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Gray Whale Feeding in a Northern California Estuary

Abstract

During the summer of 1989 a gray whale, *Eschrichtius robustus*, was discovered feeding in the Klamath River estuary of northern California. Distinct feeding behavior and feeding excavations were observed. Prey items were determined using SCUBA and hand-held core samplers. The tube-dwelling amphipod *Corophium spinicorne* was found in dense aggregations. The whale appeared to concentrate its feeding where amphipods were most dense. These findings suggest that gray whales feed selectively on benthic infauna during the summer months as far south as northern California.

Introduction

Gray whales, *Eschrichtius robustus*, migrate along the coast of California to and from their primary summer feeding grounds in the Bering and southern Chukchi Seas (Rice and Wolman 1971). In these arctic feeding areas the gray whale's major prey item is the benthic tube-dwelling amphipod *Ampelisca macrocephala* (Nerini 1984). Gray whales are known to summer along the coasts of British Columbia, Washington, Oregon, and California (Dohl *et al.* 1981, Darling 1984, Nerini 1984) and apparent feeding behavior has been observed. However, most of these reports have not documented prey items or feeding on benthic infauna (animals which inhabit bottom sediments) in areas south of Vancouver Island, British Columbia (Dohl *et al.* 1981, Oliver *et al.* 1984, Kim and Oliver 1989).

During the summer of 1989, we observed two gray whales in the mouth of the Klamath River estuary in northwestern California. This study describes the feeding activities of one of these whales and documents bottom substratum and prey.

Study Area and Methods

The Klamath River estuary is partially bounded on the west by a sand spit and on the northeast by a high-relief shoreline partly strewn with large boulders which provide several excellent vantage points from which to observe the whales (Figure 1).

Behavioral data are based on observations, of an approximately eight-meter-long juvenile, made during July and August 1989. Local residents reported occasional sightings of a second, larger, gray whale for two days in July; however, we did not confirm the presence of another whale until September. We observed and photographed the smaller whale from the bluffs, the sand spit, and by kayak. Its distinctive dorsal and rostral markings made it individually recognizable. We recorded its general behavior, movement patterns, dive times, surface intervals, and the number of blows per surfacing (Wursig *et al.* 1986). General behavior was categorized as feeding, traveling, resting, or other. Feeding was defined as repeated dives in specific areas, the whale often rolling on its side, and surfacing while trailing sediment plumes from its mouth (Nerini 1984).

On 27 July a free-diving survey of the estuary, consisting of four transects (Figure 1), revealed that the top layer of bottom sediment was composed of a dense aggregation, or mat, of tube-dwelling amphipods. This mat was bisected in the middle by a somewhat poorly defined natural channel. During the survey we photographed and recorded the presence and appearance of the amphipod tube mat, other organisms, substratum type and water depth. On 8 August marker buoys and SCUBA were also utilized to investigate the bottom in specific areas where the whale was observed to be concentrating feeding effort.

In two areas of the estuary we used SCUBA to collect random core samples penetrating the bottom sediment to a depth of three centimeters below the bottom layer of the amphipod tubes (Figure 1). The first group of four cores ("channel samples"; 0.0050 square meters each) was obtained between the estuary channel and sand spit. The

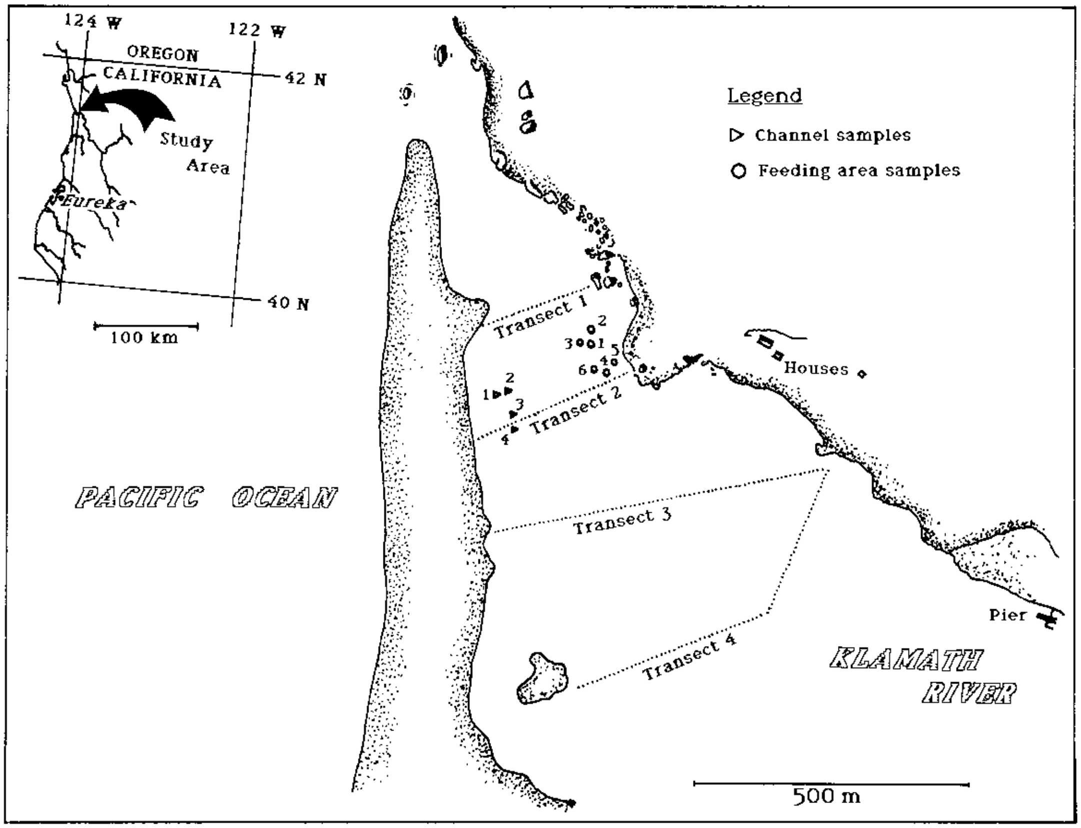

Figure 1. Study area. The mouth of the Klamath River.

second group of six cores ("feeding area samples"; 0.0042 square meters each) was collected in an area of observed gray whale feeding. Two of these samples were obtained within recent feeding excavations ("disturbed area samples"). The remaining four of the feeding area samples were taken from undisturbed areas of the tube mat and are so designated.

We preserved all samples in 5% buffered formaldehyde, and washed them over a 1.0 mm mesh screen. Infaunal organisms were removed from tubes and sediment, counted, and stored in 70% ETOH. Biomass was measured as wet weight of total infaunal organisms.

Results and Discussion

General Observations

The juvenile gray whale was initially observed in mid-July of 1989 and was seen intermittently in the Klamath as late as March of 1990, suggesting that it spent the winter in the river as well. Gray whales have been observed along the coast of northern California during the summer for years (Dohl *et al.* 1981, Mallonee 1991). To our knowledge, however, this is the first published account of an identified individual gray whale spending the summer off northern California.

We saw the gray whale daily spending long undisturbed periods foraging in the shallow waters of the estuary, usually within one-half mile of the mouth. It could move in and out of the river mouth, independent of tidal stage. It maintained a reasonably uniform series of movements within the estuary, usually swimming southward along the sand spit, then crossing the channel and making its way to the north along the opposite shoreline. The animal also made smaller loops at various places in the estuary, concentrating its feeding efforts in specific locations.

During a total of 47.5 hours of observations, the animal spent 58.1 percent of its time feeding, 29.3 percent traveling, primarily between feeding areas, 6.5 percent resting and 6.1 percent on other behaviors. The largest portion of feeding (52.5%) was concentrated along the northeast shore of the estuary, while feeding along the sand spit (36.2%) and elsewhere in the estuary (12.3%) was less common.

Respiration data collected on several different occasions revealed a remarkably consistent pattern of breathing and diving. Typically, a series of two to four respirations (blows) with relatively short blow intervals would be followed by a dive ranging from two to five minutes. The number of blows per surfacing, the surface interval, and the dive lengths showed little variation during the course of the study.

Benthic Survey

The underwater survey of the estuary bottom, ranging from 1 m depth near shore to 6 m depth in mid-channel, revealed a very extensive covering of amphipod tubes. The substratum generally consisted of fine sand or silt with occasional zones of sand and rocks. In the deeper channel sediments, amphipods were present though their tubes were least evident. An examination of the feeding area (depths of 2.5 m to 3.5 m) revealed several recent gray whale feeding excavations as well as older pits being recolonized by amphipods. The recent pits were characterized by relatively clean, straight edges, exposed amphipod tubes along the sides, and few tubes within the pit. The sizes and shapes of the excavations (Figure 2) were similar to those observed in Pachena Bay, Vancouver Island, B.C. (Oliver *et al.* 1984) and in the Bering Sea (Nerini 1984). Depths of the excavations ranged from five to ten centimeters.

Core Samples

Analysis of the core samples (Table 1) showed that the infauna were strongly dominated by *Corophium spinicorne*, with a small number of other amphipods, mostly of the genus *Anisogammarus*. Isopods and mysids were also present in very low numbers. The tube-mat density (amphipods per square meter) was highest in the undisturbed part of the feeding area. In the disturbed area, two samples were taken within recent feeding excavations and contained very few amphipods.

Mean densities and biomasses for the amphipod tube mats in the Klamath River estuary are comparable to those reported for other places where gray whales feed (Table 1). Although the corophid amphipods in the Klamath have a similar biomass to that of the ampeliscid amphipods in the Bering Sea, they are much smaller. Mills (1967) reports lengths of 12 to 20 mm for adult *Ampelisca macrocephala*, whereas we found *Corophium* ranging from 2 to 9 mm. Smaller sizes would imply a greater surface-to-volume ratio, suggesting that a larger portion of the Klamath amphipod biomass may be chitinous exoskeleton. As

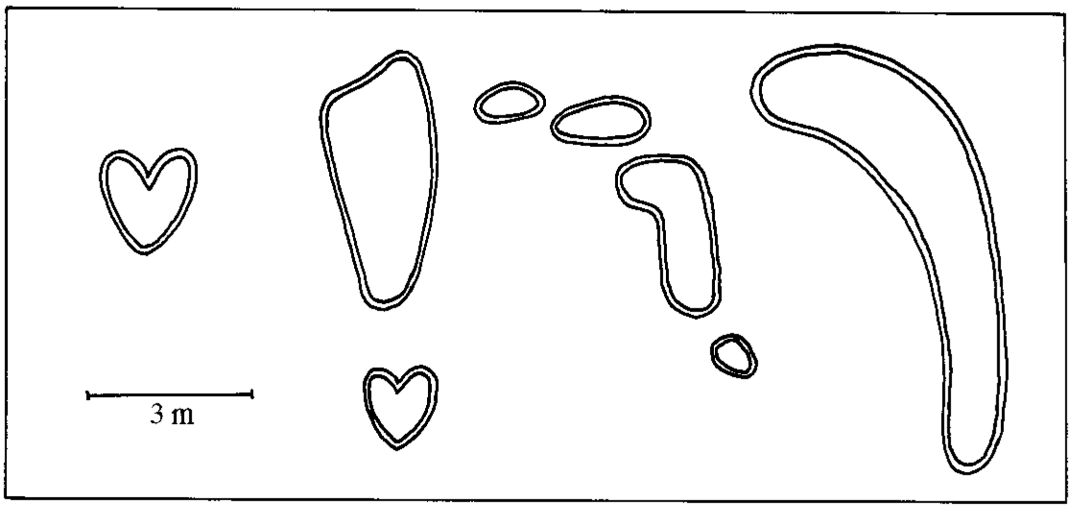

Figure 2. Gray whale feeding excavations observed in the mouth of the Klamath River located near the end of Transect 2 at depth of 2.5 meters.

TABLE 1. Mean infaunal densities (organisms/m²) and biomass (grams/m²) for this study as compared to other dense amphipod communities associated with gray whale feeding.

Location	Klamath Channel edge mean	(SD)	Klamath—Feeding area* Undisturbed mean	(SD)	Klamath—Feeding area* Disturbed mean	(SD)	Bering Sea (Oliver *et al.* 1983)** mean	(SD)	Pachena Bay, B.C. (Oliver *et al.* 1984)** mean	(SD)
Sample size		n = 4		n = 4		n = 2				
Corophium	50,700	(7,930)	84,300	(21,400)	7,260	(8,920)				
Other amphipods	7,300	(1,570)	5,540	(3,660)	476	(673)				
Isopods	100	(115)	1,370	1,680)	0					
Mysids	100	(200)	0		0					
Nematodes	850	(1,570)	950	(1,440)	476	(673)				
Total infauna	59,050	(8,900)	92,160	(18,900)	8,210	(10,300)	28,923	(8,041)	118,583	(45,220)
Total biomass (g/m²)	221	(23)	446	(105)	34	(45)	482	(226)	197	(71)

* Area of cores: channel edge—0.0050/m²; feeding area—0.0042/m². Volumes of samples are not calculated because, in all cases, the depth of the core penetrated to at least three centimeters below the level inhabited by amphipods.

** It should be noted that Oliver *et al.* washed their samples over a 0.5 mm mesh screen, whereas we washed the Klamath River samples over a 1.0 mm mesh screen. Because the organisms involved are relatively large and tend to remain in or cling to the amphipod tubes, this difference in screen mesh is not likely to affect the comparisons made here significantly.

lipid content is known to be quite variable in arctic amphipods (Percy and Fife 1981), determining the lipid content of corophids would be helpful in assessing the food value of the amphipod mats in the Klamath estuary.

The correlation between the intensity of the whale's feeding activity and the density of the corophid tube mats suggests that the whale may have been feeding selectively in areas with the greatest density of amphipods. Similar conclusions have been drawn from the observations of gray whale feeding in other areas (Oliver *et al.* 1984). It is also clear that the whale was very effective at removing the amphipods from the bottom as shown by the dramatically reduced amphipod densities within the excavations.

Conclusion

Our discovery of a gray whale feeding in a northern California estuary during the summer provides further evidence of a potentially increasing use of tertiary feeding grounds (areas other than the Bering and Chukchi seas), south of Vancouver, B.C. (Kim and Oliver 1989). As these animals rely, almost exclusively, on the food that they are able to obtain during the summer, an expansion of their summer range is dependent upon the presence of additional feeding areas where epibenthic or infaunal prey is available to them. It is very encouraging to learn that these animals can utilize estuaries, such as the Klamath River in California.

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