwelling. Given that mysids are the dominant prey item for resident gray whales, fluctuations in mysid biomass may directly affect gray whale residency.

[21] Previous studies have documented the impact of temperature and food variability on mysid growth and physiology [e.g., *Mauchline*, 1980; *Turpen et al.*, 1994]. Temperature can have a strong effect on mysid abundance. Decreased abundance of *H. costata* in 1990 appeared to be correlated with increased temperature [*Turpen et al.*, 1994]. Since mysids have about a two-month lag period from the time of initial brooding to release of juveniles, recruitment into the population will represent a delay. This was seen in our data with females carrying juveniles in the marsupium in May, a reflection of ocean conditions two months earlier. *Thomas and Brickley* [2006] showed a slight rise in chlorophyll levels in February and early March. This may have given the mysids enough food for reproduction. The lack of eggs or juveniles in early August reflects ocean conditions in June since mysids brood their young for 65–73 days [*Turpen et al.*, 1994]. With less food available in early summer, mysids may have invested less energy towards reproduction than in normal years. This contrasts with observations of other years with earlier onset of upwelling where mysids had full brood pouches throughout the summer. *Kosro et al.* [2006] documented late spring and early summer surface temperatures 3–5°C above normal in 2005 and *Pierce et al.* [2006] documented the warmest temperature ever recorded at NH-5 in July, 6.2° above the average. The response by the mysids likely reflects some combination of lack of food and decreased reproductive effort due to increased temperature. The delayed onset of strong upwelling conditions until mid July [*Kosro et al.*, 2006], resulted in a later than average increase of phytoplankton biomass. Some mysid species have narrow physiological ranges for temperature, such that *Mysis relicta* in Trout Lake, Minnesota, did not tolerate temperature increases of $1°C\ d^{-1}$ [*Mauchline*, 1980]. We conclude that the impact of reduced reproduction in *H. sculpta* was shown by the decreased thickness of swarms in June and July of 2005 relative to 2003 and 2004. In 2003 and 2004, all swarms noted in Figure 1 were present but in 2005 only two of the regularly sampled locations had swarms. Full recovery to typical physical, biological and chemical conditions was observed by early August 2005 [*Hickey et al.*, 2006]. We also observed a recovery in the number and thickness of mysid swarms. In August, mean mysid swarm thickness was at the same level as in 2003 (Figure 3) and nine swarms were present (Figure 1).

[22] Gray whales demonstrated a local response to reduced prey availability by exhibiting a low proportion of mysid feeding behavior in early and mid summer of 2005 compared to 2003 or 2004. The small numbers of resident whales seen locally in 2005 (n = 15) (Table 1) suggest that fewer whales were in the larger region of the coastal northeast Pacific than in 2003 (n = 29) or 2004 (n = 40). As noted in Table 1, the majority of residents in 2005 passed through the region without feeding. Furthermore, the relative large percentage of 2005 residents that exhibited poor body condition suggests that a nutritional deficit had developed while the whales migrated through a broad geographic region. A similar effect of food limitation was hypothesized by *LeBoeuf et al.* [2000] to explain the thinner than average blubber layers on whales off the Oregon/Washington coast that had experienced reduced food supplies in the Bering Sea during the 1997–1998 El Nino. In Newfoundland and on Georges Bank, humpback and fin whale numbers and residency times were significantly correlated with prey abundance [*Whitehead*, 1981; *Paine et al.*, 1986]. In 1984, in the Bay of Fundy, the density and quality of prey patches affected both the number of right whales and their length of stay in the area [*Murison and Gaskin*, 1989].

[23] Since baleen whales must harvest their entire year's energy requirement in four to six months, consistent availability of prey during this feeding season is essential for deposition of the lipid and protein required for maintenance and reproduction [*Murison and Gaskin*, 1989]. Disruption of feeding habitat by large scale ecosystem change can have significant impact on upper trophic levels, as has been documented in 2005 for auklets [*Sydeman et al.*, 2006] and for sea lions [*Weise et al.*, 2006].

[24] A dramatic example of such a response by gray whales was examined by *LeBoeuf et al.* [2000]. The 1997–1998 El Nino brought higher temperatures and reduced productivity in the Gulf of Alaska and the Bering Sea, one consequence was the mortality of nearly 300 gray whales in 1999, twice the number that died in 1998. It was hypothesized that higher than normal sea surface temperatures in the Bering and Chukchi Seas in 1997 may have caused a decrease in amphipod biomass. The decline in prey biomass may have weakened the physiological condition of gray whales, and likely contributed to the aberrant migration patterns and increased mortality observed in these whales in 1999. While no evidence of gray whale mortality was observed off Oregon in 2005, the number of resident whales in poor body condition suggests that feeding conditions across the coastal waters of the northeast Pacific were not favorable.

[25] Our results indicate the need to characterize the complex ecosystem linkages that exist in nearshore waters and to understand the response of those ecosystem components to environmental variability across a wide range of spatial scales. Warmer surface waters and delayed upwelling significantly perturbed the mysid – gray whale interaction in 2005, reinforcing the key role of climate variation on ecological processes in this region [*Peterson and Schwing*, 2003]. We suggest that the connection between lower and upper trophic level observations provide a unique perspective on the impacts of climate variability.

[26] **Acknowledgments.** We thank Ayesha Guzali for the gray whales illustrations, and acknowledge grants from Mamie Markum Foundation and Holt Education Grants. Thanks to captains and crew of Dockside Charters, Zodiac Tours, Zodiac Adventures, Whale Research Excursions and Tradewind (all from Depoe Bay, OR), and Seagull Charters and Discovery Tours (Newport, OR) for platform support to photograph whales and sample mysids.

## References

Brodeur, R. D., S. Ralston, R. L. Emmett, M. Trudel, T. D. Auth, and A. J. Phillips (2006), Anomalous pelagic nekton abundance, distribution, and apparent recruitment in the northern California Current in 2004 and 2005, *Geophys. Res. Lett.*, *33*, L22S08, doi:10.1029/2006GL026614.

Calambokidis, J., G. Gosho, P. Gearin, J. Darling, W. Megill, M. Heath, D. Goley, and B. Gisborne (2002), Gray whale photographic identification in 2001: Collaborative research in the Pacific Northwest. Final report to the National Marine Mammal Laboratory, Natl. Mar. Mammal Lab., Seattle, Wash.

Dunham, J. S., and D. A. Duffus (2001), Foraging patterns of gray whales in central Clayoquot Sound, British Columbia, Canada, *Mar. Ecol. Prog. Ser.*, *223*, 299–310.

Dunham, J. S., and D. A. Duffus (2002), Diet of gray whales (*Eschrichtius robustus*) in Clayoquot Sound, British Columbia, Canada, *Mar. Mammal Sci.*, *18*, 419–437.

Feder, H. M. (1981), The infauna of the northeastern Bering and southeastern Chukchi seas, final report to NOAA, *R. U. 5*, 117 pp., Inst. of Mar. Sci., Univ. of Alaska, Fairbanks, Fairbanks, Alaska.

Hickey, B., A. MacFadyen, W. Cochlan, R. Kudela, K. Bruland, and C. Trick (2006), Evolution of chemical, biological, and physical water properties in the northern California Current in 2005: Remote or local wind forcing?, *Geophys. Res. Lett.*, *33*, L22S02, doi:10.1029/2006GL026782.

Highsmith, R. C., and K. O. Coyle (1992), Productivity of arctic amphipods relative to gray whale energy requirements, *Mar. Ecol. Prog. Ser.*, *83*, 141–150.

Kosro, P. M., W. T. Peterson, B. M. Hickey, R. K. Shearman, and S. D. Pierce (2006), Physical versus biological spring transition: 2005, *Geophys. Res. Lett.*, *33*, L22S03, doi:10.1029/2006GL027072.

LeBoeuf, B. J., H. J. Perez-Cortes, R. Urban, B. R. Mate, and F. U. Ollervides (2000), High gray whale mortality and low recruitment in 1999: Potential causes and implications, *J. Cetacean Res. Manage.*, *2*(2), 85–99.

Mauchline, J. (1980), The biology of mysids and euphausiids, *Adv. Mar. Biol.*, *18*, 3–681.

Murison, L. D., and D. E. Gaskin (1989), The distribution of right whales and zooplankton in the Bay of Fundy, Canada, *Can. J. Zool.*, *67*, 1411–1420.

Nerini, M. (1984), A review of gray whale feeding ecology, in *The Gray Whale Eschrichtius robustus*, edited by M. L. Jones, S. L. Swartz, and S. Leatherwood, pp. 423–450, Elsevier, New York.

Newell, C. (2005), *A Guide to Resident Gray Whales Along the Oregon Coast*, 73 pp., Nature Unlimited, Ink, Eugene, OR.

Paine, P. M., J. R. Nicolas, L. O'Brien, and K. D. Powers (1986), The distribution of the humpback whale, *Megaptera novaeangliae*, on Georges Bank and in the Gulf of Maine in relation to densities of the sand eel, *Ammodytes americanus*, *Fish. Bull.*, *84*, 271–277.

Peterson, W. T., and F. B. Schwing (2003), A new climate regime in northeast pacific ecosystems, *Geophys. Res. Lett.*, *30*(17), 1896, doi:10.1029/2003GL017528.

Pierce, S. D., J. A. Barth, R. E. Thomas, and G. W. Fleischer (2006), Anomalously warm July 2005 in the northern California Current: Historical context and the significance of cumulative wind stress, *Geophys. Res. Lett.*, *33*, L22S04, doi:10.1029/2006GL027149.

Schwing, F. B., N. A. Bond, S. J. Bograd, T. Mitchell, M. A. Alexander, and N. Mantua (2006), Delayed coastal upwelling along the U.S. West Coast in 2005: A historical perspective, *Geophys. Res. Lett.*, *33*, L22S01, doi:10.1029/2006GL026911.

Sydeman, W. J., R. W. Bradley, P. Warzybok, C. L. Abraham, J. Jahncke, K. D. Hyrenbach, V. Kousky, J. M. Hipfner, and M. D. Ohman (2006), Planktivorous auklet *Ptychoramphus aleuticus* responses to ocean climate, 2005: Unusual atmospheric blocking?, *Geophys. Res. Lett.*, *33*, L22S09, doi:10.1029/2006GL026736.

Thomas, A. C., and P. Brickley (2006), Satellite measurements of chlorophyll distribution during spring 2005 in the California Current, *Geophys. Res. Lett.*, *33*, L22S05, doi:10.1029/2006GL026588.

Turpen, S., J. W. Hunt, B. S. Anderson, and J. S. Pearse (1994), Population structure, growth and fecundity of the kelp forest mysid *Holmesimysis costata* in Monterey Bay, California, *J. Crustacean Biol.*, *14*(4), 657–664.

Weise, M. J., D. P. Costa, and R. M. Kudela (2006), Movement and diving behavior of male California sea lion (*Zalophus californianus*) during anomalous oceanographic conditions of 2005 compared to those of 2004, *Geophys. Res. Lett.*, *33*, L22S10, doi:10.1029/2006GL027113.

Whitehead, H. P. (1981), The behavior and ecology of the humpback whale in the northwest Atlantic, Ph.D. thesis, Cambridge Univ., Cambridge, U. K.

T. J. Cowles and C. L. Newell, College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331-5503, USA. (tjc@coas.oregonstate.edu)