SURFACE FEEDING BY A JUVENILE GRAY WHALE, *ESCHRICHTIUS ROBUSTUS*

Recently Ray and Schevill (1974) summarized information on the feeding habits and feeding behavior of *Eschrichtius robustus*. The gray whale is primarily a bottom feeder whose diet consists mainly of six species of benthic gammaridean amphipods taken in the Bering and Chukchi Seas during the summer months (Zimushko and Lenskaya 1970; Rice and Wolman 1971). It is generally assumed that gray whales fast during migration and while at the breeding grounds along the Mexican coast. Several reports, however, suggest the possibility that feeding may occur occasionally outside of the Arctic region and may include a wide array of different food items, e.g., smelt, anchovylike fish; planktonic crustaceans—*Euphausia* and *Pleuroncodes* (Howell and Huey 1930; Matthews 1932; Gilmore 1961; Balcomb in Ray and Schevill 1974). In addition to these, reports of bits of woods, stones, tube worms, shell, etc., including kelp fragments have been reported in stomach contents of gray whales (Tomilin 1957). However, most of these items are probably attributable to incidental swallowing.

Herein we report observations made on a juvenile gray whale,[1] ca. 6-m long, exhibiting unusual surface feeding behavior in a kelp, *Macrocystis angustifolia,* bed near Refugio Beach State Park, 38 km west of Santa Barbara, Calif. Between 1 and 9 April 1976, four visits were made to the area and a total of 8 h were spent detailing the observed behavior. Throughout the study period the whale's activities were confined to the extensive kelp bed situated between Refugio Beach State Park and Arroyo Hondo—a distance of 3.2 km. This feeding activity was restricted to the kelp canopy and occurred in shallow water (<5-10 m depth) and 50 to 200 m offshore. We last saw the whale on 9 April 1976. Apparently it left the area shortly thereafter as subsequent searches were made on 16 and 18 April 1976.

Description of Feeding Behavior

When first sighted, the whale's head was protruding a meter or more above the surface of the water in the center of a dense kelp bed (Figure 1A). Shortly after surfacing snout first, its mouth opened and a large volume of water and kelp flowed into the oral cavity (Figure 1B). Next the jaws closed (Figure 1C) and in the process a small squirt of "excess" water issued from the most anterolateral margins of the mouth. Within moments entrapped water was forced out of the mouth across the baleen plates through the lips in a strong flush directed posterolaterally (Figure 1D). This sequence was repeated several times before the whale submerged. Prior to submerging, the head was raised at an angle approximately 60° normal to the surface of the water. The body then slid backwards through the kelp canopy with its jaws slightly agape releasing the kelp present in its mouth. Resurfacing generally occurred a short distance away. There was little deviation from this pattern during the entire observation period. Visits were made at all hours of daylight during which the intensity of the feeding behavior appeared consistent.

During a typical 27-min period when the whale was exhibiting feeding behavior, we noted that it emerged in the kelp, fed, submerged, and then reemerged a total of 18 times. A single feeding-submergence interval averaged 90 s, of which 56 s were spent feeding and 34 s submerged. Frequency of breaths during this period were recorded for 11.5 min. The average time from inhalation to exhalation was 48 s; the maximum was 70 s and the minimum 20 s. The act of breathing (i.e., exhaling, then inhaling) at the surface averaged 2 s. These data clearly demonstrate that the whale was quite active in its behavior.

At first impression the whale appeared to be "biting and eating" the kelp, but on closer inspection the fronds and stipes of the kelp incurred little if any damage. While there is no direct evidence available from stomach analyses, we suggest the whale's activities among the kelp were directed to procuring quantities of the small kelp mysid crustacean, *Acanthomysis sculpta.* Sampling of the mysid fauna was accomplished using a 50-gal plastic trash can which was lowered into the water at a horizontal angle from the boat in such a fashion that the surface water down to 30 cm flowed freely into the container. The mysids were subsequently filtered out, counted and volume determinations made. A total of four replicates provided a conservative estimate of 5 to 10 mysids/l at the canopy surface. The size range for individual mysids in our sample was 6 to 12 mm,

[1]On a number of occasions the whale laid nearly horizontal on the surface of the water only a meter from our boat (7-m Boston Whaler), thus we were able to make a reasonably accurate estimate of it's overall length. Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

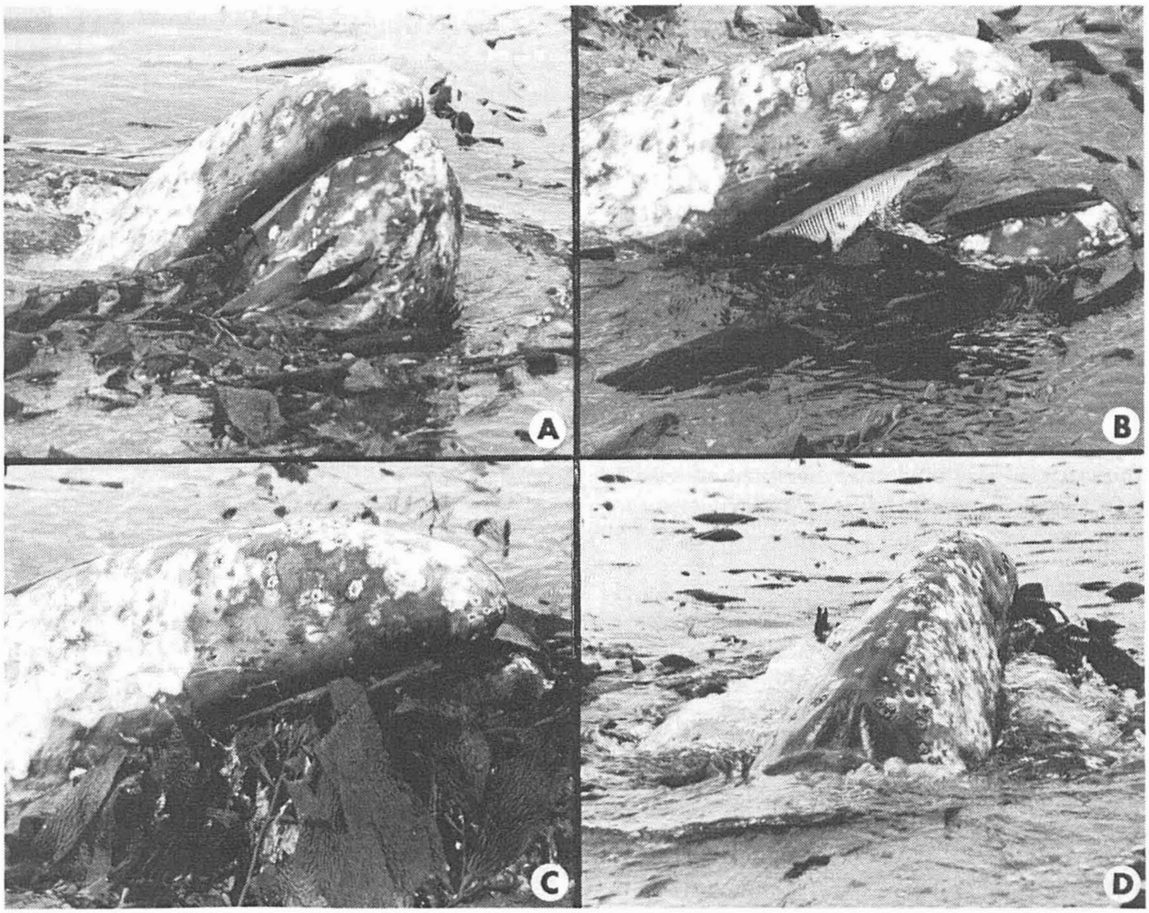

FIGURE 1.—Time sequence photographs showing the observed feeding behavior: A, the gray whale first emerging in the kelp canopy; B, jaws extended open allowing surface water to enter mouth; C, mouth closed entrapping water and kelp fronds; D, water expelled through baleen in posterolateral direction.

which falls well within the size range of the gammaridean amphipods reportedly composing 95% of the whale's diet in Arctic seas (Rice and Wolman 1971).

In addition to these observations, we noted that during feeding, water was expelled predominately through the right side of the mouth. Kasuya and Rice (1970) found that of 34 whales examined, 31 showed disproportionate wear of the baleen on the right side. Analysis from movie footage (8 mm) taken by us shows that of 31 consecutive expulsions, water passed exclusively from the right side 20 times—in the remaining cases it was passed equally or nearly equally from both sides. At no time, however, was the water expelled on the left side exclusively. It is not clear what causes the wear on the baleen plates; perhaps it is unequal mechanical rubbing action of the tongue pushing water through the plates. Possibly related to this are observations made by Ray and Schevill (1974) on the captive juvenile gray whale, Gigi. At first this whale was hand fed by her trainers on the left side exclusively. Later, after hand feeding was discontinued and feeding became voluntary, food continued to be ingested solely on the left side.

Interpretations and Conclusions of Observations

Several aspects concerning the physical characteristics of our whale are worthy of comment. The mean length at birth (January) for a normal gray whale is reported to be ca. 4.9 m and by the time of weaning (August), the animal can be expected to reach a total length of 8.5 m (Rice and Wolman

1971). The size of our whale (ca. 6 m) would indicate a juvenile at the nursing stage. However, during our observations no large whale was noted in the vicinity which could have been interpreted as a parent. Thus we suggest that this animal may be a yearling runt. Further evidence in support of this notion is the fact that the epizoic barnacles (*Cryptolepas rhachianecti*) were of a large class (>2.5 cm), too large to be considered 4 to 5 mo of age, which would be the approximate age of the whale were it born in the most recent calving season. Also, since all barnacles were of only one distinct size class we further suggest that the whale we observed had not been south to the breeding grounds this year (1975-76). Rice and Wolman (1971) stated that northbound whales have two distinct size classes of barnacles, one adult and one juvenile (2-3 and 0.3-0.5 cm in diameter, respectively).

We can only speculate on the events which may have occurred prior to our observations (e.g., abandonment or loss of the mother during the northbound journey in the previous year and consequent exploitation of an alternative food source, i.e., kelp mysids by a preweaned juvenile whale). However, we have been able to ascertain by comparative photographic analysis of barnacle scar patterns (Figure 2) that this whale was present in the San Diego area (approximately 320 km south of Santa Barbara) from early January to early February 1976 (P. Zovanyi and H. Hall pers. commun.)—just over 4 mo prior to our encounter in April.

In conclusion, this report would seem to indicate that gray whales can display plasticity in their feeding behavior. While conclusive evidence of feeding is lacking (i.e., gut content analysis), this appears to be the most logical explanation accounting for this unusual behavior.

Acknowledgments

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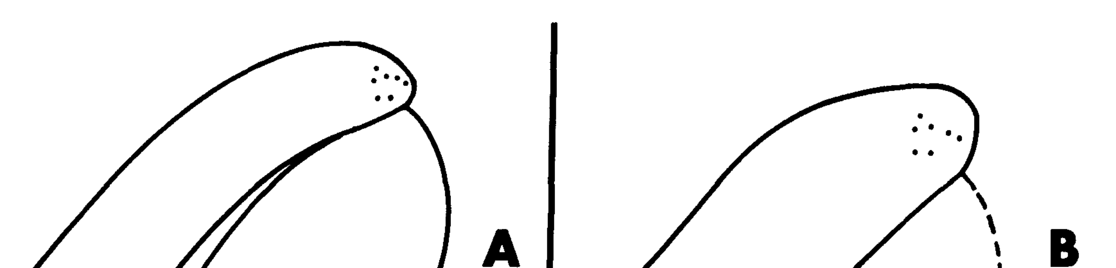

FIGURE 2.—Line drawings of barnacle scar patterns on a gray whale: A, after Figure 1A, seven barnacle scars on the gray whale seen in Santa Barbara in April 1976; B, drawn from photograph taken by H. Hall (Graves 1976) of a gray whale seen in San Diego in January 1976. The same seven barnacle scars are evident.

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HOMING OF MORPHOLINE-IMPRINTED BROWN TROUT, *SALMO TRUTTA*

Homing for the purpose of spawning is well documented for lake-run brown trout, *Salmo trutta* (Stuart 1957; Niemuth 1967), but the mechanism by which they find their natal tributary is not understood. Our own recent studies on related species—coho salmon, *Oncorhynchus kisutch,* and rainbow trout, *Salmo gairdneri*—suggest that they become imprinted to the odor of their natal tributary when they begin their downstream migration and later use this information for homing (Hasler and Wisby 1951; Scholz et al. 1973, 1975, 1976; Cooper and Scholz 1976; Cooper et al. 1976). In these experiments 18-mo-old hatchery-raised fish were exposed to a synthetic chemical, morpholine, for 40 days and then stocked in Lake Michigan. During the spawning migration the fish homed to a simulated home stream which was scented with morpholine. Since the life cycle of migratory brown trout is similar to that of coho salmon and rainbow trout, we conducted the present study to determine if odor imprinting could be extended to brown trout. The methods used in this study were similar to procedures reported by Cooper and Scholz (1976) since both experiments were conducted concurrently.

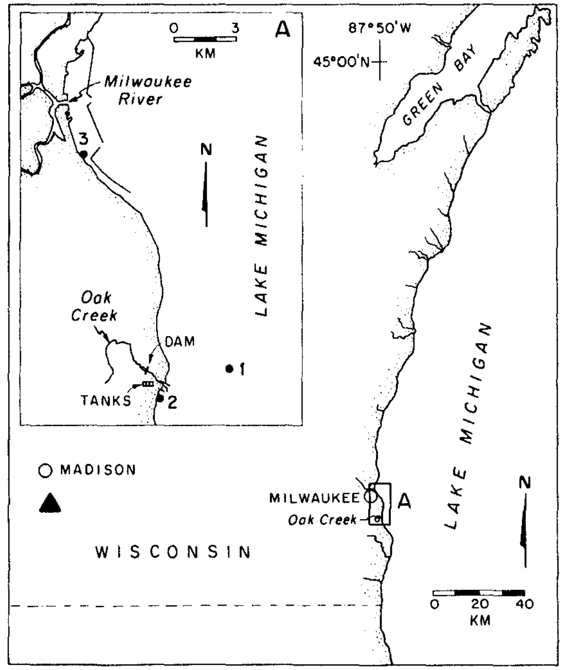

FIGURE 1.—Research area, South Milwaukee, Wis. (after Cooper et al. 1976). The solid triangle indicates the location of the hatchery where the fish were reared. Inset (A) shows detail of: 1) the water intake for the tanks at the South Milwaukee Water Filtration Plant, 2) the Oak Creek stocking site, and 3) the Milwaukee Harbor stocking site.

Methods

In 1972, hatchery-raised, 18-mo-old brown trout fingerlings were transported to South Milwaukee, Wis. (Figure 1). The fish were marked with fin clips, divided into three groups of 300 each, and held in separate tanks at the South Milwaukee Water Filtration Plant. Lake Michigan water was supplied to all three tanks from an intake crib located 1.5 km offshore. Morpholine (C_4H_9NO) was metered into one tank for 34 days in May and June. This period was selected because it is the time when brown trout would normally begin their downstream migration (Stuart 1957; Niemuth 1967). A concentration of 5×10^{-5} mg/l morpholine was maintained in the tank throughout the exposure period.

The morpholine-exposed group and one unexposed control group were then stocked in Lake Michigan at Milwaukee Harbor, 13 km north of Oak Creek (Figure 1). The second control group was released at the mouth of Oak Creek. During the spawning migration in fall 1972 and 1973, morpholine was metered into Oak Creek at the same concentration used for imprinting. The stream was surveyed for marked fish by gillnetting, electrofishing, and creel-census methods (summarized in Table 1). Fish were unable to move past a dam situated 1.5 km from the mouth. Surveys began before the spawning migration started and continued until no fish were left in the river. The results are recorded in Table 2.