OBSERVATIONS ON PACIFIC CETACEANS OF CALIFORNIAN AND MEXICAN WATERS

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INTRODUCTION

The cetaceans are possibly the world's least-known major group of mammals, at least with respect to ecology and behavior. This dearth of knowledge stems directly from the difficulties of observing these fleet aquatic mammals. In the past, knowledge has been derived largely from the fragmentary observations of whalers and of a few biologists who spent long hours at sea waiting for the rare moments when these animals could be seen. Recently, several species of cetaceans have been observed in large salt-water viewing tanks, or oceanaria. The result has been a very significant increase in knowledge of some of the smaller cetaceans (see, e.g., McBride, 1940; McBride and Hebb, 1948; Kritzler, 1952; Essapian, 1953; Schevill and Lawence, 1953; Brown and Norris, 1956; Tavolga and Essapian, 1957). Most of this new literature deals with a single species, the Atlantic bottlenose porpoise, *Tursiops truncatus* (Montagu), which must now be classed as the best-known cetacean species.

At Marineland of the Pacific the normal operations of capture and maintenance of cetaceans for exhibit have afforded remarkable opportunities for observation of several of the smaller Pacific coast species. For five years we have systematically gathered information of every available kind related to these animals. Fifteen species have been observed in sufficient detail to be considered here. These are *Ziphius cavirostris* Cuvier, *Stenella euphrosyne* (Gray), *Delphinus bairdi* Dall, *Tursiops truncatus* (Montagu), *Tursiops gilli* Dall, *Lissodelphis borealis* (Peale), *Lagenorhynchus obliquidens* Gill, *Orcinus orca* (Linnaeus), *Pseudorca crassidens* (Owen), *Globicephala scammoni* Cope, *Phocoena phocoena* (Linnaeus), *Phocoena sinus* Norris and McFarland, *Phocoenoides dalli* (True), *Eschrichtius glaucus* (Cope), and *Balaenoptera acutorostrata* Lacépède.

Even with our unusual opportunities for cetacean study, the bulk of our information has come from chance observations of short duration. As a result, our observations are mostly fragmentary, and are of many different kinds. Probably, understanding of cetacean ecology will continue to be built up in this unsystematic piecemeal fashion, particularly for species of little commercial or exhibition value. We have arranged these diverse data by species, utilizing the phylogenetic scheme and nomenclature of Miller and Kellogg (1955), except where otherwise noted. A uniform series of subheadings has been used under each species. Information on two classes of behavior, *coöperative behavior* and *assisted locomotion*, so often crossed species lines that they seemed to require separate consideration and are presented first.

Acknowledgments

Many people have helped us in gathering the observations involved in this report. Most important has been the help of the crew of the Marineland collecting vessel

Geronimo. Captain Frank Brocato and his able assistant Frank Calandrino are both keen and accurate observers, and have gathered much of the information presented here. We also wish to thank David H. Brown, Donald Hackett, Arthur Kelly, the late Conrad Limbaugh, William N. McFarland, and Wheeler North for observations reported here. John Evich, captain of the purse seiner *Clermont*, and Homer Moore, of the vessel *GM*, supplied us with specimens taken during fishing operations. We wish to thank John Fitch, senior research biologist of the California Department of Fish and Game, for identification of porpoise stomach contents listed in tables 6 and 13. Ira Cornwall provided identification of parasitic barnacles found on *Lagenorhynchus obliquidens* and *Globicephala scammoni*, and Donald Heyneman has identified parasitic roundworms taken from *Phocoenoides dalli.* Thomas Lang, Howard Kelly, Moe William Rosen, and Andrew Fabula of the Naval Ordinance Test Station, China Lake, California, have given advice on certain of the hydrodynamic aspects of the paper. Carl L. Hubbs, William E. Schevill, G. A. Bartholomew, and James Kubeck have given valuable editorial advice during preparation of the manuscript. Finally, our thanks go to our faithful and skillful secretary, Mrs. Muriel Johnson.

COÖPERATIVE BEHAVIOR

It has become increasingly obvious in recent years that many species of cetaceans will offer assistance when a "schoolmate" becomes injured or otherwise unable to maintain normal locomotion. Usually this assistance consists of a normal animal or animals swimming with the incapacitated member, helping it stay at the surface, or actually taking it away from the apparent source of danger. The first recorded observation of this sort is found in the writings of Aristotle, set down twenty-four centuries ago (see Aristotle, p. 156). He noted a Mediterranean dolphin (possibly *Delphinus delphis* Linnaeus) supporting the body of a dead baby dolphin. Even very recently the existence of such behavior has been denied (Sanderson, 1956, p. 59), but evidence has begun to accumulate which shows that, in this particular, Aristotle was correct. McBride (1940) reported the case of a stillborn baby *Tursiops truncatus* that was carried to the surface and held there for an extended period by the mother. Hubbs (1953) reported an adult of the species *Tursiops gilli* carrying a decomposing baby porpoise on its dorsal fin, off Imperial Beach, San Diego County, California. Moore (1953) saw an adult of *Tursiops truncatus* carrying a disemboweled and partially decayed newborn young on its head in Whipray Basin of southern Florida. The observations of Hubbs and Moore suggest that the dead young had been carried, presumably by the mother, for a matter of days, and perhaps as long as a week or more. Hubbs (1953) also reports the coöperative behavior of *Lagenorhynchus obliquidens,* in which schoolmates attempted to force a harpooned individual away from its captors by swimming against it and by standing between it and the ship. Siebenaler and Caldwell (1956) give two examples of coöperative behavior in *Tursiops truncatus.* An adult of this species began to swim erratically after being stunned by an underwater explosion. Two other members of its school came up under the dazed animal and supported it. The coöperating animals took station below the stricken animal, one on each side, below each pectoral flipper. In the other instance, an adult of

T. truncatus was stunned while being lowered into a holding pen. The animal sank in 7 feet of water and was then raised to the surface by two other captives, who supported it in a manner similar to that described above until it recovered. Brown and Norris (1956) reported three instances in which stricken adults of the species *Lagenorhynchus obliquidens* or *Delphinus bairdi* were assisted by other porpoises who swam beneath them, forcing them toward the surface. The positions taken by the normal animals were not always like those reported by Siebenaler and Caldwell (1956). In one case the assisting animal swam in an inverted position, with its ventral surface against that of a weakened animal, and in another case a totally helpless animal was forced upward from a tank bottom on the rostrum of the assisting animal. Interspecific coöperative behavior was noted when a stricken adult male of *Lagenorhynchus obliquidens* was assisted by an adult female of the species *Tursiops truncatus.*

Several additional examples of coöperative behavior can now be added to these reports. First, what appears to be a peculiar aberration of this behavior was observed at Marineland of the Pacific on July 13, 1956. A large adult female of the species *Tursiops truncatus* was discovered pushing a 5-foot adult leopard shark (*Triakis semifasciata*) around the 80-foot diameter circular display tank. The animal, named Myrtle, repeatedly forced the shark to the surface by pushing it upward with her rostrum. The shark died after a day of this treatment. For the next 8 days Myrtle carried the dead shark on her rostrum, supporting it under its lower jaw (pl. 27, *a*). During this period Myrtle regularly brought the shark to the surface, released it, and then dived about 10 feet downward and retrieved the sinking carcass. The staff divers attempted to take the shark from her because its rough shagreen was rubbing the skin from her rostrum, but these attempts failed until the eighth day. Myrtle, who had fed very little during the time she carried the shark, at once resumed her normal feeding habits. When the shark was removed it was in an advanced state of decomposition.

Two more sharks were placed in the tank and both were quickly killed by the two resident male bottlenose porpoises. Myrtle picked up one of these dead sharks and carried it through part of the night of July 25. The shark was found on the floor of the tank next morning. Myrtle fed nearly normally during this final episode, in contrast to her behavior in the first instance. In both cases, when she fed she dropped her burden, took her food, and then retrieved the shark, usually before it had drifted to the bottom. Her persistence, and the fact that she placed herself on a starvation diet, seem to eliminate the possibility that this behavior was play.

Coöperative behavior of a more normal type is indicated by the observations of several Mexican fishermen from the port of San Felipe, Baja California Norte, Mexico. They reported seeing an adult "*tonina*" (presumably *Tursiops gilli*) a few miles south of this fishing village carrying a dead baby porpoise on its back. This report, received in May, 1958, was unsolicited.

On December 18, 1956, Frank Brocato, captain of the Marineland vessel, observed a group of about fifteen adult pilot whales (*Globicephala scammoni*) in the San Pedro Channel, off the coast of southern California. In one subgroup of three adults, one animal was shot and apparently killed instantly. The animal became rigid upon being hit and its momentum caused it to slide toward the vessel. When it came within about 8 feet of the ship's rail, 2 or 3 feet beneath the surface, the other two animals swam rapidly to it and placed their snouts on top of its head, one on each side of the stricken animal. Their snouts were estimated to be 6 inches apart and even with the tip of the dead animal's rostrum. In this position they forced the dead animal rapidly downward into the water and literally took it away from the ship. The group of animals was not seen again.

Later in the day, 300 yards off Ben Weston Point, Santa Catalina Island, a young pilot whale, estimated at 7 feet in length, was shot. It apparently died instantly and sank. A short time later an adult pilot whale brought the smaller animal to the surface. It was supported on the adult's head and seemed to lie crosswise, approximately over the larger animal's blowhole. The young animal was pushed almost completely out of the water by the adult. The next time the pair came to the surface the adult seemed to be holding the young animal by one of its flippers. Although observation was continued for forty-five minutes longer the pair was not sighted again.

On February 7, 1957, a school of about twenty-five pilot whales was encountered a mile north of the west end of Santa Catalina Island. The animals were proceeding in a westerly direction. One fairly large adult, apparently a female, was noted carrying the 4-foot partially decomposed body of what appeared to be a newborn baby pilot whale. We observed the pair for thirty minutes and were able to see clearly the head and pectoral flippers of the dead animal. Its skin was brownish-white, marked here and there with darker flecks. Our impression was that the dark superficial layers of the skin had almost all been eroded away, exposing the blubber beneath. The little animal was so flaccid that when the adult temporarily released it on the surface, wavelets could be seen passing unimpeded through its body. Each time the adult dived, the dead baby was carried down with it. Usually the baby was held by one of its little flippers, though on one occasion we were able to see both flippers of the carcass. It generally rested crosswise on the adult's melon. The skin of the adult's broad melon was itself distinctly white, we presume either from abrasion or from becoming coated by fat from the carcass.

On May 27, 1960, a pilot whale estimated at 15 feet in length, was seen in the San Pedro Channel carrying a dead foetus. The postition of the foetus was similar to that described for the February 7, 1957, sighting. However, it was not possible to tell if the adult animal held any part of the calf in its mouth, and the adult's melon was a normal blackish-brown.

On November 26, 1956, an adult male Dall porpoise (*Phocoenoides dalli*) was placed in Marineland's porpoise pool. The animal was badly frightened and apparently had undergone eye damage during capture. After battering itself against the tank wall for a while it sank passively toward the bottom. Before it reached the tank floor two adult females of the species *Lagenorhynchus obliquidens* swam to it and placed their snouts on its flanks at the posterior insertion of the pectoral flippers. With their bodies extending obliquely outward from its body at about 20°, they forced the stricken animal back to the surface. Only their snouts were in contact with the victim. The same behavior was noted again the following day. The positions of the three participating porpoises were strikingly similar to those noted for *Tursiops truncatus* by Siebenaler and Caldwell (1956).

Conrad Limbaugh, of the Scripps Institution of Oceanography, La Jolla, California, observed what may have been coöperative behavior among adult California gray whales (*Eschrichtius glaucus*) on January 20, 1958. Limbaugh and others noted a group of gray whales thrashing on the surface directly west of the Scripps Institution, 1.5 miles offshore in about 250 feet of water. Limbaugh's notes are quoted in part as follows:

As we approached, a fast-moving shiny black whale, approximately 10 feet long, with a large curved dorsal fin, left the group of gray whales and came toward our skiff. I believe this was a female killer whale [*Orcinus orca*], but could not be sure. Later on I saw this same whale or a very similar one several times near the main group (which proved to be composed of five gray whales). Two divers, Jimmy Stewart and Harold Scotten, also observed this animal or animals and noted a white patch behind the eye. At this time we could see bits of white material, suspended or sinking in the water, which later proved to be organisms scraped from the gray whale's skin.

After a few minutes it became clear that four gray whales, from 30 to 35 feet long, were buoying a larger animal (about 40 feet in length) and attempting to roll it over in the water. The smaller animals made free use of their flippers for supporting the large whale and pushed at it from below. Occasionally the larger whale would blow but made no movement with its pectoral flippers, which were flat against its sides. The feeble movements of its flukes may have been caused by turbulence from the activities of the other whales.

Twice the smaller whales rolled the larger animal away from us and started it moving along the surface at fair speed. At no time did the smaller whales make any attempt to sound or otherwise retreat.

Finally, when it seemed that all danger from possible killer whales was gone Jimmy Stewart and I entered the water close to the whales. Once beneath the surface we could see that two whales, one on top the other, supported the larger whale just in front of its midsection. A third animal joined these from below. The three fitted together so exactly that I can't help feeling that this was a normal behavior pattern. The fourth supporting whale was on the other side of the group. The group moved off in a southerly direction and when next observed the large adult was missing.

During our observations we could detect no injuries and there was no blood in the water. The largest whale was quite plump and may have been pregnant. All individuals supported considerable growths of external parasites and one had a ruffled pink growth along the trailing edge of one flipper.

Coöperative behavior in cetaceans is of obvious survival value and it is to be expected that other examples will come to light from time to time. Even a momentary disability might end in death by drowning unless the stricken animal is somehow raised to the surface. From the rather meager evidence now on hand it seems possible that cetaceans generally may possess coöperative behavior patterns useful in coping with a variety of emergency situations such as those occurring during injury, sickness, and birth.

ASSISTED LOCOMOTION

Most cetaceans swim through the water with remarkable ease and efficiency. The mechanisms of this locomotion are still imperfectly known. Gray (1953) and Gero (1952) give some idea of the efficiency of porpoise and fish locomotion when they suggest that these animals approach a laminar boundary layer during swimming. Kelly (1959) says: "Furthermore, it is well known that the streamline body of a porpoise shows no evidence of flow separation, and that the very narrow wake consists principally of the shed boundary layer." Such hydrodynamic efficiency allows porpoises to utilize relatively small forces to assist their locomotion under certain circumstances. Two cases will be discussed here.

It is a common observation that porpoises will sometimes come from considerable distances to play about the bow of a moving vessel. Only recently has it become apparent that these porpoises actually obtain a free ride by positioning themselves in front of the moving vessel as it cuts through the water (Woodcock, 1948; Woodcock and McBride, 1951; Hayes, 1953, 1959; Scholander, 1959*a*, *b*). Quite independently of these workers, the senior author happened upon this behavior while studying cetacean locomotion. A plot was being made of the number of tail beats per second against speed, for three cetacean species (*Delphinus bairdi, Lagenorhynchus obliquidens,* and *Phocoenoides dalli*); it was soon obvious that none of these animals regularly beat its tail when stationed close to the bow. At first it was thought that since the observer was stationed above the porpoise, vertical movements of the tail could not be seen. However, on several occasions the porpoises turned partly or entirely onto their sides and it was then obvious that the flukes were held stationary in relation to the body. It is interesting to compare these naïvely made field observations in detail with the theories now presented in the literature, since they agree remarkably well in some cases and disagree in others.

On February 13, 1957, an unusually fine opportunity for observing bow-riding behavior occurred near the west end of Santa Catalina Island. The sea was glassy calm. Two adults of *Lagenorhynchus obliquidens* took up station at the bow of the Marineland collecting vessel *Geronimo* and stayed there for 20 minutes (pl. 27, *b*). The vessel was traveling at 8½ knots, as judged from engine revolutions that had been previously checked against speed. Every movement of the animals could be seen clearly and we were even able to determine that both were females when they rolled onto their backs. Both animals stayed at the bow, with only an occasional beat of their flukes, during the entire period. Some of the periods during which no tail beats at all occurred were timed at 7, 7, 15, 30, 34, and 47 seconds, respectively.

During this and other observations the tail flukes of the gliding animal were generally, although not always, turned downward at about 30° from the horizontal and the tail stock itself was slightly flexed downward (fig. 1). Scholander (1959*a*) determined that there is actually a forward thrust upon a streamlined vane placed in the bow wave of a vessel which is greatest when the vane is slanted upward at 28° from the horizontal, but which rapidly becomes a drag on either side of this angle. This position of maximum forward thrust would correspond to a porpoise with its flukes turned upward at 28° rather than downward at a similar angle, as noted here. It is not clear from Scholander's paper whether he tested the thrust through an entire 180° rotation of his vane.

The animals guided themslves by bending their heads and bodies slightly, and by tiny movements of the pectoral flippers. These positioning movements allowed the porpoises to flip onto their sides or even to spin completely over without losing station.

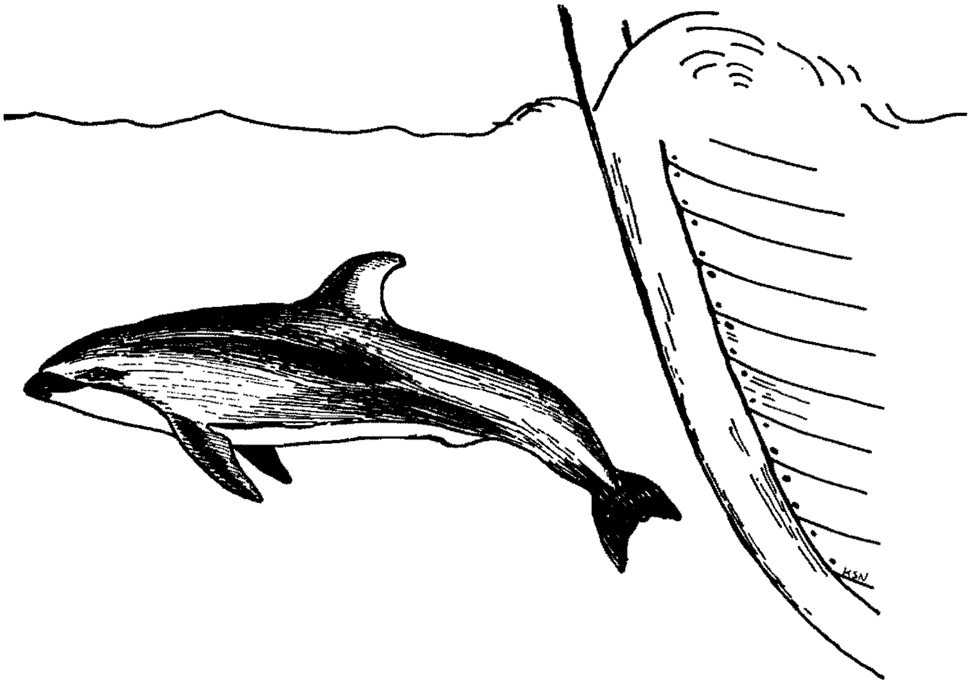

Fig. 1. The posture of a porpoise riding the bow of the Marineland collecting vessel *Geronimo.*

It was obvious during these observations that the area around the bow within which a porpoise could place its tail flukes and obtain a free ride was rather well defined. On the *Geronimo,* which is a 37-foot gill-net boat, the region is small. It consists of a small crescentic area around the stem and back along each side for a short distance. The area extends forward of the cutwater about 15 to 20 inches and about 2 feet back along the bow to each side. At any one level only two or three porpoises can ride it simultaneously. When many porpoises play at the bow only a few are able to get the desired push by placing their flukes in this region. Furthermore, competition between animals in the school causes the rides to be much shorter when several animals are present than when one or two animals are riding. It is conceivable that flow patterns around large numbers of animals might also shorten the rides by disrupting the pressure system that provides the propulsion.

The rides are not only obtained close to the surface but at least 4 feet down. We have seen porpoises riding in tiers, the highest nearly breaking the surface and the lowest deep enough so that their tail flukes were held back under the curve of the bow, virtually out of sight. It was sometimes difficult or impossible to be sure that these deep animals were obtaining a free ride and not beating their flukes, because their tails could not always be seen.

In rough weather, porpoises will seldom attempt to ride the bow of the *Geronimo.* If a pass at the bow is made by them they generally veer away quickly and then ignore or avoid the vessel. We believed that the animals were either frightened by the sound of the vessel pitching into the sea or were afraid of being hit. Perhaps neither of these ideas is wholly correct. Scholander (1959*a*) showed that pitching caused the propulsive thrust to vary rather widely. It may well be that such a fluctuating push as would be obtained on a rough day is not suitable for riding.

The smaller species in California waters (*Lagenorhynchus obliquidens, Delphinus bairdi,* and *Phocoenoides dalli*) exhibit the best and most sustained bow-riding behavior. Larger forms, such as *Tursiops gilli,* are more unpredictable and usually ride only on calm days in the open sea, or on the bows of fairly large vessels. They regularly rode on the bow waves of large sea-going tugs in San Diego Harbor while ignoring our more modest vessel. Larger species, such as the pilot whale *Globicephala scammoni* and the pygmy finback whale *Balaenoptera acutorostrata,* have never been observed to attempt bow riding.

It is perhaps significant that we have never seen a porpoise riding a nonbreaking wind wave, but only in breakers or breaking wind waves, in which the velocity of the forward component of particle movement is greatly increased. The bubble streams often emitted by porpoises as they station themselves at the bow may not indicate underwater vocalization but, instead, adjustments of buoyancy. The animals may trim themselves in this manner until the optimum level of negative buoyancy is achieved.

Moe William Rosen, scientist of the Naval Ordnance Test Station, Pasadena, California, has presented what seems to us to be a logical explanation of bow-riding behavior in porpoises (personal communication). Rosen postulates that the flow patterns near the bow vary significantly from vessel to vessel, depending largely upon the shape of the prow. Vessels with a broad beam and relatively blunt bow, such as the Marineland collecting vessel, tend to force a major portion of the water meeting the prow downward and to the sides of the ship; in sharper-prowed vessels, such as the ice breaker used by Scholander (1959*a*) for his vane studies, an important part of the flow is directed upward away from the sides of the vessel. Because of the sharpness of the bow in the latter class of vessels, less water is forced downward beneath the hull, but is instead cleaved apart and forced laterally upward as a large bow wave (fig. 2).

In the blunt-prowed vessel a porpoise, according to Rosen's postulate, can obtain a forward thrust by bending its flukes downward to achieve a slightly negative angle of attack to the water being deflected beneath the ship. Its flukes are in effect a hydrofoil producing a large lift component directed downward and forward.[1] This lift force, as on an aircraft wing, is exerted perpendicularly to the flow lines, and propels the porpoise forward. Thus the animal compensates for a tendency to tip its snout upward toward the surface by downward movements of the anterior parts of its body, and by control forces that its flippers can also exert as hydrofoils. An upward force due to the over-all body curvature probably balances the downward component of the lift on its flukes. This posture is, in fact, exactly that observed by us for porpoises riding in front of the *Geronimo* (pl. 27, *b*). Further, one would expect the best flow pattern for riding to occur in front and slightly to the sides of such a vessel, and this is also what occurs.

[1] Malcolm Gordon (*Science* [1961], vol. 133, pp. 204–205) has published observations on bow-riding porpoises which appeared subsequent to the submission of this monograph for publication. In these observations he notes that the pectoral flippers and body of a porpoise may act as hydrofoils and thus serve to adjust the animal's position in front of the prow of an on-coming ship.

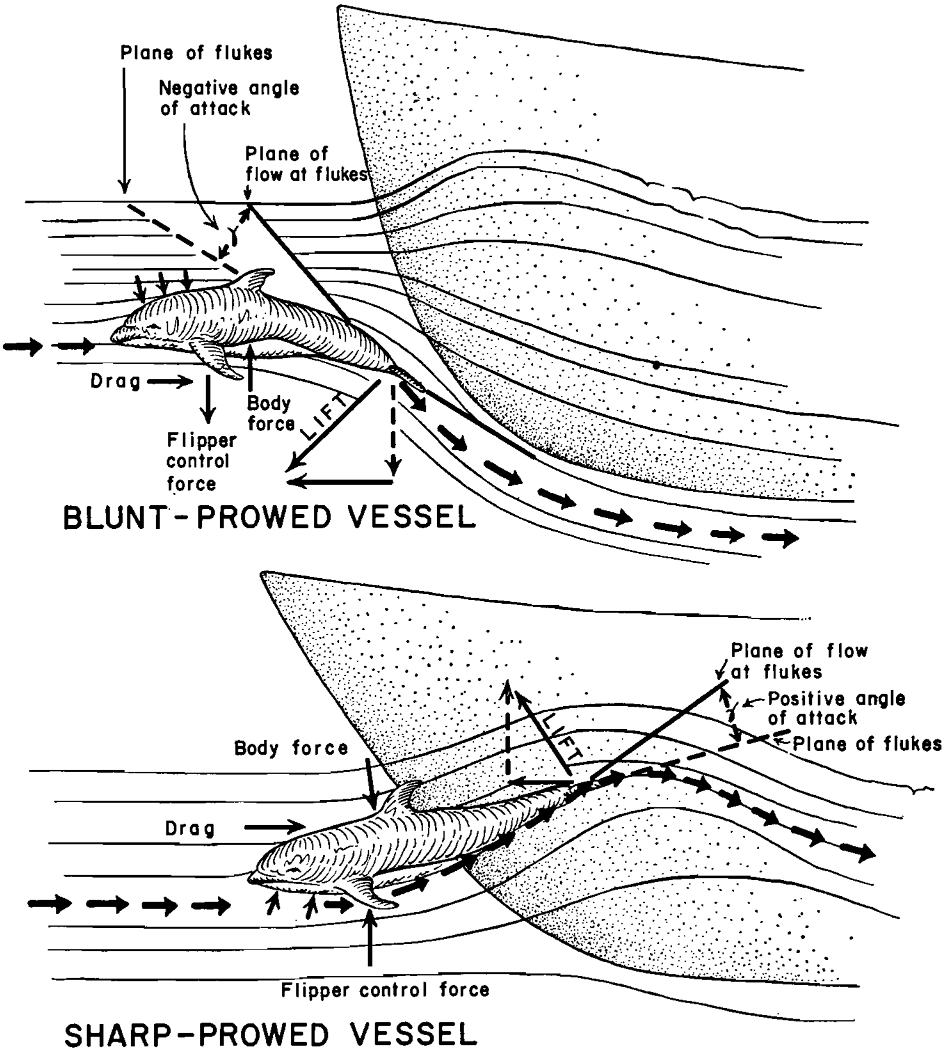

Fig. 2. A diagram of forces acting upon a bow-riding porpoise.

For the sharp-prowed vessel, the posture expected by this explanation would be just the reverse. Within the rising flow lines the animal should tilt its flukes upward to produce a positive angle of attack, and an upward forwardly directed lift. The pitching moments are compensated by bending its anterior body upward slightly, and the flippers can, by hydrofoil action, exert the necessary forces to provide balance and control. Again the over-all curvature of the body may produce a downward force to balance the vertical component of the fluke lift.

The flow and pressure system would be expected to be best for riding just to the sides of the prow and backward for a short distance. The pressures expected are those found by Scholander (1959*a*) and in the position found by him. These ideas should be tested by determining the flow patterns around the bows of blunt- and sharp-prowed vessels.

Bow-riding behavior is probably a behavior pattern of widespread occurrence. A recent motion picture (*The Silent World*, produced by Jacques Yves-Cousteau) taken in the Mediterranean shows individuals of *Delphinus delphis* exhibiting this behavior. Matthews (1948) reports it from the south Atlantic Ocean and Scholander (1959*a*) and others have reported it from various parts of the Atlantic. We think it is most likely world-wide, wherever porpoises live. In view of this probability it becomes interesting to speculate about the origin of the pattern. McBride and Kritzler (1951) have noted that newly born specimens of *Tursiops truncatus* play in front of their mother's snout in somewhat the same fashion as adults ride the bow of a boat. They also say: "We have seen adult Bottlenose Dolphins play in this manner about Right Whales, *Eubalaena glacialis*." Such interspecific associations between porpoises and larger whales may be fairly widespread. We have noted the species *Lagenorhynchus obliquidens*, *Delphinus bairdi*, and *Tursiops gilli* swimming in close association alongside adult pilot whales but we have seen nothing resembling bow-riding behavior.

All three of these species exhibit assisted locomotion in the form of riding within waves. We have often seen these animals racing along within waves from our spreading wake or sometimes within breaking storm waves. The species *Tursiops gilli* and *Tursiops truncatus* ride within waves, both in the wakes of ships and in the surf zone (see Caldwell and Fields, 1959). At Puertacito, Baja California, Mexico, in the northern Gulf of California, from a vantage point on the edge of a high bluff, we watched about a half-dozen adults, presumably of the species *Tursiops gilli*, disporting themselves in the surf. We watched for thirty minutes, and during this entire time the animals took turns racing in from about 100 yards offshore, cruising in within the mass of a wave crest, turning just as it broke, running parallel with the shore in water no deeper than 4 feet, turning again out to sea, and then repeating the performance again and again.

Many times, small groups of Pacific bottlenose porpoises have been seen riding waves along the beaches of southern California, particularly in the La Jolla area. The same sort of behavior has been noted for the Atlantic bottlenose porpoise. In October, 1953, the senior author watched a school of the species *Tursiops truncatus* planing down within the slopes of storm waves just before these waves crashed onto the beach at St. Augustine, Florida.

This wave-riding behavior is seemingly quite different from bow-riding behavior and may have played no part in the development of the latter. It seems very unlikely that bow-riding is a pattern that has arisen *de novo*, but is more likely one in which a natural behavior pattern has become adjusted to an unnatural situation, since the advent of sea-going vessels fast enough to provide a satisfactory bow wave. Exactly what the natural behavioral precursor has been is a mystery.

The second form of assisted locomotion is what has been termed echelon-formation swimming by Kelly (1959). It was first noticed by us in Marineland of the Pacific's circular oceanarium tank. A half-grown female individual of *Lagenorhynchus obliquidens* was seen positioning itself alongside an adult and coasting this way for as many as three complete circuits of the 80-foot tank. The distance of these glides was often so great that it was soon obvious that the little animal was somehow obtaining a "free ride." Repeated observations revealed that the smaller animal positioned itself alongside the adult above the latter's mid-line with its pectoral flipper nearly or actually touching the adult's side just below the dorsal fin (fig. 3). The smaller animal's pectoral flipper was occasionally held in other positions, such as just in front of the larger animal's dorsal fin when making an outside turn. This flipper was held in a slightly different plane than the outboard flipper. It was usually rotated downward so that it was slightly broadside to the oncoming water stream, while the outer flipper was held with its broad surface horizontal to the plane of the moving animal. The tail flukes of the riding animal were also held horizontal to the plane of motion, presumably in a position of least resistance. Perhaps they may provide a significant lift component.

We thought that we could detect a slight slowing of the larger animal whenever the smaller animal began echelon-formation swimming behavior. The adult oc-

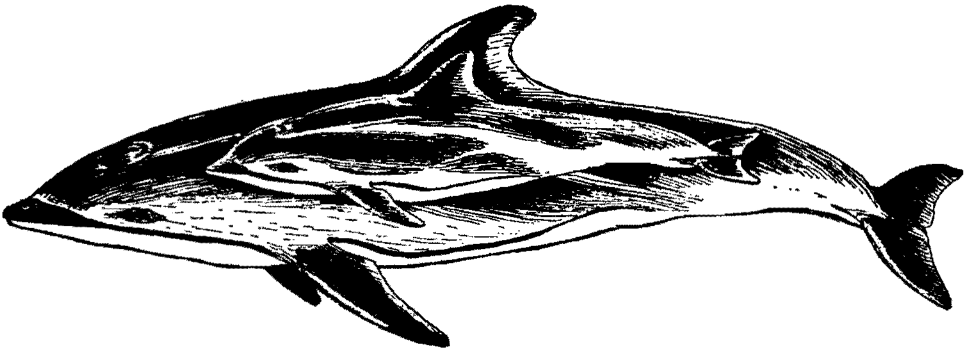

Fig. 3. Positions of mother and baby Pacific striped porpoises (*Lagenorhynchus obliquidens*) during echelon swimming.

casionally turned and chased the smaller animal away when it began to station itself. It seemed as if the adult had grown tired of providing all the effort of locomotion for both animals. The junior author even noted the adult obtaining a free ride from the half-grown specimen. In this instance the smaller animal very obviously had to expend far more than the usual amont of energy to maintain its speed.

Since our initial observation of this behavior in specimens of *Lagenorhynchus obliquidens* we have seen adults of *Lagenorhynchus* obtaining rides on the large pilot whales (*Globicephala scammoni*) that share their tank. The position of the smaller animal alongside these big cetaceans seems much less critical than on the members of their own species. Whenever the rather lethargic pilot whales decide to swim at fair speed they are almost certain to be accompanied by one of the striped porpoises as a "hitchhiker."

The discovery of echelon-formation swimming brings into focus some field observations made many times in the past but never understood.

Baby porpoises and whales of the species *Tursiops truncatus, Tursiops gilli, Lagenorhynchus obliquidens, Delphinus bairdi, Globicephala scammoni,* and *Orcinus orca* are always seen swimming in close company with an adult animal. Not until the young animals are at least two or three months old are they seen to leave the adult's side during normal movements of the school. The position maintained by these small animals is that observed for echelon-formation swimming. In all probability these small cetaceans are aided in their efforts to keep up with a fast-moving school by this method of assisted locomotion, and, in fact, this may be the only way in which they could keep up with a school moving many miles per day at a rapid pace. McBride and Hebb (1948) mention that when a young Atlantic bottlenose porpoise was pursued by an aggressive adult male of the same species, the young animal stayed very close to its mother's side and was able to keep up with her although she was swimming at close to top speed. This was taken as a demonstration of great powers of locomotion in the young porpoise, but it may have only represented a case of echelon-formation swimming. When a pair of porpoises swim at a very rapid pace, as in this instance, the young animal may possibly use its flukes to some extent and thus obscure any assisted locomotion that may actually be occurring.

We have noted mixed schools of the species *Globicephala scammoni* and either *Lagenorhynchus obliquidens, Delphinus bairdi,* or *Tursiops gilli.* Adults of *Lagenorhynchus* have been seen swimming in the proper position for echelon-formation swimming with the larger pilot whales, but this has not been noted for *Delphinus* or *Tursiops.*

Kelly (1959) has provided a physical analogy for echelon-formation swimming. He concludes: "It has been shown that the idea of a porpoise getting a free ride is not at all unreasonable from the standpoint of hydrodynamic theory." Briefly, Kelly's analogy is that two spherical bodies moving forward in echelon formation in a fluid may have a net attractive force between them. This can be resolved into a forward component (thrust) and a lateral component (lift). The attractive force, and therefore the thrust, diminishes rapidly with increasing distance between the two bodies. The attractive force can be thought of as due to Bernouilli's Law, which relates the increase in speed of a fluid passing through a restriction to a decrease in pressure. The forward thrust is a component of the vector sum of the pressure forces, and is due to the staggered position of the two bodies.

Some other observations of aspects of porpoise locomotion deserve mention here. Shuleykin (1949) has presented evidence which supposedly shows that a circularly polarized solid wave passes back over the body of a porpoise during swimming, contributing to its locomotion. Detrimental forces acting perpendicularly to the wave, tending to cause a rotation of the porpoise's body, are considered to be compensated for by a conformation of the tail flukes corresponding to a very slight pitch screw. Also, the well-known asymmetry of the cetacean skull (see Miller, 1923) is supposed to counteract this rotational force to some extent. Shuleykin also states that the movement of the tail flukes is not strictly in the vertical plane, but actually rotary.

We have observed what we believe to be the slight pitch mentioned. It appears to be related to turning movements of cetaceans and seems to be absent when these animals are swimming in straight lines. As an animal turns, the flukes tilt slightly on the longitudinal axis of its body without any detectable asymmetrical curving or cupping of the flukes themselves. The propulsive stroke of the tail stock is still in the vertical plane relative to the animal. This serves to bring the flukes downward at a slight angle to the animal's body with the lowest fluke tip on the inboard side of the turn. The angle of tilt increases with the tightness of the turn. In tight turns there is often a very noticeable longitudinal flexion of the tail stock as well (see pl. 28). We have never observed the rotary motion of the flukes mentioned by Shuleykin. In fact, lateral movements of the tail stock, other than the flexion mentioned above, seem virtually absent during strong locomotion.

When specimens of the Pacific striped porpoise circle near the bottom of the 80-foot display tank prior to making a leap from the water, they can sometimes be seen beating their flukes to alternate sides just as they swing sharply into the high-angle path to the surface. This is accompanied by rolling of the entire body from side to side and the tail beats still seem to be nearly or entirely in the plane vertical to the animal's longitudinal axis. The vertical movements of porpoises' tail stock during propulsion have been well described by Parry (1949).

The lateral tips of the flukes of *Tursiops* and *Globicephala* seem capable of being reflexed upward when the flukes are lifted out of the water. In captive belugas, *Delphinapterus leucas* (Pallas), a symmetrical cupping of the tail flukes on the downstroke has been noted by the senior author.

Although the skulls of cetaceans are, without exception, asymmetrical to some degree, such skeletal asymmetry does not seem to be reflected on the external surfaces of any captives that we have observed. The slightly asymmetrical cast and topographic diagram of a porpoise figured by Shuleykin (1949) may well have resulted from deformation produced after death. Numbers of such topographic diagrams of fresh porpoise heads or of live animals are needed before it can be concluded that internal asymmetry is reflected in the external contours of porpoises.

Parry (1949) has refuted the experiments of Stas (described in Shuleykin, 1949), said to substantiate the rotary motion of the porpoise tail. Stas strapped a recording device on the back of a porpoise. This apparatus recorded both the vertical and lateral components of tail movement which were transmitted by means of two lateral straps from a cuff strapped tightly at the base of the flukes. Both lateral and vertical components of movement were recorded in the test, and taken as proving rotary tail motion. Parry (1949) noted that tiny displacements of the straps or cuff could have produced the record with purely vertical movements of the flukes. We would like to add another possible explanation. The heavy recording gear strapped to the back of the porpoise, ahead of its dorsal fin, would undoubtedly have disrupted the delicate balance of the animal to some extent, and very likely would have caused it to roll back and forth in the water, and hence to make compensatory movements of its tail flukes. If the cuff was tight about the base of the flukes it would probably have been rotated somewhat during these compensatory movements and during turns, even though the tail stock continued to beat in the vertical plane. No control tests appear to have been run.

ACCOUNTS OF SPECIES

Cuvier's Beaked Whale
Ziphius cavirostris G. Cuvier

DISTRIBUTION

Range.—*Ziphius cavirostris* G. Cuvier has seldom been recorded from, or near, California. Hubbs (1946) reported on a beached specimen from Del Mar, San Diego County, California. Orr (1948) gave information on a specimen from the northern California coast and Hubbs (1951) discussed a probable record from San Ramón, at the mouth of the Río Santo Domingo, Baja California Norte, Mexico. Roest, Storm, and Dumas (1953) reported on a stranded specimen from Oceanlake, Lincoln County, Oregon. The latest record is that reported by Houck (1958) from the mouth of the Mad River, Humboldt County, California.

CAPTURE OBSERVATIONS AND SIGHTINGS

The immature female specimen reported here was found stranded on Pebbly Beach, just east of Avalon Harbor, Santa Catalina Island, California, on February 21, 1956, by Al Hanson. Mr. Hanson and his son escorted the whale into Avalon Harbor, by swimming with it. There they tethered it to a pier. When our collecting crew arrived the animal was floating at the surface and seemed to be abnormally high in the water. She was easily handled and did not object strenuously when placed into a mattress-lined partially sunken skiff. The water-filled skiff was secured to the stern of the collecting vessel and towed to Marineland without further incident.

MORPHOLOGY

Morphometrics and anatomy.—Hubbs (1946) reported finding thirty-three or thirty-four small teeth, some as long as 6 millimeters, buried in the gum of the right mandible of a stranded beaked whale. No external teeth were visible on our animal but the gums were rough and knobby like those of *Phocoenoides dalli* (see Miller, 1929). It seems possible that buried teeth were present but we were not aware of Hubb's finding until after our specimen had been skeletonized.

The flukes of ziphiid whales are usually without a median notch; however, our specimen had a definite median notch, a half an inch deep (pl. 29, *a*). A similar median notch is reported by Roest, Storm, and Dumas (1953).

During the trip to Marineland we noted that the pupils of the whale's eyes were broadly ovoid and possessed a tapetum, judging from the marked amber eyeshine.

No external ear openings were apparent. The animal had two throat creases, the left 6 and the right 5.75 inches in length. A very prominent scar, 10.5 inches in length, marked the left flank of the animal. It consisted of two deep parallel furrows and most probably produced by the two mandibular teeth of a male beaked whale. At the time the wound was made it must have penetrated completely through the blubber coat and into the underlying musculature. It was partially healed at the time of capture.

Measurements are given in table 1.

Color and pattern.—The color of the animal in life was grayish fawn, with some small blotches of a slightly darker gray on the ventral surfaces. The areas around the eyes were dark gray (pl. 29, *b*). This coloration differs markedly from that of the immature female specimen reported by Hubbs (1946), who says: "The color of the well-preserved external surface was deep leaden gray above, approaching blackish, and only moderately lighter, definitely not whitish, below. The entire beak and fins were dark." We have noticed that dead individuals of the species *Tursiops gilli*, *Phocoena phocoena*, and our specimen of *Ziphius cavirostris* became very dark soon after death, particularly if exposed to the sun. This phenomenon may have occurred in the whale reported on by Hubbs. On the other hand, both Roest, Storm, and Dumas' (1953) and Houck's (1958) specimens were very similar to each other in coloration. Both were predominately dark below and heavily blotched with ovoid white markings on the posteroventral parts of the body. Both were lighter above, particularly on the face and jaws. Both were moderately large males (Roest *et al.*, 18 feet, 4 inches; Houck, 19 feet, 7 inches).

BEHAVIOR

Respiration.—During the trip across the channel the animal breathed in a fairly regular pattern. Two or three breaths were taken, 10 to 20 seconds apart, followed

TABLE 1

MEASUREMENTS AND PROPORTIONS OF *Ziphius cavirostris*

Measurement	February 21, 1956 Pebbly Beach, Santa Catalina Island, Calif. Immature female	
	Cm.	Proportion[1]
Total length—snout to fluke notch	340.3	.....
Snout to eye	41.2	0.128
Snout to end of mouth crease	20.3	0.059
Snout to anus	231.1	0.679
Snout to origin of dorsal fin	215.9	0.634
Flipper (right)—anterior origin to tip	36.8	0.108
Flipper (left)—greatest width	19.0	0.056
Flukes, spread—tip to tip	78.7	0.231
Median notch of flukes to dorsal fin at deepest point of posterior curve	106.6	0.313
Dorsal fin—height	22.2	0.065
Blowhole—width	10.1	0.029
Projection of lower jaw beyond upper	1.9	0.005
Girth—at anterior origin of dorsal fin	193.0	0.567
Girth—at anterior origin of flukes	40.6	0.119
Anus to median notch of flukes	101.6	0.298

[1] Proportions expressed in one-thousandths of total length.

by a period of apnea lasting as long as 1 minute, 15 seconds. Breaths were very brief. No vapor cloud was expelled except when water was present over the blowhole, and then a "spout" of sorts occurred, directly obliquely forward.

MORTALITY AND DISEASE

At Marineland of the Pacific, the animal was placed in the oval fish tank, which is 100 feet long, 50 feet wide, and 22 feet deep. She circled slowly until nightfall and seemed to adjust to confinement. Next morning she began circling rapidly, rubbing her flukes against the tank walls. Soon she went into a frenzy, lashing the entire tank into a froth. Then she swam the length of the tank at high speed and crashed into the far wall with a thud that was felt throughout the building. A few moments later she was escorted from the tank into the connecting flume, where she died. Her charge against the wall had broken her lower jaw. As the animal was being removed to the freeze box about a pint of thin greenish fluid squirted from her blowhole. Autopsy indicated that the animal had been seriously ill with a congestion of the lungs.

Gray's Long-Snouted Porpoise

Stenella euphrosyne (Gray)

NOMENCLATURE

We follow Kellogg and Scheffer (1947) in considering the North Pacific form of the long-snouted porpoise to be *Stenella euphrosyne* and not *S. coeruleo-albus*, on the basis of color pattern. However, the pattern of our specimen does not allow the clear-cut separation thought to be present in Kellogg and Scheffer's Oregon coast specimen, as will be discussed under morphology.

DISTRIBUTION

Range.—This species is considered to occur in both the North Atlantic and North Pacific oceans by Kellogg and Miller (1955) under the name *Stenella styx*. On the Pacific coast of North America *S. euphrosyne* has been recorded from the Bering Sea (Kenyon and Scheffer, 1949) to 10 miles south of the mouth of the Columbia River, Oregon (Kellogg and Scheffer, 1947). We can now extend this known range to Playa del Rey, Los Angeles County, California, 960 miles to the south.

CAPTURE OBSERVATIONS AND SIGHTINGS

On June 24, 1960, Los Angeles County lifeguards at Playa del Rey noticed a porpoise swimming in circles outside the surf zone. It later came through the surf and stranded. The guards then helped it back through the surf. At dusk it was still circling from 300 yards to half a mile offshore. Next morning it was found stranded and apparently dying. A policeman, noting this, shot it six times through the skull. The guards notified Marineland and the animal was brought at once to the laboratory. Photographs (pl. 30) and measurements (table 2) were taken, and the undamaged skeletal parts saved.

After examining this very distinctive animal it became apparent to us that we had, in all probability, been seeing *Stenella euphrosyne* with fair regularity, in the San Pedro Channel area. We had dubbed them "bull *Delphinus*" because of their large size and resemblance to the common dolphin. Casual estimates placed the animals at well over 7 feet in length. The dorsal pattern and form is sufficiently similar to *Delphinus bairdi* that they apparently went unidentified as a form new to us. These schools of large porpoises were usually small, often numbering less than fifteen animals.

MORPHOLOGY

Color and pattern.—Our detailed color notes were recorded after the porpoise had been frozen for several days. Initially, when the animal was first taken from the beach, we noted that the dark pattern was brownish, and not the distinct steel blue that we found on the long-dead animal. It is also worthy of mention that the initial report by the lifeguards was of a brown animal. No mention was made of any bluish coloration. It was this brownish coloration that made the freshly dead

TABLE 2

MEASUREMENTS AND PROPORTIONS OF *Stenella euphrosyne*

Measurement	June 25, 1960 Playa Del Rey Beach Park, Los Angeles Co., Calif. Male; 223 lbs.	
	Cm.	Proportion[1]
Total length—snout to fluke notch	216.0	.....
Snout to eye	32.0	0.148
Snout to mouth crease, inside corner	25.0	0.116
Snout to anterior origin of flipper	48.0	0.222
Snout to apex of melon	11.0	0.051
Snout to center of blowhole	32.0	0.148
Snout to anus	152.0	0.705
Snout to center of dorsal fin	108.0	0.500
Flipper (left)—anterior origin to tip	29.0	0.134
Flipper (left)—axilla to tip	20.0	0.092
Flipper (left)—greatest width	10.0	0.046
Flukes—depth of median notch	2.5	0.016
Flukes, spread—tip to tip	46.0	0.213
Median notch of flukes to dorsal fin at deepest point of posterior curve	100.0	0.46
Dorsal fin—length of base	29.0	0.134
Dorsal fin—height	18.0	0.088
Blowhole—width	2.0	0.009
Projection of lower jaw beyond upper	0.7	0.003
Genital slit—length	14.0	0.065
Girth—at blowhole	75.0	0.349
Girth—at anterior origin of flippers	96.0	0.445
Girth—at anterior origin of dorsal fin	110.0	0.510
Girth—at level of anus	70.0	0.324

[1] Proportions expressed in one-thousandths of total length.

animal resemble *Delphinus bairdi* sufficiently so that we feel we could have confused them in the field.

The color pattern of the frozen animal was dark steel blue along the top one-third of the body from the snout and upper margins of the lower jaw, to the flukes. Below the dorsal fin a narrow light-blue stripe (probably white or tan in life) slanted obliquely forward toward the eye. Actually, this stripe was a branch of a pale dorsolateral band extending from just above the corner of the mouth, over the eye and posteriad to the insertion of the flukes. The general color of the band was pale blue in its anterior portions, darkening below the dorsal fin and assuming a brownish tinge along the lateral surfaces of the tail stock. Below the dorsolateral pale band was a dark mid-lateral stripe that extended from the dark-bluish patch surrounding the eye, to the anal region. Initially very narrow, this stripe bifurcated immediately behind the eye and became increasingly more brownish posteriorly. The bifurcation extended diagonally ventrad and tapered to a point nearly opposite the tip of the adpressed flipper. Behind the bifurcation the dark stripe widened and curved slightly downward over the anal region. This dark stripe was then continuous to the fluke insertion as right and left stripes merged along the

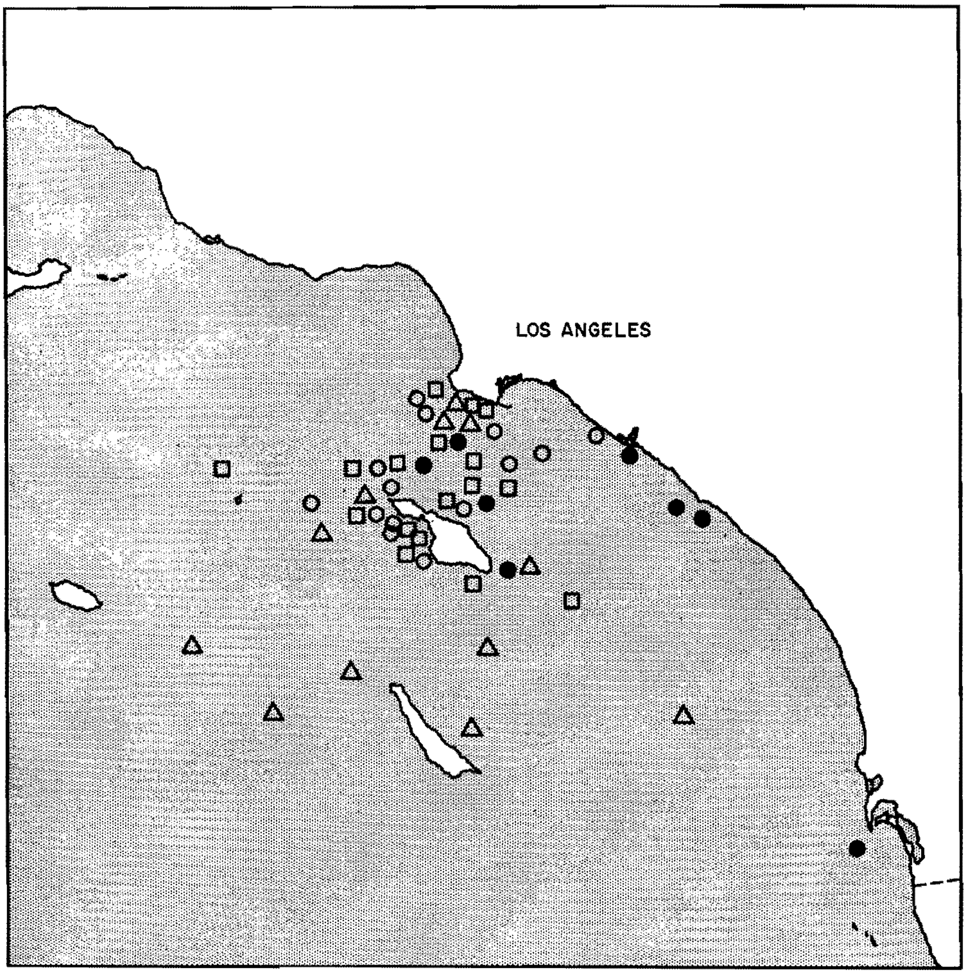

Fig. 4. Sight records and localities of capture of the Pacific common dolphin (*Delphinus bairdi*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

ventral edge of the tail stock. The color of this fuzed stripe was not as intense on the tail stock as in the separate narrower anterior portions. Above this dark stripe on the tail stock was an area of blue-brown spotting spread over a slightly lighter ground color. The spots occurred on the lateral surfaces over most of the tail stock as far forward as the posterior insertion of the dorsal fin. The lighter parts of the tail stock had a decided reddish tinge, as did the ventral whitish area below the eyes. The ventral parts of the animal, except the tail stock, flukes, and flippers, were white. A narrow dark bluish-brown stripe extended from the anterior origin of the flipper to the eye.

Kellogg and Scheffer (1947) present a photograph of their Oregon specimen which shows three details thought to separate their animal from *Stenella coeruleo-albus*, a form they relegate to the South Atlantic. First, they state that in *S. coeruleo-albus* but not in *S. euphrosyne* "a very dark blue band commencing below the dorsal fin extends obliquely forward and downward and it is markedly attenuated anteriorly. Dorsal to this dark blue band is a *lighter streak of approximately the same width which extends from below the dorsal fin to above the eye* [italics theirs]." The dark band is present in our animal, as can be seen in plate 30 and does become attenuated forward. Furthermore, there is a lighter streak dorsal to this band which extends from below the dorsal fin to nearly above the eye. The light band in our animal, however, is very much narrower than the dark band below it. Even so, we do not consider these features to be significant. The animal whose photograph is presented by Kellogg and Scheffer (1947) is rolled partly onto its side and these pattern characteristics are probably obscured as a result. These authors note that their specimen has a short ventral bifurcation of the thin mid-lateral dark streak, which branches off farther back of the eye than in *S. coeruleo-albus*. This line, in our animal, begins considerably closer to the eye than in Kellogg and Scheffer's specimen, and thus tends to ally our animal to *S. coeruleo-albus*. However, Kellogg and Scheffer's specimen has a dark beak in contrast to the white beak of *coeruleo-albus*. In this well-defined character our animal is allied to *S. euphrosyne*. We feel there is little likelihood that our specimen is of a species distinct from that reported by Kellogg and Scheffer, in spite of the variations in pattern noted above, and hence refer it to *S. euphrosyne*.

PACIFIC COMMON DOLPHIN
Delphinus bairdi Dall

DISTRIBUTION

Range.—*Delphinus bairdi* occurs in the eastern North Pacific from Pacific Beach, Washington (Scheffer and Slipp, 1948) southward at least to the Gulf of California (Escondido Bay; Miller and Kellogg, 1955).

Seasonal movements.—The common dolphin is one of the two most abundant species of cetaceans in southern California waters (the other is *Lagenorhynchus obliquidens*). Although the common dolphin is present in inshore waters throughout the year, it is seemingly less abundant during the later summer and early fall months than at other times (fig. 4).

MORPHOLOGY

Morphometrics and anatomy.—Measurements and proportions of specimens of this species are given in table 3.

REPRODUCTION

Young.—Our data indicate that young are born in the midwinter months in southern California and continue to travel with adults throughout the spring. Segregated subgroups of half-grown and three-quarter-grown animals have been seen from early summer (June) to winter. Young of the year can be distinguished easily from adults by eye, until the following winter.

Mating behavior.—A presumptive mating was noted on April 9, 1957, in a school sighted 11 miles west-southwest of Point Vicente, Los Angeles County, California. Two animals were noted rolling together at the surface but further details were not seen.

TABLE 3

MEASUREMENTS AND PROPORTIONS OF *Delphinus bairdi*

Measurement	February 13, 1959 Huntington Beach State Park, Orange Co., Calif. Female; 128 lbs.		March 13, 1958 10 miles W. of West End, Santa Catalina Island, Calif. Female; 113 lbs.		March 18, 1958 4 miles S. of Pt. Fermin, Los Angeles Co., Calif. Male; 128 lbs.		June 24, 1960 5 miles S. of Pt. Vicente, Los Angeles Co., Calif. Male;	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	162.5	.....	169.0	.....	187.0	.....	160.0	.....
Snout to eye	30.5	0.180	31.8	0.187	33.7	0.179	28.0	0.175
Snout to end of mouth crease	25.4	0.156	.....	.....	.....	.....	22.0	0.220
Snout to anterior origin of flipper	44.5	0.271	40.9	0.242	35.6	0.258	38.0	0.237
Snout to apex of melon	.....	.....	12.7	0.075	14.6	0.077	18.0	0.112
Snout to center of blowhole	27.9	0.171	35.3	0.190	35.0	0.186	.....	.....
Snout to anus	.....	.....	.....	.....	136.5	0.710	109.0	0.681
Snout to origin of dorsal fin	.....	.....	77.5	0.458	86.5	0.462	.....	.....
Flipper (left)—anterior origin to tip	27.3	0.167	26.7	0.157	27.9	0.149	.....	.....
Flipper (left)—axilla to tip	19.7	0.120	.....	.....	.....	.....	.....	.....
Flipper (left)—greatest width	8.9	0.054	.....	.....	10.1	0.054	.....	.....
Flukes—depth of median notch	2.5	0.015	.....	.....	.....	.....	2.0	0.012
Flukes, spread—tip to tip	34.3	0.210	34.9	0.206	38.1	0.204	32.0	0.200
Median notch of flukes to dorsal fin at deepest point of posterior curve	71.4	0.437	80.0	0.473	91.5	0.489	67.0	0.418
Dorsal fin—length of base	25.4	0.156	26.7	0.157	30.5	0.163	29.0	0.181
Dorsal fin—height	15.2	0.093	16.5	0.097	17.8	0.095	15.0	0.093
Dorsal fin—anterior origin to center of blowhole	35.0	0.215	.....	.....	.....	.....	.....	.....
Blowhole—width	1.5	0.009	.....	.....	2.16	0.012	2.0	0.012
Projection of lower jaw beyond upper	0.0	0.000	0.0	0.000	0.0	0.000	0.5	0.003
Genital slit—length	.....	.....	10.9	0.064	8.4	0.044	.....	.....
Girth—at level of anus	49.5	0.304	.....	.....	.....	.....	.....	.....
Umbilicus to anus	36.8	0.226	.....	.....	.....	.....	.....	.....
Anus to median notch of flukes	45.8	0.281	47.3	0.285	56.0	0.299	.....	.....

[1] Proportions expressed in one-thousandths of total length.

BEHAVIOR

Locomotion.—Speed: The standard cruising speed of the collecting vessel *Geronimo* is between 8¼ and 8½ knots. At this speed we have always been able to overtake schools of common dolphins. Their normal cruising speed is considerably less than this, probably about 5 to 6 knots when the school is moving rapidly.

Casual observations suggested that different species of porpoises and different size groups within a given species exhibited different tail beat rates for a given swimming speed. There is some meager evidence of a difference between subadults and adults in *Delphinus,* given in table 4. Table 12 shows the tail movements of the Dall porpoise and indicates the possibility of a somewhat faster stroke than is found in the common dolphin, at the same speed.

TABLE 4

Speed of Tail Beat in *Delphinus bairdi*

Period of timing (seconds)	No. of beats	Beats/second	Boat speed (knots)	Age class
11	21	1.9	8¼	¾ grown
7	16	2.3	8¼	¾ grown
6.5	12	1.8	8¼	¾ grown
11.5	20	1.7	8¼	¾ grown
10	18	1.8	8½	adult
5	7	1.4	8½	adult
6	10	1.7	8½	adult

Schooling: Large traveling schools of common dolphins often form a single broad rank, two to five animals deep and many animals in width. These schools are often shaped like a broad crescent, with the cusps trailing off somewhat to the rear. When in this order, the animals usually leap from the water periodically as they cruise along. To a person sitting quietly in a skiff the splashing noise made by these schools sounds like a heavy rain storm and is audible for a considerable distance.

Feeding aggregations seem to have no definable shape.

Feeding behavior.—Common dolphins have been seen feeding on sardines (*Sardinops coerulea*), anchovies (*Engraulis mordax*), sauries (*Cololabis saira*), small bonito (*Sarda chiliensis*), and squid(*Loligo opalescens*).

On April 15, 1958, 3.5 miles west of the west end of Santa Catalina Island, a school of about twenty adult common dolphins was found feeding on sauries. Several times the dolphins were seen catching sauries in mid-air as they both leapt above the surface. In one instance a fish was caught in mid-leap, an estimated 1.5 feet above the surface. One dolphin was observed to jump out of the water upside down and catch a leaping saury while in this position.

Atlantic Bottlenose Porpoise

Tursiops truncatus (Montagu)

BEHAVIOR

Feeding.—On the morning of August 16, 1956, five yellowtail (*Seriola dorsalis*) approximately 1.5 to 2.5 feet long and between 3 and 6 pounds in weight, were placed in the circular porpoise tank. This pool was occupied by four adult Atlantic bottlenose porpoises, and two Pacific striped porpoises. It was hoped that these fish would be swift enough to survive in the company of the porpoises. This was an idle hope, as the smaller fish were quickly captured and swallowed headfirst. The 5- and 6-pound fish were treated much differently than the smaller ones. Each of the two recently caught female Atlantic bottlenose porpoises captured one of the larger fish and killed it by worrying it in mid-water. Each fish was then grasped by its head at right angles to the longitudinal axis of its body, so that the side of the porpoise's jaw held the fish at the posterior edge of the opercle. Each female porpoise then took her prey to the bottom and forced its body into the bottom gravel, thus bending it sharply. One of the females, named Mabel, pushed her fish 20 feet along the bottom during one of these maneuvers, leaving a deep furrow in the gravel. The porpoises took their fish to the surface, dropped them while they took a breath of air, and then retrieved the drifting fish as they dived to repeat the pattern again. Freeing the fish had the effect of rotating it over and over. After ten to fifteen minutes, the fish held by the other female (Myrtle) became fragmented and the head fell away from the body. Mabel worked for twenty minutes before she achieved the same result. Once the head was freed it was discarded and the behavior of the porpoises changed abruptly. The frayed body of the fish was then taken into the porpoise's mouth, and in Myrtle's case, swallowed shortly thereafter. Mabel, however, swam rapidly across the tank in mid-water and flipped quickly onto her back. This strongly flexed the extended body of the fish. She repeated this action several times. Then she took the fish almost entirely into her mouth, leaving only the tail protruding, and repeatedly rubbed it into the bottom sand. She then went to the surface and tossed the limp fish into the air several times. She often let the fish float freely in the water while other bottlenose porpoises were near, but they never attempted to take the fish from her. Finally, thirty minutes after the initial capture, she swallowed the flabby remains of the yellowtail, anterior end first.

The two captive-born males watched the entire process without taking part in it, except to nose the dead fish from time to time, and to follow the females to the bottom as they prepared their prey for swallowing. About thirty minutes after Myrtle had swallowed her fish, one of the males, named Frank, was seen with a 5- or 6-pound yellowtail. He repeatedly swam to the bottom with the fish, but generally held it in a longitudinal fashion, sticking straight out of his mouth. Sometimes he held it by the head, as the females had done, and was once seen very lightly pushing it against the bottom. These efforts did not break the head loose. After an hour's effort the fish was still intact and firm. Frank made repeated chewing movements with his jaws, which seemed to have more effect than any other part of his behavior toward preparing the fish for swallowing. He dropped the fish several times and swam away from it. Once Mabel picked it up very briefy, but the other porpoises left the fish completely alone, though they swam around it and looked at it. The impression given was that the fish was strictly the property of the porpoise who was preparing it.

Unfortunately observations could not be carried on to the completion of the behavior. The females, raised to adulthood in the wild, certainly seemed much more adept at preparing large fish for eating than the captive-bred males, which had been fed small fish or portions of fish all their lives. It would appear that at least part of the behavior exhibited by the females is learned.

Pacific Bottlenose Porpoise
Tursiops gilli Dall

NOMENCLATURE

It is relatively certain that all of the bottlenose porpoises inhabiting California waters are to be classed in this species. There are, however, seemingly separate inshore and offshore populations. Offshore animals do not present the usually heavily scarred and battered appearance of animals often seen in such localities as San Diego Bay. Instead they tend to be without major scars such as might have been produced by encounters with ships and other obstacles in harbors. Superficially, however, these two groups of bottlenose porpoises appear identical except for scarring.

The relationships of *T. gilli* to the little-known *T. nuuanu* (Andrews, 1911) remain obscure. In fact the validity of the latter species is in need of verification. Relationships are particularly obscure for populations of *Tursiops* within the Gulf of California and southward to Panama. Animals taken in the vicinity of San Felipe, Baja California, in the upper Gulf of California, have been classed as *T. gilli,* whereas animals taken farther south have sometimes been allocated to *T. nuuanu* (Mayer, 1950).

The erection of the species *T. gilli* by Dall (1873) was, in itself, based upon inadequate evidence, namely the lower jaw, and the outlines of the animal drawn by Captain Scammon. We can add a few observations concerning the difference between the *T. gilli* and *T. truncatus,* based upon observation of captives of both species. California specimens of *T. gilli* give the impression of being considerably slimmer animals than Florida *T. truncatus,* though there is great individual variation in both species in this regard. The pattern of *T. gilli* is darker and bolder than that of Florida specimens of *T. truncatus,* but essentially similar with regard to individual markings. The most obvious superficial difference is in dentition. The teeth of *T. gilli* are very much the stouter of the two species. Adequate skeltal material is now available in various museums to resolve the relationship between the two forms.

DISTRIBUTION

Range.—The Pacific bottlenose porpoise was described from a specimen taken at Monterey, California, but the species is absent there today and now seems uncommon north of Orange County, California, at least in shallow subtidal waters. It is often seen in the surf zone during summertime, in San Diego and Orange counties, along the Pacific Ocean shore of Baja California, and in the Gulf of California, Mexico. It is therefore of some interest that we can now list this species as a relatively common inhabitant of deep offshore waters from the Huntington Flats area south of Los Angeles Harbor, and throughout the San Pedro Channel (fig. 5). In nearly every instance where we have sighted schools of *T. gilli* in these deep-water locations they have been closely associated with a school of Pacific pilot whales (*Globicephala scammoni*).

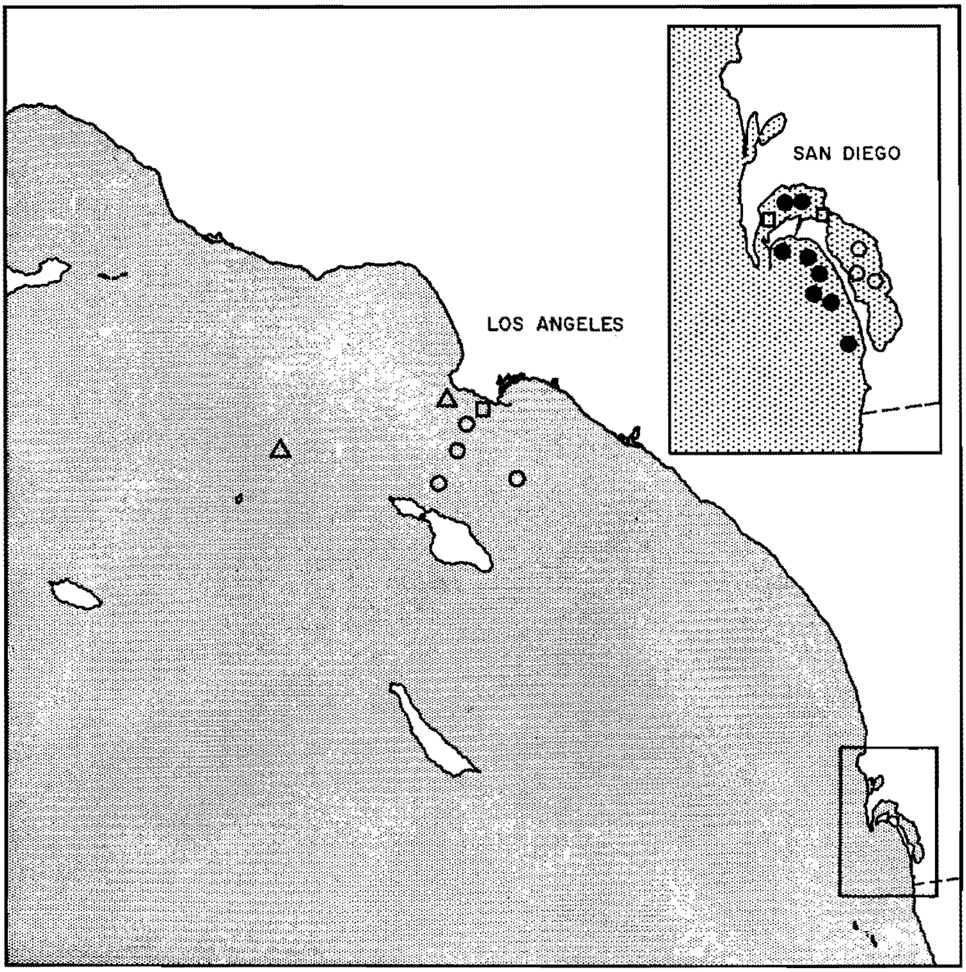

Fig. 5. Sight records and localities of capture of the Pacific bottlenose porpoise (*Tursiops gilli*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

Seasonal movements.—This species occurs in the surf zone along the unprotected coast line north of San Diego Bay mostly in summertime, when they are often seen disporting themselves in the waves, or swimming in small groups just beyond the breaker line.

CAPTURE OBSERVATIONS AND SIGHTINGS

It is convenient to divide our sightings of these animals into instances where they have been noted in bays and in shallow nearshore waters, and in the open ocean, since their behavior is somewhat different in each situation. First we will list the bay and nearshore observations.

The Pacific bottlenose porpoise regularly enters shallow lagoon waters. At Scammon's Lagoon, on the Pacific Ocean coast of Baja California, on August 12, 1952, the senior author observed a school of seven bottlenose porpoises playing alongside the skiff in the entrance channel; they were surfacing and blowing within a few feet of the gunwhale. Inside this lagoon the north shore is lined with steep dunes, which at some places drop precipitously into the water. Single individuals of the bottlenose porpoise swam parallel to shore within 10 feet of the edge of such a dune. In one instance an adult swam along, partly on its side, seemingly undisturbed by the presence of men only a few feet away.

Bottlenose porpoises often enter the elongate lagoon called Estero de Punta Banda, south of Ensenada, Baja California, usually entering at high tide across the shallow sand bar at the entrance. They then range through all but the shallowest parts (see feeding).

Several series of observations have been made on the population of *Tursiops gilli* that inhabits San Diego Bay, San Diego County, California, in the course of our repeated attempts to capture animals there. During the period from November 29, 1956, to January 12, 1957, a total of eight days was spent in pursuit of these animals. In November and December, 1957, the area was revisited for a total of seven days, and again on April 28, 1958, one day was spent in observation and capture attempts.

The movements of the resident population were usually consistent within one observation period but often varied between periods. For instance, during the winter of 1956–57 the entire population, estimated at between twenty-five and thirty-five animals, regularly spent the day in the bay. They usually made their appearance at the entrance one to four hours after sunrise, and began working their way up the bay. Later they could be found in the deeper parts of the inner bay, swimming among the naval vessels and following the Coronado auto ferry (for a previous observation of this behavior, see Kenyon, 1952). Occasionally they entered shallow water at the south end of the bay. By dusk the entire group was usually found moving toward the entrance, and at dusk was either out of the bay or near the federal breakwater at the entrance. In sharp contrast to these observations were those made the following fall in November and December, 1957. During this time the porpoises were seen entering the bay only once, and then at dusk. The remainder of the time the animals were found traveling slowly along the Coronado strand, 5 miles or more from the bay entrance, presumably feeding. They ranged at least 18 miles south along this uninterrupted stretch of beach. Most movements in and out of the bay appeared to be into the tidal flow.

Often, though not always, when approached by the collecting boat, the porpoises would swim into the breaking surf rather than under the vessel. The animals raced in with the waves and returned by swimming directly out to sea, sometimes leaping directly through approaching waves.

The porpoise population in the San Diego Bay area seems to have some constancy, though it does not seem to be entirely stable from month to month. Three animals were seen that were so distinctly marked that their presence could be determined easily by visual observation. An old male, whom we dubbed "Old Scarback," had had his dorsal fin sliced off 2 or 3 inches shorter than normal, along the leading edge. The fin, as a result, was low and triangular and with a conspicuous white anterior edge. The white scar continued forward nearly to the tip of his snout. As can be imagined, this animal was easily identified, even at a considerable distance. Another animal had four deep scalloped notches cut in the dorsal edge of its tail stock. A third had both tips of its tail flukes sliced away. Since any major wound in this species seems to heal without deposition of additional pigment, all these marks were white, contrasting with the lead gray of the unscarred animal.

Old Scarback was seen many times during our operations in the bay area. He was first noted during the January 11–12, 1957, observations in the bay, though he had not been noted during the fall of 1956. He was seen several times during the November-December, 1957, observation period, and was finally netted and drowned inadvertently in April 28, 1958, at the north tip of North Island.

The individual with the scalloped tail stock was noticed on our first trip to the bay on November 29, 1956, but was not seen during the January 11–12, 1957, observations. It was almost certainly not in the immediate area of the bay, or within the schools that we located and followed, since our search was exhaustive. It was seen again both during the fall of 1957 and in April, 1958.

The third marked individual with scarred fluke tips was seen during November, 1956, and January, 1957, but was not noted afterward.

Pacific bottlenose porpoises proved exceedingly difficult to capture in San Diego Bay, both because of their own wariness and cleverness at escape and because of the heavy ship traffic normal in the area; however, we were successful on two occasions in netting entire schools. The first instance occurred on January 12, 1957, when a group of bottlenose porpoises was sighted swimming northward along Coronado strand, about 100 yards offshore from the surf pounding on the beach. When the boat came about 75 yards offshore from the school the school's reaction was to turn out to sea even though it meant turning toward the boat. A 1,200-foot nylon gill net was set around them. We had counted five animals in the school before setting the net, but once the net was closed we soon saw that there were actually ten animals. We mention this because it indicates the lack of reliance that one may place upon counts made from the surface.

The school surfaced in the circle of the net, and despite our best efforts they would not swim into it, even though the water was quite murky. We threw boulders into the water, slapped oars, and even brought our 37-foot vessel inside the net and circled after the animals, all to no avail. We then halved the area of the net by bunching corks. Then we cut the area in quarters by pulling opposite sides together. Then this area was halved again. Still the porpoises surfaced in one of the small open areas. Finally, one lobe of the net collapsed in the outgoing tide and five animals became trapped in it. Old Scarback was among them. He promptly leaped over the cork line to freedom, but refused to leave the vicinity. Another animal rammed its way through the heavy netting and three became entangled. One adult female measuring 10 feet, 1 inch (snout to fluke notch) was saved, while her young and another adult female were drowned. The measurements of all three are given in table 4. The remaining five animals were allowed to escape. Old Scarback had been swimming around the net, 75 to 150 yards away from its edge, during the two hours since his escape. The five quickly joined him and swam directly out to sea.

We felt that Old Scarback, at least, had learned to recognize our collecting vessel after we had pursued the school for a few days. This distinctive animal was seen from time to time lying on his side, with his head partly raised from the water, apparently looking at us. The school became increasingly difficult to approach with every attempt at capture.

The second successful attempt was made on April 28, 1958. Instead of attempting to encircle the animals, the net was set well ahead of an approaching school of porpoises on the north tip of North Island. One end was anchored on shore and the remainder of the net was run parallel to the beach, some distance offshore. Four animals entered the trap and were caught when the offshore end was hauled rapidly ashore. Old Scarback rushed into the net and was immediately enmeshed and drowned.

Fully as instructive as the successful attempts at capture were our numerous failures. On one occasion a group of three porpoises was encountered in the shallow south end of San Diego Bay. Even though we could not always see the animals, the water was muddy and shallow enough that we could easily see the boils of murky water rising from each of their tail beats. The vessel maneuvered on a course parallel to theirs and about 75 yards to one side. When somewhat ahead of the school the net was payed off the stern of the vessel and then, under full speed, set around the animals by first crossing in front of them and then cutting around to their rear. By their occasional surfacing and their tail beats we could see the animals head into the trap, turn away from the net ahead when they were an estimated 100 feet from it, orient to the 20-foot opening that we were straining to close, race directly for it and through it without any searching behavior whatso ever. Quite obviously these animals were able to sense this opening a long way from it in very murky water in which visibility was a few feet at best. This parallels the observations of McBride (1956) and is almost certainly related to echo-location behavior in these animals. This same sort of observation was made with lesser degrees of perfection in several other capture attempts.

In another instance a school of seven or eight animals was pursued northward along Coronado strand toward the bay entrance. Their path into the bay was blocked by the very long federal breakwater that juts out from the south side of the entrance. The water behind this breakwater on the Coronado strand side is shallow, murky, and seemingly ideal for capture of the porpoises. As the animals swam rapidly into this cul-de-sac the collecting crew nearly released the net several times, but each time the boat was in position the animals raced ahead at a faster speed and had to be overtaken again. They swam directly toward the breakwater, and instead of turning when they reached it, the entire school headed into a spot where several rocks had rolled down, leaving a channel only a few inches in depth across the breakwater. Without any hesitation they plunged into this tiny channel and, while partly out of water, swam to the other side and safety. Once they had gained the other side they slowed their pace and moved calmly up the bay, leaving the Marineland collectors helplessly waiting on the other side.

In the turbid waters of San Felipe Bay, Baja California, Mexico, a series of attempts was made to capture bottlenose porpoises by the various net techniques discussed above, entirely without success. Each time the net was being closed the animals disappeared through the opening and swam to safety. After several days of such frustration we took the advice of a native fisherman and agreed to let him try hook and line, though this method is very seldom successful in taking porpoises in California waters. He baited a large hook with a whole half-pound croaker of the species *Micropogon ectenes* and tossed it over the side into a group of porpoises milling about the stern of the shrimp trawler. The time was near midnight of a very black night on January 26, 1958. The bait was almost immediately snapped up and the thin nylon line streaked through the fisherman's fingers, disappearing over the side before it could be secured. Minutes later another attempt was made, this time with a nine-thread manila line attached to the steel leader and hook. Once again the bait was taken within a short time, but in this instance the manila line was soon secured to a heavy skiff, with another astern. Then followed a wild chase through the night, with the lumbering shrimp trawler following astern, trying to keep in contact with the skiffs by watching the beams of our flashlights. The porpoise towed the skiff and passengers for about five hours, and just as dawn was breaking the animal was pulled alongside the skiff, exhausted. A small piece of heavy nylon gill net was set around it. The two skiffs were tied alongside each other for stability and the weary collectors attempted to roll the huge animal into the nearest skiff. The girth of the animal was so great that the men could not stretch their arms around it. Finally they relaxed their hold and the animal slipped into the muddy water and out of sight. It was seen no more as it had located and escaped under a portion of the lead line that was held up from the bottom by a small piece of wire entangled in the net. The animal was estimated at 12 feet in length, probably about 800 pounds in weight.

Offshore schools of the species *Tursiops gilli* are almost uniformly found in the company of pilot whales. A typical capture sequence was recorded on September 28, 1956, 3.5 miles south of Long Point, Palos Verdes Peninsula, in the deep San Pedro Channel. A group of four pilot whales with young was sighted and the collecting vessel *Geronimo* approached at 7 knots. Soon it became apparent that the pilot whales were accompanied by a school of about twenty bottlenose porpoises. With the approach of the vessel the porpoises veered away from the whales and began to play about the bow. The pilot whales stayed well clear of the vessel and began to drop astern. After a few minutes at the bow the entire group of bottlenose porpoises veered away and swam astern to reëstablish company with the whales. The boat was again turned toward the school and the porpoises returned to the bow for a few minutes and then swam back to the lagging whales. The majority of the porpoises were very large adults estimated to be about 12 feet in length. The smallest member of the school was netted, a 7-foot, 11-inch female. As soon as she was hit with the net she checked her forward progress and began to spin around, apparently trying to shake it loose. Then she sounded. When she surfaced, one of the large adult bottlenose porpoises was in close company with her. This animal stayed with the captive throughout her struggle. Twenty minutes after being netted the animal sounded again, taking out about 180 feet of line. At the bottom of her sound the line stood taut, vertically downward from the gunwhale of the skiff. After two or three minutes she returned to the surface with her companion.

Once the collectors had grasped the tail stock of the captive she ceased all struggle and was hauled aboard without incident.

TABLE 5

MEASUREMENTS AND PROPORTIONS OF *Tursiops gilli*

Measurement	January 12, 1957 Off Coronado Island, San Diego Co., Calif. Male; 136 lbs.		November 30, 1957 3 miles S. of Coronado, San Diego Co., Calif. Male;		September 28, 1956 3.5 miles SSW. of Pt. Vicente, Los Angeles Co., Calif. Female;		February 13, 1958 10 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male;	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	179.0	.....	232.5	.....	236.0	.....	246.5	.....
Snout to eye	28.6	0.158	33.0	0.142	34.3	0.145	31.8	0.128
Snout to end of mouth crease	24.1	0.134	.....	.....	.....	.....	29.2	0.118
Snout to anterior origin of flipper	.....	.....	54.6	0.234	55.9	0.236	53.4	0.216
Snout to apex of melon	.....	.....	10.1	0.043	9.5	0.040	10.2	0.041
Snout to center of blowhole	.....	.....	33.0	0.142	35.6	0.150	34.3	0.139
Snout to anus	124.5	0.695	137.5	0.592	171.0	0.724	.....	.....
Snout to origin of dorsal fin	.....	.....	104.0	0.448	106.6	0.451	.....	.....
Flipper (left)—anterior origin to tip	26.0	0.144	36.8	0.158	35.6	0.150	38.8	0.156
Flipper (left)—axilla to tip	.....	.....	.....	.....	.....	.....	29.2	0.118
Flipper (left)—greatest width	10.8	0.063	.....	.....	12.7	0.053	14.0	0.056
Flukes—depth of median notch	.....	.....	.....	.....	.....	.....	5.1	0.020
Flukes, spread—tip to tip	41.9	0.234	56.6	0.242	48.6	0.205	54.7	0.221
Median notch of flukes to dorsal fin at deepest point of posterior curve	.....	.....	.....	.....	.....	.....	127.0	0.515
Dorsal fin—length of base	22.9	0.127	30.8	0.132	29.2	0.123	35.6	0.144
Dorsal fin—height	14.6	0.080	.....	.....	17.8	0.075	25.4	0.10
Dorsal fin—anterior origin to deepest portion posterior curve	.....	.....	.....	.....	25.4	0.107	30.5	0.123
Dorsal fin—anterior origin to center of blowhole	.....	.....	73.7	0.316	69.2	0.293	78.8	0.319
Blowhole—width	2.8	0.015	.....	.....	3.8	0.016	3.2	0.012
Projection of lower jaw beyond upper	0.63	0.002	.....	.....	0.95	0.003	0.6	0.002
Genital slit—length	7.6	0.042	.....	.....	11.4	0.048	.....	.....
Girth—at anterior origin dorsal fin	97.0	0.541	123.0	0.530	.....	.....	.....	.....

[1] Proportions expressed in one-thousandths of total length.

TABLE 5—*Continued*

Measurement	December 2, 1957 3 miles S. of Coronado, San Diego Co., Calif. Female;		April 28, 1958 Entrance San Diego Bay, San Diego Co., Calif. Female;		January 12, 1957 San Diego Bay, San Diego Co., Calif. Female; 557 lbs.		January 12, 1957 San Diego Bay, San Diego Co., Calif. Female; 690 lbs.	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	297.5	.....	297.5	.....	300.0	.....	307.0	.....
Snout to eye	34.3	0.115	35.0	0.112	38.8	0.128	36.8	0.119
Snout to end of mouth crease	.....	.....	30.5	0.102	33.0	0.110	33.0	0.107
Snout to anterior origin of flipper	.....	.....	.....	.....	.....	.....	.....	.....
Snout to apex of melon	7.6	0.025	24.1	0.081	.....	.....	.....	.....
Snout to center of blowhole	24.8	0.082	36.8	0.123	.....	.....	.....	.....
Snout to anus	.....	.....	207.0	0.616	209.0	0.699	.....	.....
Snout to origin of dorsal fin	90.0	0.303	129.0	0.453	.....	.....	.....	.....
Flipper (left)—anterior origin to tip	42.5	0.142	44.5	0.149	40.6	0.135	45.8	0.148
Flipper (left)—axilla to tip	.....	.....	.....	.....	.....	.....	.....	.....
Flipper (left)—greatest width	15.2	0.051	16.5	0.055	17.8	0.059	.....	.....
Flukes—depth of median notch	.....	.....	.....	.....	.....	.....	.....	.....
Flukes, spread—tip to tip	66.7	0.223	73.7	0.247	68.0	0.226	73.7	0.239
Median notch of flukes to dorsal fin at deepest point of posterior curve	.....	.....	.....	.....	.....	.....	.....	.....
Dorsal fin—length of base	36.8	0.123	.....	.....	39.4	0.131	43.2	0.140
Dorsal fin—height	26.7	0.089	25.4	0.080	22.9	0.076	25.4	0.082
Dorsal fin—anterior origin to deepest portion posterior curve	.....	.....	31.8	0.106	.....	.....	.....	.....
Dorsal fin—anterior origin to center of blowhole	.....	.....	.....	.....	.....	.....	.....	.....
Blowhole—width	.....	.....	5.0	0.017	4.4	0.014	5.7	0.018
Projection of lower jaw beyond upper	0.6	0.004	0.6	0.004	1.3	0.004	2.5	0.008
Genital slit—length	.....	.....	17.8	0.059	15.2	0.050	.....	.....
Girth—at anterior origin dorsal fin	.....	.....	.....	.....	160.0	0.533	.....	.....

[1]Proportions expressed in one-thousandths of total length.

MORPHOLOGY

Measurements of various specimens of *Tursiops gilli* taken at Marineland of the Pacific are listed in table 5.

REPRODUCTION

Young.—The adult female captured off Coronado strand on January 12, 1957, was closely accompanied by a young male animal when swimming in the net, and was lactating when brought on deck. The young animal was not feeding independently at the time of capture since examination of its stomach revealed no food other than what appeared to be partly digested milk. The adult female was kept in captivity until May 16, 1957, when it died. Autopsy revealed that the animal contained a well-developed nearly term embryo. Thus this animal was still nursing one young while producing another. It has been thought that *T. truncatus* produces young only every other year (Tavolga and Essapian, 1957), and sometimes suckles its young for as long as twenty months. If this was true in the instance reported here the suckling young would have been approximately nineteen months old. Its small size and weight make it far more likely that it was seven or eight months old. Its weight (estimated between 125 and 150 lbs.) is comparable to that of a nine-month old *T. truncatus* reported by Tavolga and Essapian (1957) (137 lbs.). Thus, it seems likely that this female was in the process of producing young in two successive years, if the young captured with her was, indeed, her own.

BEHAVIOR

Locomotion.—Pacific bottlenose porpoises seldom swam or played around the bow of our 37-foot collecting vessel in San Diego Bay, though they were seen riding at the bow wave of heavy tugs. The animals ran our bow much more readily in open waters outside the bay, and when in deep water they accompanied the vessel for more extended periods still. Schools of bottlenose porpoises encountered in the deep San Pedro Channel can nearly always be induced to play about the bow on calm days but refuse to do so if the sea is rough with chop or swell.

Schooling: Pacific bottlenose porpoise schools are relatively small in California waters, usually numbering under twenty individuals. When undisturbed they often travel in very loose relationship to one another; the general grouping in quiet bays is a group of two or three in one place, another similar group 75–100 yards away, and so on, all moving in the same general direction. The groups seen just offshore from breaker lines are usually more compact and tend to move as a cohesive unit. Normal speeds for any of these groups is slow, probably not usually exceeding 3 or 4 knots. The schools encountered in deep water have varied from about five animals to about twenty-five, and are usually gathered in fairly tight swift-moving groups that maintain their identity in the midst of the pilot whale schools.

The groups sighted in the upper Gulf of California have sometimes been much larger than those of the California coast, numbering a hundred or more animals in several instances.

Social behavior.—We have already noted some rather remarkable instances of social behavior in other parts of this discussion, such as the marked affinity between pelagic bottlenose porpoise schools and pilot whale schools, and the intraspecies assistance behavior shown when a school member was being captured. In addition to these observations we have noted a few other items that seem worthy of record. Lobtailing is a very common behavior pattern in this species. Many times when we were pursuing a particular group of animals they would sound immediately after one or more members had slapped their flukes on the surface. The pattern was sometimes used when no pursuit was involved, such as when animals were quietly feeding in the still waters of a bay. Usually before each deep extended dive one or more adult members would lightly slap its tail flukes upon the surface, and then sound.

Leaping from the surface occurs from time to time, and was particularly common in bay schools toward the end of the day, when they were sometimes seen moving slowly along leaping out of the water, falling back on their sides or backs.

Feeding.—Our observations of the feeding behavior of these porpoises are particularly interesting since they indicate a remarkable degree of flexibility in the behavior of the species. The feeding habits of various populations seem closely adjusted to local, and sometimes transient, conditions. For example, the San Diego Bay population regularly made its way out of the bay and southward along the coast some 18 miles to Imperial Beach to feed around the Navy garbage buoy, where the fleet anchored in the harbor dumped its daily load of refuse. A more remarkable example of this behavioral plasticity occurs in San Felipe Bay, in the northern Gulf of California. At this locality the main industry centers around the shrimp fishing fleet, which operates only during a restricted season each year. The boats drag large otter trawls across the muddy bottom of the gulf, gathering shrimps and many species of small fish as well. The nets fish for three or four hours and then are winched onto the after decks of the vessels. It is a common sight just before a net comes on board to see bottlenose porpoises, who were nowhere in sight while the net was out, leaping out of the water as they race toward the vessel. In one instance the senior author estimated the animals as starting their dash toward the boat from 2 miles away. By the time the net is on board and the cod-end opened, they are milling around the vessel in the murky water, sometimes so close aboard that they can be hit or poked by the fishermen. The fishermen sort the shrimps from the catch and shovel the trash fish over the side to the waiting porpoises. One cannot help but conclude that these animals hear and recognize the specific sounds produced by the boat winching in its net, and from very considerable distances.

The stomach contents data listed in table 6 indicate a catholic taste, including free-swimming fish and a number of shallow-water bottom-dwelling fish and invertebrates. For a porpoise to ingest such items as bivalves, gastropods, and hermit crabs, it would have to feed directly on the bottom layer or even actually root in the mud or sand. We have seen porpoises that, from the surface, appeared to be engaged in such bottom feeding. The porpoises that follow the Coronado ferry interminably back and forth seem to be diving in the propellor wash, perhaps to retrieve food items dislodged by the currents.

Antonio Perisky, an American fisherman, who had lived at Estero de Punta Banda, Baja California, for thirty-six years at the time we met him in 1956, reported that many times he had seen bottlenose porpoises feeding during his netting operations in the lagoon. The porpoises were observed to come to the surface and repeatedly throw 2- or 3-pound fish into the air. Mr. Perisky thought these fish were probably spotfin croakers (*Roncador stearnsi*). This behavior is reminiscent of that reported earlier in this monograph, in which captive Atlantic bottlenose porpoises softened large fish before swallowing them by tossing them into the air, and may in fact have been the same thing.

Respiration.—A group of three bottlenose porpoises was observed diving in about 65 feet of water around the stern of an aircraft carrier anchored in San Diego Bay. The animals were moving slowly and aimlessly about, presumably feeding on or near the bottom. Their respiratory behavior consisted of one, two, or three breaths at short intervals of ten seconds or less, followed by a long dive of from a minute and a half to about two minutes in length. These observations are summarized in figure 6.

TABLE 6

STOMACH CONTENTS OF ADULT FEMALE *Tursiops gilli* (MLP57-1)

Species[1]	Remains[2]	No. of Otoliths	Left	Right	Probable no. of fish
Genyonemus lineatus (White Croaker)	otoliths and skulls	45	23	22	25 plus
Seriphus politus (Queen Fish)	otoliths	16	9	7	9
Menticirrhus undulatus (Corbina)	otoliths and pharyngeal teeth	10	6	4	6
Amphistichus argenteus (Barred Surfperch)	otoliths and pharyngeal teeth	12	7	5	11
Cymatogaster aggregatus (Shiner Perch)	otoliths	5	3	2	3
Phanerodon furcatus (White Seaperch)	otoliths and pharyngeal teeth	2	1	1	1
Miscellaneous embiotocids	otoliths	7	3	4	4 plus
Atherinops affinis (Topsmelt)	otoliths	3	1	2	2
Paralichthys californicus	otoliths and skull	2	1	1	1

[1] None of the fish were longer than about 10 inches.
[2] Also ingested were barnacle tests, crab claws, shrimp remains, one intact bivalve (*Nuculana taphria*), and three gastropod shells (two of *Nasarrius perpinguis*, containing hermit crabs and one empty *Mitrella gausapata*).

NORTHERN RIGHT WHALE PORPOISE

Lissodelphis borealis (Peale)

DISTRIBUTION

Range.—*Lissodelphis borealis* (Peale) is a northern cold-water form sometimes found far at sea. It has been reported twice in California waters, once from 200 miles off Cape Mendicino (True, 1889) and once as far south as San Diego Bay (Scammon, 1874). It ranges northward into the Bering Sea (Miller and Kellogg, 1955).

In view of this paucity of California records, six southern California sight records become of interest. A fisherman described to us an hour-long encounter with a school of these animals between Santa Barbara and Anacapa islands during the winter of 1957. His description of this highly distinctive animal left little doubt that he had seen a school of right whale porpoises. Then, on January 25, 1960, Marineland's collecting vessel *Geronimo,* manned by Frank Brocato and Frank Calandrino, encountered a large school of these animals, composed of an estimated ninety individuals, 8 miles south of Long Point, Palos Verdes Peninsula, Los Angeles County, California. The animals were pursued for more than two hours in an attempt at capture. A minute description of the animals was recorded, and they were certainly *Lissodelphis.* Two days later, what may have been the same school was encountered off the east end of Santa Catalina Island by a fisherman, Herbert Gale. The Marineland collectors encountered northern right whale por-

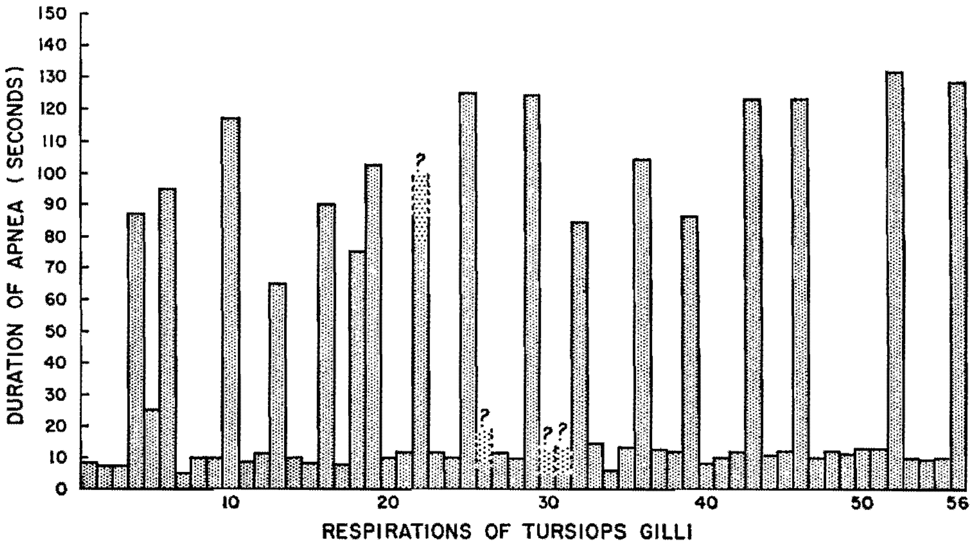

Fig. 6. Respiratory cycle in a school of two adult and two young Pacific bottlenose porpoises (*Tursiops gilli*) diving in approximately 45 feet of water, San Diego Bay, California. The animals were apparently feeding on the bottom at the time the record was made.

poises a second time on February 17, 1960, when 4 miles east of Long Point, Santa Catalina Island, California.

None of the observers who saw these right whale porpoises knew of the existence of the species prior to their encounter and yet all gave a number of specific details that clearly describe it.

CAPTURE OBSERVATIONS AND SIGHTINGS

The first school encountered by the Marineland collectors was composed of three subgroups of about thirty animals each. When first sighted the porpoises were floating quietly, each with a small part of its head showing above the surface. A group of pilot whales (*Globicephala scammoni*) was swimming nearby. When approached, the right whale porpoises bolted and raced through the water with considerable speed. As soon as the boat took chase the animals began to jump out of the water in series of regular low-angle leaps. As the boat began to close on the school the porpoises sounded; when they resurfaced they were scattered over a considerable area. Further pursuit caused them to regroup and flee.

The animals were of uniform size, estimated at about 6 feet in length and 140 pounds in weight. They were very slender, possessed no dorsal fin, and had extremely small pectoral flippers and very narrow flukes. A very pronounced and sharp caudal keel was noted. The animals were described as brownish-black above with ventral surfaces white from the tip of the lower jaw along the abdomen to the ventral surfaces of the flukes. As seen from a scouting plane, the dorsal margin of the flukes appeared light brown in color, making them quite distinct from the remainder of the flukes and body. This contrasting outline made it evident that the flukes were no wider than the widest part of the body.

On the second encounter the Marineland collectors found an estimated twenty right whale porpoises swimming in the midst of a group of about two hundred adults and young of *Lagenorhynchus obliquidens*. The right whale porpoises were followed for about 2 miles and the boat approached within about 30 feet of them. Dall porpoises were also noted in the area. The sea temperature was 56° F.

On April 18, 1960, a mixed group of about sixty right whale porpoises and about thirty pilot whales was located 4 miles north-northwest of Long Point, Santa Catalina Island, California, from a scouting plane. The animals were traveling on a northwest course. The two species were often intermixed. The right whale porpoises occasionally grouped closely together and tended to lead the pilot whales. The collecting vessel *Geronimo* was directed to this group. As the boat approached the intermixed porpoises and whales, the porpoises immediately bunched together and left the pilot whales. They swam rapidly away for nearly a mile. Meanwhile the *Geronimo* pursued the whales and followed them for about forty minutes while the scouting plane circled overhead. From the high vantage point in the plane both the whales and porpoises could be seen easily. While the collecting boat pursued the pilot whales the right whale porpoises could be seen keeping station with the whales, making turns when the whales turned. Sometimes these turns were as great as 180° for both groups. The distance between whales and porpoises varied between .75 of a mile and a mile during these maneuvers. The groups were obviously maintaining some sort of contact with each other. Since the distance was so great, visual contact seems an unlikely explanation; auditory contact seems most likely.

On May 3, 1960, northern right whale porpoises were again sighted in the San Pedro Channel. This school was composed of about twenty adults and ten or twelve young. The school was moving very slowly when first sighted, but as the collecting vessel approached, the young began to leap from the water. These tiny porpoises were estimated to be 24 to 28 inches long and to weigh about 15 pounds. Their color and pattern appeared to be identical with that of the adults.

Robert Orr, of the California Academy of Sciences, has provided us with the record of a stranded northern right whale porpoise. This animal was taken alive from Dillon Beach, Marin County, California, on June 12, 1948. It died shortly afterward. Photographs were taken and there is no question that animal was of this species. The specimen was a 6-foot, 8-inch male, and the skeleton is now on deposit at the Pacific Marine Station at Dillon Beach. The original identification was made by Margaret Barr and later confirmed by Carl L. Hubbs.

On November 7, 1960, lifeguards found a porpoise stranded on the beach near the foot of 22nd Street in Manhattan Beach, Los Angeles County, California. The animal was still alive when found but died almost immediately from two gunshot wounds which passed through its dorsal surface, lungs, and out the sternum. The animal was brought to Marineland of the Pacific for photography, measurement, and dissection.

MORPHOLOGY

Morphometrics and anatomy.—Measurements and other pertinent data are tabulated in table 15 (p. 366).

Color and pattern.—The over-all color pattern of the animal, recorded a few minutes after death, was jet black above and on the lateral surfaces, and pure white below (pl. 41). The tip of the lower jaw and the distal two-thirds of the lower surfaces of the tail flukes were white. On the dorsal surface of the flukes this same distal two-thirds was light gray, which darkened and became almost indistinguishable from the fluke bases after the animal had been dead for a few days. The ventral white blaze mark originated mid-ventrally below the level of the eye and widened to cover the entire chest, extending from one flipper base to the other, then narrowed sharply, continuing posteriad as a relatively thin white line, widening somewhat over the urogenital area and continuing along the lower margin of the caudal peduncle onto the fluke base.

BEHAVIOR

Feeding.—The stomach of the Manhattan Beach animal contained several hundred squid beaks, probably of *Loligo opalescens,* plus a quantity of unidentifiable material.

PARASITISM

A number of unidentified cysts were found beneath the blubber in the body muscle sheaths. There was an extremely high concentration of these cysts in the urogenital area.

Pacific Striped Porpoise

Lagenorhynchus obliquidens Gill

DISTRIBUTION

Range.—The Pacific striped porpoise has been reported in eastern Pacific, from Valdez, Alaska, in Prince William Sound to Ballenas Bay, Baja California, Mexico (Scheffer, 1950).

Seasonal movements.—Brown and Norris (1956) reported that this species was common in the inshore waters of southern California during winter and spring months and found only in offshore waters during the summer and fall. We can now add four additional years of observations to this report. The species is very seldom encountered in San Pedro Channel during the warmest months of the year (July, August, September) but has been sighted or reported repeatedly around San Nicolas Island during this period (fig. 7). Abundance rises very markedly

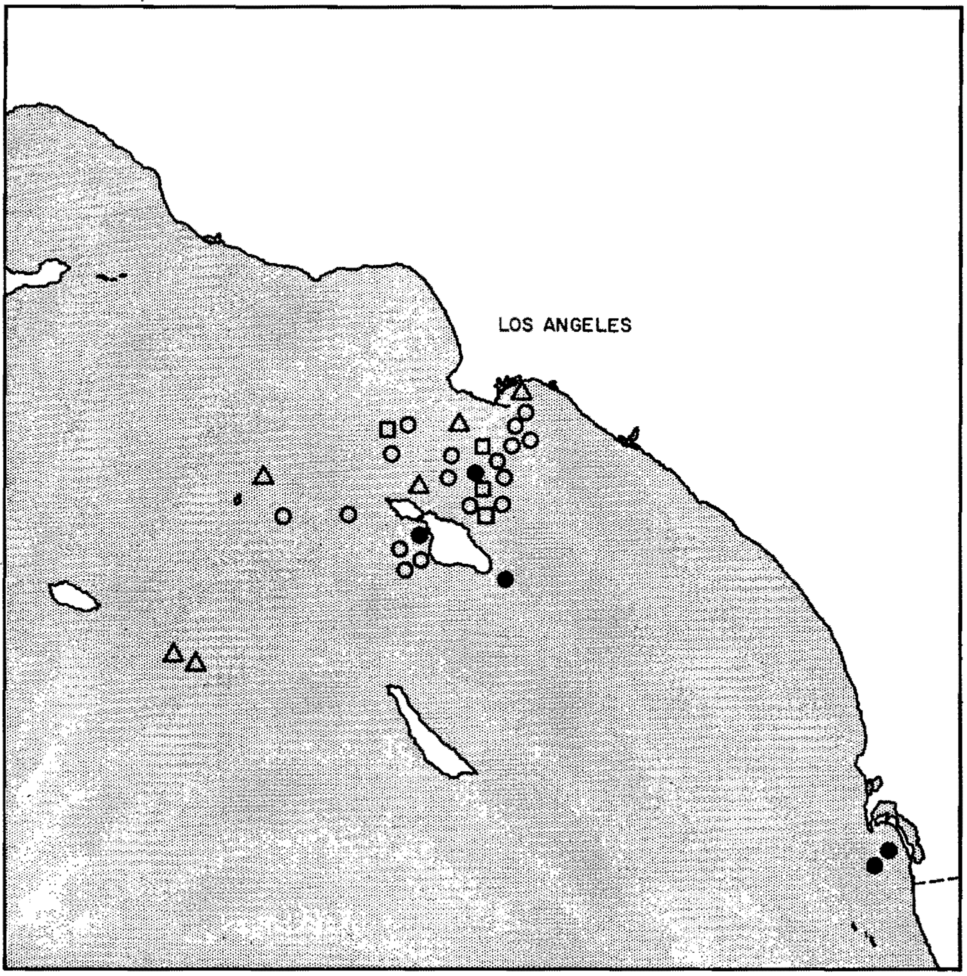

Fig. 7. Sight records and localities of capture of the Pacific striped porpoise (*Lagenorhynchus obliquidens*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

with the cooling of surface waters in the San Pedro Channel. This population movement is probably related to seasonal variations in food supply, since the squid (*Loligo opalescens*) becomes abundant during late fall and winter months in nearshore areas.

CAPTURE OBSERVATIONS AND SIGHTINGS

On September 3, 1956, a report was received at Marineland that a porpoise was swimming under the pier at Pacific Landing, Long Beach, California. This report was very unusual as cetaceans are seldom seen inside the Los Angeles Harbor breakwater, where this landing is located. We suspected one of the relatively rare occurrences of the Pacific bottlenose porpoise (*Tursiops gilli*) but were suprised to find a large adult female Pacific striped porpoise instead. By the time of our arrival she had been hooked by a fisherman using a thin monofilament line and an

TABLE 7

MEASUREMENTS AND PROPORTIONS OF *Lagenorhynchus obliquidens*

Measurement	January 24, 1957 7 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male; 211¾ lbs.		January 24, 1957 7 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male; 270¾ lbs.		January 24, 1957 7 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Female; 242 lbs.		February 15, 1960 6–8 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Female;		December 9, 1959 9 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male; 280 lbs.	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	183.2	.....	199.0	.....	203.0	.....	204.0	.....	228.5	.....
Snout to eye	26.7	0.145	28.0	0.142	28.0	0.140	30.5	0.149	29.2	0.127
Snout to end of mouth crease	23.2	0.126	25.1	0.126	25.4	0.125	26.0	0.127	25.4	0.111
Snout to anterior origin of flipper	.....	.....	.....	.....	.....	.....	50.8	0.249	53.4	0.233
Snout to apex of melon	.....	.....	.....	.....	.....	.....	4.4	0.021	2.5	0.010
Snout to center of blowhole	.....	.....	.....	.....	.....	.....	30.4	0.149	29.2	0.127
Snout to anus	130.5	0.715	143.0	0.715	146.0	0.718	.....	.....	.....	.....
Flipper (left)—anterior origin to tip	36.8	0.197	38.5	0.192	36.5	0.178	35.6	0.174	38.1	0.166
Flipper (left)—axilla to tip	.....	.....	.....	.....	.....	.....	27.9	0.136	29.2	0.127
Flipper (left)—greatest width	12.1	0.065	12.7	0.063	13.3	0.065	12.7	0.062	15.2	0.066
Flukes—depth of median notch	.....	.....	.....	.....	.....	.....	3.8	0.018	4.4	0.019
Flukes, spread—tip to tip	49.6	0.270	56.0	0.280	50.8	0.250	51.4	0.251	56.0	0.245
Median notch of flukes to dorsal fin at deepest point of posterior curve	.....	.....	.....	.....	.....	.....	96.5	0.473	108.0	0.472
Dorsal fin—length of base	23.5	0.128	29.2	0.146	29.2	0.143	26.7	0.130	34.3	0.150
Dorsal fin—height	17.8	0.097	17.1	0.085	19.7	0.096	19.0	0.093	21.6	0.094
Dorsal fin—anterior origin to deepest portion posterior curve	23.4	0.127	28.7	0.141	29.2	0.143	25.4	0.124	31.8	0.139
Dorsal fin—anterior origin to blowhole center	.....	.....	.....	.....	.....	.....	53.4	0.261	63.5	0.277
Blowhole—width	2.8	0.015	3.7	0.015	3.7	0.015	3.8	0.018	4 4	0.019
Projection of lower jaw beyond upper	0.4	0.004	0.4	0.003	0.6	0.002	1.2	0.005	0.0	0.000
Genital slit—length	12.7	0.069	13.3	0.066	14.0	0.068	.....	.....	.....	.....
Girth—at anterior origin of flippers	.....	.....	.....	.....	.....	.....	99.0	0.485	105.5	0.461
Girth—at anterior origin dorsal fin	114.0	0.625	127.0	0.636	120.5	0.593	115.5	0.566	116.5	0.509
Girth—at level of anus	.....	.....	.....	.....	.....	.....	62.2	0.304	67.3	0.294
Umbilicus to anus	.....	.....	.....	.....	.....	.....	53.3	0.261	63.5	0.270
Anus to reproductive aperture	.....	.....	.....	.....	.....	.....	7.6	0.037	27.9	0.122
Anus to median notch of flukes	.....	.....	.....	.....	.....	.....	55.9	0.274	63.5	0.277

[1] Proportions expressed in one-thousandths of total length.

anchovy for bait. The fisherman had played the porpoise for about two hours. We quickly netted her and brought her into a skiff. There she began a tremendous struggle, futilely battering the skiff and her captors. Before the animal could be taken ashore her heart beat became irregular and shortly ceased altogether. Her left eye protruded in an unusual manner during the struggle and it is surmised that she wandered into the harbor while in a diseased condition.

MORPHOLOGY

Morphometrics and anatomy.—Measurements and proportions of five individuals are given in table 7.

REPRODUCTION

Young.—A diffuse school of perhaps five hundred striped porpoises was sighted on September 18, 1956, 7 miles south of Point Vicente Lighthouse, in the San Pedro Channel. At first sighting, the school was thought to be composed of common dolphins because many animals could be seen leaping clear of the water. Closer inspection showed that, instead, it was a school of Pacific striped porpoises containing many young animals that were jumping periodically. The porpoises were spread over at least a square mile of the sea and for the most part, were gathered in subgroups of a dozen animals or less. One subgroup of approximately forty adults and young was seen. These young were in various stages of growth, ranging from one tiny animal that measured about 2.5 feet in length and weighed an estimated 30 pounds, to larger animals hardly distinguishable from adults. The smaller young each stayed close to the side of an adult animal, while the larger young were sometimes seen in separate groups. The smallest animal swam in perfect unison with its accompanying adult, as if glued to its side. Adults with young were wary of the boat and only once did we have a small animal at the bow for more than a few seconds. This individual was about 3 feet long. Its colors, and those of other small young, seemed less vividly dark and light than those of the subadults and adults. The dorsal fins of the young were distinctly more pointed and triangular than those of adults, and did not possess a hooked posterior contour.

The young were very playful and constantly jumped from the water, rolling over in the air or falling back into the water on their backs. Sometimes these little animals jumped time after time, and with each fall, slapped their tail flukes against the water. One young animal jumped fourteen times in quick succession and another leaped eight successive times. Some larger animals, which were either adults or subadults, were also seen leaping.

The subgroups of the school were of distinctly variable age groups. In addition to groups of adults and young, there were other segregated subgroups of either subadults or adults.

An adult female was captured from the school. On September 25, 1956, eight days after her capture, she passed portions of foetal membranes, including a part of the placenta.

It seems obvious that some of the young in the school were newborn or nearly so. Brown and Norris (1956) recorded young accompanied by adults on June 6, 1954, in the San Pedro Channel. Thus the species must produce young at least throughout the late spring and summer months. This spread in birth period is also attested to by the wide range of size groups that have been seen in summer and fall schools.

BEHAVIOR

Locomotion.—A discussion of some aspects of locomotion in this species is recorded in the section entitled "Assisted Locomotion."

Social behavior.—Play: Captive adult Pacific striped porpoises have been seen performing leaps much like those described above for young animals (pl. 31, *a*). On one occasion an adult repeatedly leaped from the water, did a complete tail-over-head flip, and slapped the dorsal surface of her tail flukes against the water with a resounding smack. A variation of this leaping behavior was noted in which the animal leaped from the water in a normal upright position and rotated on her longitudinal axis, smacking the water with the broad side of her dorsal fin as she fell back.

Still another kind of leap was seen several times; the animal leaped from the water belly up, did a complete flip, and entered the water again headfirst, still belly up.

PARASITISM

An adult female captured September 18, 1956, had an ectocommensal barnacle attached to its caudal peduncle. The barnacle was identified as *Xenobalanus globicipitus* Steenstrup, by Ira Cornwall of Vancouver, British Columbia.

KILLER WHALE
Orcinus orca (Linnaeus)

DISTRIBUTION

Range.—Along the Pacific coast of North America the killer whale has been reported from the Bering Sea (Hanna, 1920; Preble, 1923) to Baja California (Scammon, 1874) and Alijos Rocks (Brown and Norris, 1956).

Seasonal movements.—Although the majority of our records for killer whales in southern California waters are for fall, winter, and early spring months, some sightings have been made during the entire year, without any obvious stable periods of absence (fig. 8).

CAPTURE OBSERVATIONS AND SIGHTINGS

On December 1, 1956, when 4 miles southwest of Point Loma, San Diego County, California, a group of eight killer whales was sighted. Two bulls were sighted first but could not be approached. The remainder of the group swam separately, 4 miles farther out to sea. It consisted of five females and one small calf. These whales showed no great concern at the approach of the boat. One female, estimated to be 18 to 20 feet long, swam toward the vessel and appeared to examine the two skiffs tied astern. She then leaped completely out of water on two occasions when no more than 20 yards from the railing (pl. 31, *b*). The whales were followed and they passed many times across the bow, stern (pl. 32, *a*), and sometimes completely under the vessel. Then the calf accompanied by a big female swam over to the ship and stationed itself just in front of the bow. The calf was estimated at 7 feet in length. The chief collector, Frank Brocato, took his place in the pulpit that overhangs the bow, in an attempt to snare the little animal. On one occasion he was

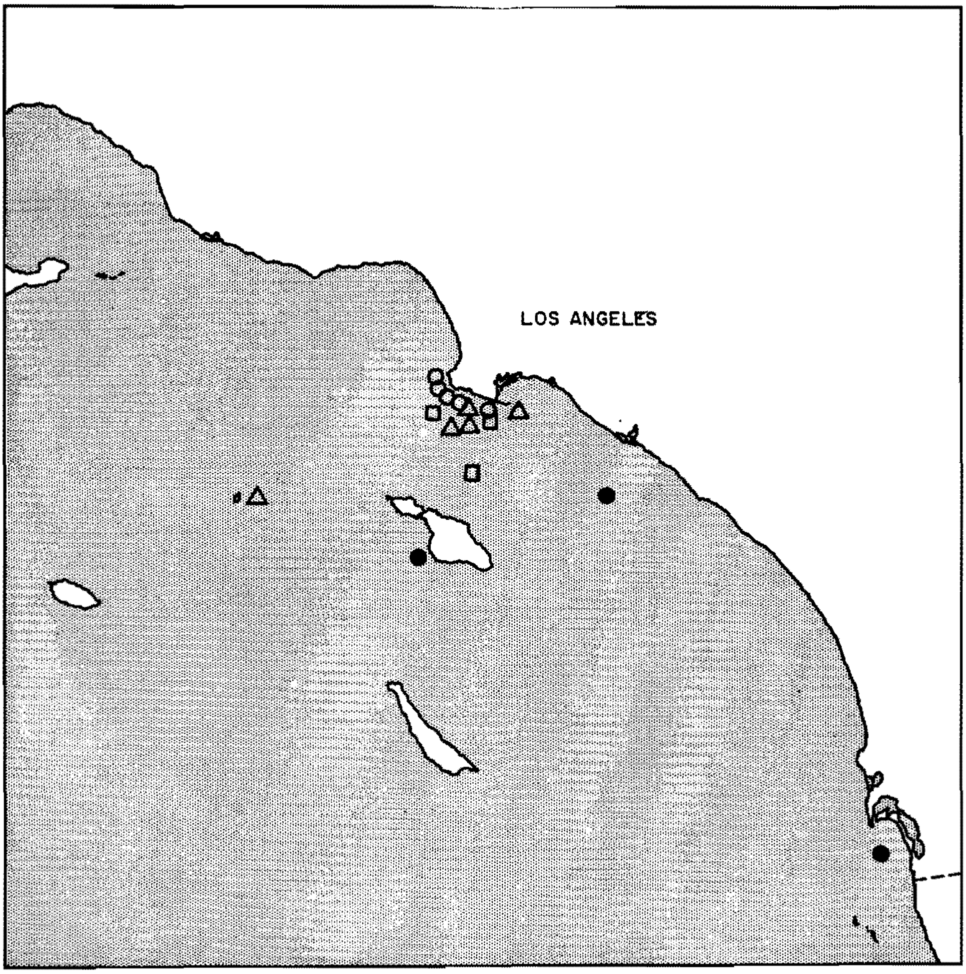

Fig. 8. Sight records of the killer whale (*Orcinus orca*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

almost successful in accomplishing this, and it was interesting to observe the young whale roll on its side and watch the collector, who was poised just above it. The cow, which closely accompanied the calf, also came to the surface and rolled on her side, making a perfunctory pass at the line that trailed from the snare into the water.

Many times, as they started to dive, the females flipped their flukes from the water and slapped the surface just before submerging. Lobtailing by killer whales has been noted by Dakin (1934) in Twofold Bay, Australia.

MORPHOLOGY

Color and pattern.—The 7-foot calf mentioned above was strikingly colored. All of its light-colored patches, which on adults are white, were lemon yellow. Its flanks appeared furrowed with several vertical creases. This calf was a few days old at most, as judged from the creases, which are thought to result from folding of the skin within the mother's uterus (McBride and Kritzler, 1951). Also, the unusual yellow coloration has been noted by Andrews (1931) for a foetal *Orcinus,* which he described as being patterned with reddish-yellow and black markings.

BEHAVIOR

Locomotion.—Schooling: Killer whale schools often appear to be segregated into sex and age groups. Females and young usually swim together in close company, whereas males often may travel alone or in subgroups swimming some distance

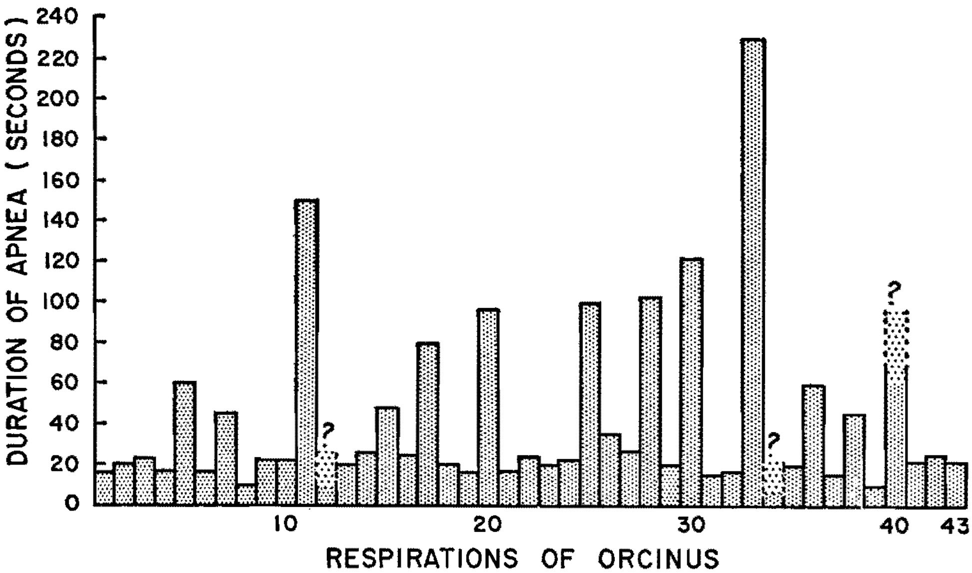

Fig. 9. Respiratory cycle in an adult male killer whale (*Orcinus orca*). The animal was traveling with four adult females and another adult male in the open ocean, at about 4 knots.

away. If males, females, and young are seen swimming together the females and young often still cluster as a subgroup. Immature males have been seen swimming with females and young.

Even though the separate groups of a killer whale school are separated by as much as 4 miles, all usually move on closely similar courses unless disturbed.

Killer whales often leap from the water as they swim along. These leaps usually consist of the animal hurling itself into the air until its tail flukes barely clear the surface or nearly break the surface, whereupon the animal turns on its side and falls into the water with a resounding smack amid a great spray of water. Lone males traveling a mile or more from the group of females and young have been seen leaping from the water on several sightings. It is conceivable that their leaps may serve as a position signal to the remainder of the school.

Diving: On November 25, 1956, a school of four adult female and two adult male killer whales was sighted 6.5 miles south-southwest of Newport jetty, Orange County, California. A series of stopwatch observations was made on the breathing rhythm of one of the adult males. The pattern was very irregular but it can be said that, in general, three, four, or five short dives of ten to thirty-five seconds duration were followed by a longer dive of from one to four minutes. The dive following one of these long dives was usually of the shortest duration of all, lasting from ten to twenty seconds (see fig. 9). The whale was traveling at about 4 knots during the observation period.

Feeding.—During August, 1955, the junior author sighted a school of killer whales a quarter of a mile north of Northeast Anchorage, Santa Barbara Island, California. The school consisted of four adult females and two adult males. The two bulls cut inshore of a herd of sea lions (*Zalophus californianus*). One of the male killer whales rushed from the water, leaping completely free of the surface holding an adult male sea lion crosswise in its jaws. The sea lion could be sexed because its marked saggital crest was seen clearly. The whale then played with the sea lion for about twenty minutes, sometimes throwing the carcass high into the air. The observer could not tell if other sea lions had been captured. A large area of water was red with blood.

Antonio Perisky, whose observations of *Tursiops gilli* were recorded earlier in this monograph, reports that in previous years, until the early 1940's, small groups of killer whales occasionally entered the Estero de Punta Banda, Baja California Norte, Mexico. These animals swam as far as the first sand bar, which is about 300 yards inside the entrance. There they fed upon the resident herd of harbor seals (*Phoca vitulina*). In late June of 1956 we counted thirty-eight seals of this species sleeping on this particular sand bar.

An incident involving the feeding habits of killer whales has come to our attention through a correspondent, John D. Chase of Canoe Cove, Fernie Island, British Columbia, Canada. Although these observations are from a locality beyond the area covered by this report, we feel that they are of sufficient interest to include them here, particularly since the species involves is that found also in California waters. Mr. Chase's account is quoted in part:

> The killer whale story happened, unfortunately, not to me but to a neighbor of ours, Jack Reid. However, Jack and his brother and sister, who all saw the episode, remember it very well. They live on Johnstone Island, a very small (about one acre) island just to the north of Fernie Island; both islands serving as a separation between Page Passage, on our west side, and Iroquois Passage on the east side. Page is only 800 feet wide but is 30 feet deep at low tide. Several times a year we have seen small schools of killer whales go up Page; there is usually at least one whale 25 feet long with a dorsal fin six feet tall. So my own observation leads me to believe Jack's story.
>
> On the southwest point of Johnstone Island there is a level ledge extending about 15 feet out to the edge of deep water. At the time the whales came through the tide was low enough so that this ledge was just out of water, making a perfect runway for the dog. This all happened in April of 1937, in the middle of the afternoon. Jack says it was the largest school of killer whales he ever saw hereabouts, about 30 to 40, moving slowly up the pass and making a lot of noise with their blowing and splashing. All the Reids stood on the bank watching this spectacle when the dog, a big Alsatian shepherd, ran out on the rock ledge and barked. One big whale, Jack claims it was at least 30 feet long, longer he says than his 30 foot fishing boat, saw the dog and came up with a rush in an attempt to grab the dog. He just missed the dog, who ran back up to the house, and who from then on, ran onto the house porch before barking at killer whales. In the meantime the whale had stranded himself on the ledge, about one half of him out of water. Only after wriggling and splashing with his tail for more than two minutes did he manage to slide back into deep water, apparently uninjured. He was black and white with a tremendous dorsal fin.

Warren Beadle, captain of the gill-net boat *Wolverine*, reported to us that just at dawn on a day in May of 1949 he sighted a tremendous disturbance on the surface of the sea 7 miles west of Point Dume, Los Angeles County, California. He investigated and found three killer whales (described as being black and white with tall dorsal fins) and about eight porpoises in a melee. Both the porpoises and the larger whales were jumping and there was blood in the water.

On November 26, 1958, the fishing boat *Vinmar* was cruising in 10 fathoms of water near Iron Bound Bay, on the windward side of Santa Catalina Island, when three killer whales were encountered. One was an adult male and the other two were smaller and presumably females. All were in the process of devouring a large electric ray (*Torpedo californica*). The whales would not shy from the boat but allowed it to come up until it was virtually on top of them. The entire incident lasted ten minutes.

John E. Fitch, Supervisor of Investigations, southern California, of the California Department of Fish and Game, reports an interesting observation of killer whales feeding inside Magdalena Bay, Baja California Sur, Mexico. The date is somewhat uncertain but thought to be April, 1952. Mr. Fitch states:

At the time, the research vessel was under way when I noticed a great deal of splashing between our vessel and shore. It looked as if a fast-moving school of large fish was heading toward shore. I put the binoculars on this "school" and saw some 10 to 15 sea lions heading toward shore as fast as I have ever seen sea lions move. They appeared to be skipping over the surface of the water, torpedo-like, in low-angle leaps. Herding them were several (five to seven) killer whales, apparently enjoying themselves. It was obvious that the sea lions were terrified. The killer whales appeared to stay in a crescentic formation at the rear and sides of this closely packed group of sea lions. Occasionally a killer whale would dive under the sea lions and come up under one. When this happened the sea lion was either bumped or thrown several feet into the air. It did not seem, however, that the killer whale was attacking the sea lion, rather it appeared as if the killer whale was enjoying a game and that the fright response of the sea lion, resulting from the contact, was stimulating to the killer whale.

The game lasted for about a mile or slightly more until the sea lions were about a city block offshore. At that time the entire group of killer whales attacked and for a few minutes not much could be seen but flying spray and large heaving bodies. The water over several hundred feet was churned into a bloody froth, and then there were no more sea lions visible.

The killer whales worked their way slowly through the bloody area—apparently feeding upon their victims, although no feeding observations were made by me. In fact, because of the distance involved, it was not possible to observe any of the actual killing process or tactics, although it must have taken place since no sea lions were observed reaching shore or any point beyond the battle area.

I have made several other trips into Magdalena Bay and beyond, but no other time have I seen killer whales there or for several hundred miles north.

False Killer Whale
Pseudorca crassidens (Owen)

Distribution

Range.—Bullis and Moore (1956) have summarized the North American records for the false killer whale and conclude that it is predominately a pelagic tropical or subtropical species. On the Pacific coast of North America the species has rarely been reported. Miller (1920) discusses skeletal material of this species taken at Pichilinque Bay, near La Paz, Baja California, Mexico. Staeger and

Reeder (1948) gave the only previous record for California, based on four skulls retrieved from San Nicolás Island, off the coast of southern California. Scheffer and Slipp (1948) reported on a specimen captured in Puget Sound, southern Washington.

CAPTURE OBSERVATIONS AND SIGHTINGS

On December 1, 1959, a school of what were very likely false killer whales, estimated to number three hundred animals, was encountered 3 miles northwest of the west end of Santa Catalina Island, California. The elongate school was judged to be 2 miles in length and about a half a mile wide.

The animals in the school were estimated to range in size from 5 feet to a little more than 10 feet in length. Many of the animals, estimated at 9 feet in length, were accompanied very closely by young.

One of the largest animals in the school was harpooned from the skiff that was being towed astern of the Marineland collecting vessel. The animal sounded, taking out about 25 fathoms of line, and stopped dead in the water. The animal was then simply hauled in to within 50 feet of the boat. It then raced away; only after an additional hour and a half of struggle was it brought alongside. Its schoolmates left it almost immediately after it was harpooned and swam away at a rapid pace.

While the animal was being secured alongside the ship with head and tail lines, it gave a mighty lunge and thrashed free of both lines and harpoon, and disappeared. However, during the several minutes it was close to the ship there was ample opportunity to inspect the animal and to make reasonably sure of its identification as a false killer whale.

MORPHOLOGY

Morphometrics and anatomy.—Although in general aspect the animals in this school resembled the familiar pilot whales, they possessed much smaller and noticeably more triangular dorsal fins. The fins possessed a moderately hooked posterior contour, and in general shape were remarkably like those of *Tursiops gilli* in appearance. The pectoral fins were very much smaller than those of pilot whales and conformed closely to those pictured in Scheffer and Slipp (1948) for the Puget Sound specimen of *Pseudorca*. The head was not nearly so bulbous as that of a pilot whale, but was longer and slimmer in appearance. The lower jaw of the harpooned animal projected slightly beyond the upper.

Color and pattern.—All animals were glossy black in color. The harpooned individual turned on its back while alongside the ship, revealing a medium-gray blaze mark not unlike that of *Globicephala scammoni*. This mark started at the ventral tip of the lower jaw and spread to form a broad shield-shaped mark between the pectorals, narrowing again and finally disappearing along the mid-ventral line, 2 or 3 feet posterior of the pectoral flippers. Such a blaze mark is not noted by either Moore (1953) or Bullis and Moore (1956) for Atlantic false killer whales. However, Richard (1936, p. 57) says of two males taken near São Miguel, Azores: "Ils étaient noirs avec le ventre plus ou moins gris, à peu près comme chez le Globicéphale."

The only other cetacean that seems even a possibility is the little-known genus *Feresa*. These rare animals are known from only three specimens, two from Japan (Yamada, 1954) referred to the species *F. occulta*, and a skull taken from an unknown locality in the south Pacific, referred to *F. attenuata*. *Feresa*, so far as is known, is smaller than the animals sighted by us, reaching about 8 feet in length. Its dorsal fin is pictured as being proportionately much larger than those of the animals we saw (Hall and Kelson, 1959). The ventral gray chevron of our harpooned animal is unmentioned for *Feresa*, though *Feresa occulta* is described as having white lip margins and a white area around the anal region. Its similarity to our harpooned animal is that it is essentially a slim small pilot whalelike cetacean with rather short pectoral flippers. We feel, however, that our sighting was almost certainly of *Pseudorca* and not *Feresa*.

BEHAVIOR

Locomotion.—Speed: The movements of the entire school were far swifter than those of Pacific pilot whale schools. The entire school was moving rapidly, at an estimated 6 knots during the entire encounter.

Schooling: The school was composed of many subgroups of four to six animals traveling so closely packed that they may actually have been touching each other. These tightly packed units were separated by considerable stretches of untenanted water. Almost constantly one or more whales could be seen leaping from the water as they moved along. These jumps were generally graceful arcing leaps in which the animal returned to the water headfirst. Occasional leaps were noted in which the animal fell back on its side with a great splash. Sometimes two animals leaped in unison, staying very close together all the while.

Lobtailing was seen several times. An animal would lift its flukes from the water and smack them on the surface up to seven times in rapid succession, making a sharp cracking report with each blow.

The animals were not frightened of the vessel until the animal was harpooned. They crossed repeatedly under the skiff tied astern and swam within 15 feet of the bow for several seconds at a time.

Sound production.—One of the most striking things about the encounter with these cetaceans was their constant squeaking. The squeaks were loud enough to be heard when the animals were 50 feet or more away. Only a single type of call was noted, which consisted of a rather drawn out high squeak of a constant pitch.

PACIFIC PILOT WHALE
Globicephala scammoni Cope

DISTRIBUTION

Range.—The Pacific pilot whale is known from Kanatak, on the western shore of the Alaska Peninsula, to the Gulf of Dulce, on the coast of Guatemala (Miller and Kellogg, 1955).

Seasonal movements.—The Pacific pilot whale is present in southern California waters throughout the year (fig. 10). During the winter months, coincident with the spawning season for the squid (*Loligo opalescens*), Pacific pilot whales congregate on these spawning grounds, notably in the vicinity of the La Jolla sub-

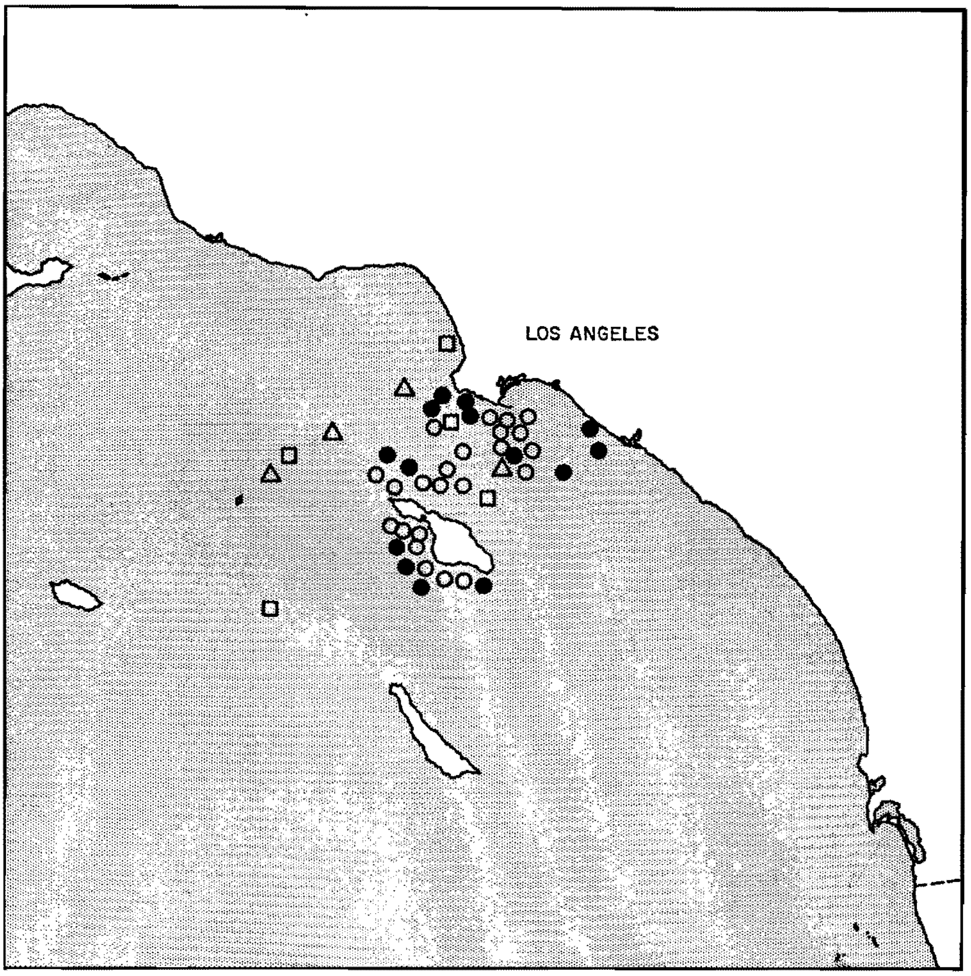

Fig. 10. Sight records and localities of capture of the Pacific pilot whale (*Globicephala scammoni*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

marine canyon, San Diego County, California; the Isthmus, Catalina Harbor, Little Harbor, Ben Weston Point, and Silver Canyon, all around Santa Catalina Island; and offshore from Point Vicente, Los Angeles County, California. In these areas congregations usually occur during the latter half of December, and during January and February.

Throughout the remainder of the year pilot whale schools are less evident but are seen fairly regularly in deep offshore waters.

CAPTURE OBSERVATIONS AND SIGHTINGS

On February 27, 1957, a young adult female pilot whale was netted 5 miles north of Avalon, Santa Catalina Island. After a five-and-a-half-hour battle the animal was brought alongside the collecting vessel and placed in a rubber life raft. During her entire struggle, which took place during the evening, she was accompanied by five or six other pilot whales. They swam constantly a short distance in front of her, and she sounded nearly simultaneously with each of their dives. On the initial dive, the female took out approximately 600 feet of manila line but did not swim straight down. It is doubtful if she was submerged as much as 400 feet at the bottom of the dive. She surfaced after approximately four minutes. As the whale was brought alongside the collecting vessel, into the circle of light cast by the boom lamp, the other whales disappeared. She was accompanied by several Pacific striped porpoises (*Lagenorhynchus obliquidens*), and these animals stayed near her even after she was secured alongside the ship. Some of them surfaced so close aboard that they could almost be touched. These porpoises disappeared when the whale was placed into the raft.

On January 21, 1959, a 17-foot, 3-inch male was captured from a large traveling school. The animal was netted from a small subgroup of three animals which was composed of the male, a presumptive adult female, and a half-grown animal. These latter two animals stayed with the captive until he was placed in the rubber life raft.

On February 8, 1959, a 9-foot, 4-inch male was captured 4 miles south of San Pedro Lighthouse, in the San Pedro Channel, Los Angeles County, California. The animal was traveling in company with four adult animals when it was netted. After a brief struggle the animal was hoisted onto the deck, out of sight of the animals in the water. While the boat lay dead in the water for thirty minutes, the captive emitted birdlike chirps almost constantly. During this entire time the other pilot whales circled the vessel a short distance from the rail. The adults left only when the boat got under way for Marineland's pier.

In another instance, on March 2, 1959, a 6-foot, 10-inch female pilot whale was seen swimming in very close company with what was presumed to be an adult female. The little animal was netted and quickly brought alongside the collecting vessel. The capture took place 4 miles northeast of the Isthmus of Santa Catalina Island. During the struggle the adult attempted to force the smaller individual away from the boat by draping itself over the restraining line and by actively swimming against the side of the smaller animal. As the little creature was being placed into a stretcher, the adult came up underneath it and bumped it rather violently with its dorsal fin. During the entire capture the small animal appeared to be calling. Bubbles sporadically streamed from her blowhole, and she squeaked and chirped almost constantly once she was placed on deck. While the animal was on board the adult circled the vessel, from 20 to 50 feet away from the railing. The young animal was thought to be nursing, and consequently she was put back into the ocean after measurements were taken. She raced off, trailing a stream of bubbles from her blowhole, rejoined the larger animal and disappeared.

MORPHOLOGY

Morphometrics and anatomy.—The meager data presented in table 8 support the idea that the major proportional change occurring during growth is a relative shortening of the head region, anterior to the dorsal fin, with relation to the rest of the body. Certain other growth changes are evident to the observer which are not clearly apparent from the measurements. The pectoral fins of old males become relatively thin, elongate, and sickle-shaped (pl. 32, *b*). The caudal keel also becomes relatively much deeper in old males. Instead of tapering rather gradually from the tail stock to the flukes, the caudal keel of adult males tapers only slightly and then angles sharply downward to the insertion on the flukes (pl. 28). A more gradual taper is present in adult females (pl. 33, *a*). The dorsal fins of adult pilot whales are conspicuously more hooked than those of young animals.

The fatty melon (the fatty protruberance on the foreheads of many whales) develops gradually during growth, and in adult males may extend 4 inches or more ahead of the tip of the upper jaw. In nursing or yearling animals the tips of the jaws protrude beyond the melon. Two captive females at Marineland of the Pacific showed different stages of melon development. In the smallest animal, which was slightly less than 11 feet in length, the melon still did not protrude beyond the tips of the jaws, but in the larger female, which was between 12 and 13 feet long, the melon protruded about an inch. The time when the melon first protrudes beyond the jaw tips seems to coincide approximately with the attainment of sexual maturity, judging from the smallest animals seen directly accompanied by baby pilot whales. The smallest of these presumptive parents was estimated at about 11 feet in length. These observations have interesting implications that will be discussed under the section dealing with reproductive behavior.

The eyes of pilot whales possess a dark-brownish iris with a large dorsal median semicircular palp or operculum that extends downward over the curved lower arc of the iris. A trail of a "tough" mucus can always be seen streaming from the eyes of pilot whales, both when the animals are above and below water.

Close examination of the skin of a living pilot whale shows that it is not always entirely glassy smooth, but sometimes lined with extremely tiny parallel ridges and grooves, particularly on the area of the body between the level of the eyes and the level of the dorsal fin. These are somewhat finer than the ridges and grooves of a fingerprint. In general the ridges appear to run around the circumference of the animal's body, rather than longitudinally. These ridges and grooves are apparently primarily in the thin, almost parchmentlike epidermal layer. They seem to be produced and eliminated during the course of each full tail stroke during locomotion. They have also been noted in *Lagenorhynchus obliquidens*.

One wonders if these folds might not function in the damping of turbulence over the skin surface as it is produced during locomotion.

Color and pattern.—On February 27, 1957, a school of pilot whales was sighted 5 miles north of Avalon Harbor, Santa Catalina Island. There were four young animals in the school, including one that was estimated to be about 4 feet long. This animal was marked with several vertical light-colored bars or creases, which seemed to follow folds in its skin. The animal swam and dived in very close company with an adult, presumably a female (judging from the criteria for recognizing the sexes in the field, given by Kritzler [1952], for *Globicephala macrorhyncha*). This little animal was probably newborn. McBride and Kritzler (1951) noted this pattern of lateral body creases in newborn young of *Tursiops truncatus.* They say: "Particularly noteworthy is the presence, on each side of the trunk, of six symmetrically placed vertical creases. These creases lack pigment at birth. They

TABLE 8

MEASUREMENTS AND PROPORTIONS OF *Globicephala scammoni*

Measurement	March 2, 1959 4 miles NNE. of Isthmus, Santa Catalina Is., Calif. Female		May 31, 1960 12 miles S. of Pt. Vicente, Los Angeles Co., Calif. Female		March 2, 1959 4 miles NNE. of Isthmus, Santa Catalina Is., Calif. Male		February 8, 1959 4 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male		February 6, 1957 2 miles S. of Ribbon Rock, Santa Catalina Is., Calif. Male	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	208.0	.....	263.0	.....	275.0	.....	287.0	.....	290.0	.....
Snout to eye	25.4	0.121	27.0	0.102	31.7	0.115	34.3	0.119	34.9	0.120
Snout to end of mouth crease	21.6	0.103	25.0	0.095	26.7	0.096	26.7	0.092	18.4	0.063
Snout to anterior origin of flipper	41.3	0.197	50.0	0.190	53.3	0.193	52.0	0.181	.....	.....
Snout to center of blowhole	22.9	0.109	29.0	0.110	33.6	0.121	36.8	0.128	.....	.....
Flipper (left)—anterior origin to tip	34.3	0.164	45.0	0.171	45.0	0.163	61.0	0.212	48.6	0.169
Flipper (left)—axilla to tip	29.9	0.142	35.0	0.133	34.3	0.124	49.5	0.172	.....	.....
Flipper (left)—greatest width	11.4	0.054	15.0	0.057	14.0	0.050	16.5	0.057	.....	.....
Flukes—depth of median notch	1.9	0.003	2.2	0.008	2.6	0.011	2.54	0.008	.....	.....
Flukes, spread—tip to tip	46.4	0.222	.....	.....	58.4	0.211	66.0	0.230	64.0	0.221
Median notch of flukes to dorsal fin at deepest point of posterior curve	118.0	0.567	153.0	0.581	160.0	0.580	168.0	0.584	.....	.....
Dorsal fin—length of base	45.7	0.219	43.0	0.163	44.4	0.161	50.8	0.176	.....	.....
Dorsal fin—height	15.2	0.073	14.0	0.053	19.0	0.069	22.9	0.079	19.1	0.065
Dorsal fin—anterior origin to deepest portion posterior curve	33.0	0.158	.....	.....	33.0	0.119	39.4	0.137	42.5	0.146
Dorsal fin—anterior origin to center of blowhole	45.0	0.215	59.0	0.224	48.2	0.175	48.2	0.168	.....	.....
Blowhole—width	2.66	0.018	5.5	0.020	6.35	0.023	5.4	0.018	6.35	0.021
Girth—at anterior origin flippers	119.5	0.572	.....	.....	133.5	0.482	142.0	0.495	.....	.....
Girth—at anterior origin dorsal fin	146.0	0.670	.....	.....	157.5	0.570	150.0	0.522	145.0	0.501
Girth—at level of anus	88.9	0.420	.....	.....	104.0	0.376	94.0	0.327	.....	.....
Umbilicus to anus	48.3	0.231	.....	.....	66.0	0.239	61.0	0.212	.....	.....
Anus to reproductive aperture	.....	.....	.....	.....	20.3	0.073	25.4	0.088	.....	.....
Anus to median notch of flukes	68.0	0.325	.....	.....	94.0	0.341	.....	.....	.....	.....

[1] Proportions expressed in one-thousandths of total length.

TABLE 8—*Continued*

Measurement	March 2, 1959 4 miles NNE. of Isthmus, Santa Catalina Is., Calif. Male		February 3, 1959 6-9 miles S. of San Pedro lighthouse, Los Angeles Co., Calif. Male		February 27, 1957 5 miles N. of Avalon, Santa Catalina Is., Calif. Female		January 21, 1959 5 miles S. of Cabrillo Beach, Los Angeles Co., Calif. Male		June 12, 1958 King Harbor, Redondo Beach, Los Angeles Co., Calif. Male	
	Cm.	Proportion[1]	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion	Cm.	Proportion
Total length—snout to fluke notch	334.0	.....	368.0	.....	424.0	.....	524.0	.....	556.0	.....
Snout to eye	33.0	0.098	33.0	0.089	38.1	0.089	.....	.....	47.0	0.083
Snout to end of mouth crease	26.0	0.077	.....	.....	30.5	0.071	.....	.....	41.8	0.079
Snout to anterior origin of flipper	57.2	0.171	64.7	0.175	86.4	0.203	96.5	0.184	78.8	0.141
Snout to center of blowhole	35.5	0.106	30.5	0.082	64.8	0.152	43.2	0.082	47.0	0.084
Flipper (left)—anterior origin to tip	59.0	0.176	68.5	0.186	55.9	0.131	.....	.....	118.0	0.212
Flipper (left)—axilla to tip	44.4	0.133	.....	.....	81.2	0.191	.....	.....	92.7	0.166
Flipper (left)—greatest width	17.8	0.053	.....	.....	22.8	0.053	.....	.....	38.1	0.069
Flukes—depth of median notch	2.66	0.011	.....	.....	3.8	0.008	.....	.....	7.6	0.013
Flukes, spread—tip to tip	71.2	0.212	88.9	0.241	89.0	0.209	117.0	0.223	141.0	0.248
Median notch of flukes to dorsal fin at deepest point of posterior curve	118.0	0.567	.....	.....	229.0	0.540	.....	.....	331.5	0.548
Dorsal fin—length of base	48.2	0.044	55.9	0.151	.....	.....	96.5	0.184	94.0	0.168
Dorsal fin—height	22.2	0.066	.....	.....	.....	.....	43.2	0.082	39.4	0.070
Dorsal fin—anterior origin to deepest portion posterior curve	44.4	0.133	.....	.....	.....	.....	.....	.....	81.3	0.146
Dorsal fin—anterior origin to center of blowhole	65.4	0.195	.....	.....	.....	.....	.....	.....	89.0	0.159
Blowhole—width	5.7	0.016	8.9	0.024	.....	.....	8.9	0.016	10.2	0.018
Girth—at anterior origin flippers	162.5	0.486	234.0	0.634	.....	.....	.....	.....	235.0	0.422
Girth—at anterior origin dorsal fin	195.5	0.584	.....	.....	.....	.....	281.0	0.583	262.0	0.424
Girth—at level of anus	117.0	0.348	.....	.....	.....	.....	.....	.....	199.0	0.353
Umbilicus to anus	72.5	0.216	.....	.....	.....	.....	.....	.....	147.5	0.264
Anus to reproductive aperture	27.9	0.083	.....	.....	.....	.....	.....	.....	59.7	0.107
Anus to median notch of flukes	117.0	0.349	.....	.....	.....	.....	.....	.....	203.0	0.365

[1] Proportions expressed in one-thousandths of total length.

are evenly spaced from the posterior insertion of the pectoral fin to the level of the anus. It is thought that they are produced by orderly wrinkling of the skin as the fetus lies doubled in the uterus."

When wet, larger young appear to be a uniform light brownish-gray on the dorsal and lateral surfaces. This coloration gradually becomes darker with age and adults are a dark brownish-slate when wet, and a dark brownish-black when dry. Adults of both sexes are marked with an irregular light reddish-gray saddle behind the dorsal fin. This saddle is difficult to see at some angles of illumination and well-defined in others. It is apparently more distinct than the saddle of *G. melaena* described by Sergeant and Fisher (1957).

Both young and adult animals show a mid-ventral blaze mark that is considerably less well-developed than that pictured for *Globicephala melaena* by Sergeant and Fisher (1957, p. 110). It usually consists of a broad gray patch anterior to and between the pectoral fins, extending posteriorly as a thinning mid-ventral line that disappears entirely at about halfway to the tip of the adpressed pectoral flipper (pl. 33, *b*). The genital area is usually surrounded by an elongate gray patch. The blaze marks are generally more pronounced in young animals than in adults.

Adult males, and to a lesser extent, adult females, show a V-shaped, indistinctly bordered dark-brown marking with its apex just posterior to the blowhole. The legs of the V extend forward and merge into the generally dark brown of the melon (pl. 34, *a*).

REPRODUCTION

Young.—Very young animals swimming with adults have been seen in southern California waters during late summer, fall, and winter months (August 18 through March 2). The young sighted in late fall and winter have been of variable size, ranging from newborn to approximately 8 feet in length, indicating that the period during which births occur is probably quite long, extending at least from August through the entire winter.

On December 19, 1956, a school of approximately fifty pilot whales was sighted over Farnsworth Bank, off the south coast of Santa Catalina Island. The school was divided into subgroups of eight to ten animals. Twice, single adults were seen, each accompanied by two young; one young swimming on each side of the adult, very close to its flanks. One of the young towed a big wad of kelp in its mouth. It is possible that these groupings represent twin births.

BEHAVIOR

Mating behavior.—On February 15, 1957, a probable mating was observed in a "loafing group" of pilot whales off Ben Weston Point, Santa Catalina Island. The senior author and Captain Frank Brocato rowed quietly to within about 50 feet of a group of approximately twenty animals that were lolling at the surface. Two animals were seen, lying venter to venter. These animals thrashed about in the water and waved their pectoral flippers above the surface from time to time. The extended penis of the male was seen briefly. A peculiar sound emitted by an undetermined member of the school was heard only at this time. It is described under the section on sound production.

Indications that the large fatty melon of adult pilot whales may have a function in courtship are given by the following observations. On February 6, 1959, the captive 13-foot female and the 17-foot, 3-inch male were seen resting at the surface on opposite sides of the 80-foot display tank. Suddenly the female sounded, and when about 12 feet below the surface she began to emit a stream of bubbles from her blowhole, and at the same time, began to swim toward the male. As soon as the stream of bubbles appeared the big male immediately sounded and swam rapidly toward her. At about the middle of the tank the two animals rammed into each other, head on. Both animals were facing downward at a slight angle, which made them contact each other on their melons. The stream of bubbles continued almost until the moment of contact. The impact was so great that shock waves could be seen traveling down the bodies of both animals, and the smaller female was forced backward a few feet in mid-water. Then the two animals swam off, very close to each other, either touching or almost in contact. This pairing continued for from 10 to 15 seconds. Then, when the male slipped back so that his head was at about mid-body on the female, she flexed and hit him just back of the eye with the broadside of her flukes. The pair then separated and resumed their resting postures on the surface.

This head-butting behavior has been seen several times during the winter months and was, on at least two occasions, followed by desultory attempts at mating, on the part of the male.

Often the two captive females have been seen bumping their heads against the tank walls and bottom, sometimes with considerable force. The male has occasionally exhibited this behavior (pl. 34, *a*).

As has been noted earlier, the melon apparently does not develop sufficiently to overhang until about the time sexual maturity is attained. Thus, head-butting behavior seems correlated with this growth, because if animals in which the melons did not project beyond the jaw tips were to ram each other, the results could be disastrous. The smallest captive female at Marineland at the time this was written developed an overhanging melon after being brought into captivity. Her early attempts at battering the tank walls with her head led to numerous abrasions, which have become more and more infrequent since the melon has grown.

Locomotion.—Speed: Pilot whales give the impression of being slow-swimming animals. Certainly they are seldom seen moving more than 4 or 5 knots per hour in the open ocean. However, they are capable of rapid and powerful swimming on occasion.

For such a bulky animal, leaping from the water requires tremendous power and considerable speed. It is undoubtedly rare for this species to leap above the surface, and this behavior has been seen only twice during many hours of observation of pilot whales at sea.

One observation of the 13-foot captive female named Bubbles is of interest here. Bubbles was often irritated by the Pacific striped porpoises that shared her tank, because from time to time they swam up behind her and nipped at the margins of her flukes. On one such occasion she turned on the offending animal and pursued it around the 80-foot circular tank. With the striped porpoise maintaining a position a few feet in front of her snout, apparently without effort, Bubbles made three circuits of the tank in what was estimated as a 70-foot diameter circle in approximately fifteen seconds. The circuits were timed by the junior author, using the sweep-second of his wrist watch. If it is assumed that the animals were swimming in a 70-foot circle, the calculated speed was 30 miles per hour, or 26.4 knots. If the diameter of their path is assumed to have been 60 feet, the speed is 25.6 miles per hour, or 22.5 knots.

Admittedly, there is considerable margin for error in this speed measurement, but it seems reasonable to say that the animals were swimming in a tight circle at a rate of at least 20 knots during the brief period of observation.

During rapid locomotion such as this the very elongate tail stock of the animal moves through strokes of large amplitude, and the snout can be seen to yaw through a lesser amplitude.

Schooling: Three major types of schools have been noted for the Pacific pilot whale. The first is the *traveling* or *hunting school.* When pilot whales are traveling they usually move in schools formed as a broad ragged rank, many animals in width, and a few or only one in depth. We have seen these ranks up to 2 miles in width. The individuals in these ranks are not always evenly spaced, but are gathered as subgroups. There seems to be a tendency for these subgroups to represent age and sex groups, though this is not always the case. Females and young may occur in one part of the school while adult males are found elsewhere, sometimes alone. We have seen subgroups that seemed to be composed entirely of juveniles that had struck out on their own, away from their parents.

The young animals plunge along, throwing their heads out of water as they swim. The adults seldom do this, but generally rise until their eyes just clear the surface. The melon breaks the surface with each rise but the mouth generally does not.

The striped porpoise (*Lagenorhynchus obliquidens*) and, to a lesser extent, the common dolphin (*Delphinus bairdi*) swim in close company with traveling schools of pilot whales, almost in contact with the flanks of the big animals. This may well represent assisted locomotion, as has been discussed earlier. The Pacific bottlenose porpoise is almost always found close to groups of pilot whales when seen far at sea. In traveling schools the porpoises often form the end groups in the rank.

These traveling schools may serve to heighten an individual's chances of locating food. Such a broad school could examine a wide path of ocean as it moved along. If food was located in one part of the school, sound signals would likely be used to draw the others to it. The various porpoises that accompany pilot whales may simply be taking advantage of the food-locating abilities of the large school.

Traveling schools of pilot whales usually move fairly rapidly, 4 to 5 knots representing average speeds. They seem to move with great purpose, the form of their school being difficult to disrupt. Usually a segment, or the whole school if it is small enough, will sound when a boat crosses the rank. On one occasion we harried such a school for about an hour. The animals moved steadily westward. Finally, almost in unison, the entire school (estimated at a half a mile in width) turned and began swimming southward in single file. This sudden movement could well have been cued by underwater acoustic signals. After a few minutes on the southward course the school turned again and resumed its westerly course and its former shape.

The second type of school that we have recognized is the *feeding school.* Many times during February of 1957 we saw pilot whales feeding during daylight hours among the schools of spawning squid. In these groups there was a general movement of the whales in a given direction, but the individual animals tended to remain fairly independent of one another. Their movements were quick and erratic, as they pursued their food.

The third schooling type is what we have called the *loafing group* (Norris, 1958). These groups are almost stationary aggregations of about a dozen to thirty or more animals. Most of the whales lie at the surface with their backs, from the dorsal fin to the bulbous snout, exposed above the water. The groups are usually discoidal. The movements of animals in these loafing groups are varied. Some animals move slowly, and apparently aimlessly, on their backs, sometimes with both pectoral fins extended above the water. Several times animals have been seen "standing" bolt upright in the water with 4 or 5 feet of their bodies above the surface. This behavior usually occurred just as we approached the school. In this peculiar position the whales were able to rotate their bodies to some extent and to turn their ventral surfaces toward us. Our impression was that the whales were able to watch us by this maneuver, since their binocular vision is directed obliquely downward. They looked much like big brown stumps standing in the water. Scammon (1874) has noted this same sort of behavior in Pacific pilot whales. Italian fishermen call the pilot whales "mònaco," or monk, which is particularly fitting when one considers this behavior. On one occasion two whales rose up vertically to the level of their pectoral flippers, venter to venter, as we approached.

The reverse behavior was observed. Several times we saw whales completely inverted in the water; 4 or 5 feet of the tail sometimes extended above the surface. One whale maintained this grotesque position for four seconds, gently waving its flukes in the air, before it fell back into the water.

As has been described earlier, mating was observed in a loafing group.

Diving: Both young and adult animals may throw their flukes free of the surface as they sound, or they may merely arch their backs and slide beneath the surface. Sometimes, when the flukes break the surface, they may be slapped against the water with a resounding smack. Sounding animals have been observed from above, and they sometimes swam almost vertically downward. The longest dive that we recorded was by a group of pilot whales searching in 1,200 feet of water for a member of their school that had been killed. The dive lasted four minutes, fifty seconds.

Sleep.—We have repeatedly observed the captive pilot whales sleeping with eyes tightly closed, both during the day and at night. Sleep seems much deeper during nighttime. The Pacific pilot whale does not seem to be nocturnal, unlike *G. macrorhyncha,* which is reported to be largely nocturnal by Kritzler (1952). During the deepest sleep the whales hang almost immobile in the water with their tails downward at about a 30° angle from the surface. The blowhole and the anterior part of the melon are above the surface. The tip of the dorsal fin is usually also out of water. The only visible activity is a slight sculling movement of the tail that serves to keep the sleeping animal on an even keel. The melon, which is composed largely of fatty tissue, may serve as a float allowing these whales to sleep with their blowholes out of water.

The two females nearly always slept with the pectoral fin tip of one animal in contact with the flanks of the other animal (pl. 34, *b*). The large male usually slept alone.

Social behavior.—Agonistic behavior: We have never observed agonistic behavior in nature, but it obviously is of common occurrence in this species. Immature male pilot whales, as small as 6 feet in length, are usually literally covered with scars and tooth marks that seem, by their size and spacing, to have been inflicted by larger members of their own species. Females and larger animals of both sexes are usually noticeably less heavily scarred. The skin of young males is usually dotted with tiny pin holes arranged in parallel lines. These seem to represent old wounds that have not entirely healed. Some of the larger wounds that have been seen obviously had penetrated entirely through the blubber layer into the flesh below. Fin and fluke margins are apt to be frayed in these young individuals.

Sound production.—Several distinct sounds are emitted by pilot whales. Very often when the whales blow after a long dive, the expelled air creates a high-pitched whistle. On February 15, 1957, we approached within about 50 feet of a loafing group and had the unique opportunity of hearing three distinct vocalizations. The most commonly heard sound was a distinct stacatto popping, which sounded much like the noise created by rubbing a finger over the surface of a balloon. We estimated that there were about three "pops" per second. A distinct high-pitched element was present in the sound.

Another common sound was a single chirp, like that of a small bird. The most unique noise was heard only once, but very distinctly. The sound lasted from two and a half to three seconds and sounded like a medium-pitched wail or siren. The pitch of the wail varied as the call progressed. The mating discussed earlier was taking place at the time the call was noted, but it could not be determined if one of the participants made the sound. This sound must have been similar to that described by Kritzler (1952) for *G. macrorhyncha.* He says: "The most noteworthy sound produced by the pilot whale was quite unlike anything which the writer has ever heard in the dolphins. It sounded like the peevish whining of a young child." Kritzler describes this sound as being made internally rather than by expressing air through the pursed lips of the blowhole.

Observations have been made during the actual production of sound by newly captured animals as they lay on the deck of the collecting vessel. The chirping sound was made internally at the same time that the nasal sacs (Lawrence and Schevill, 1956) were being inflated with air. This inflation caused a distinct, easily visible swelling of the top of the head. When the inflation stopped so did the sound. A regular pattern of sounds was emitted by a 108.5-inch male. In this instance, a series of clicks or pops was emitted, followed by four chirps in quick succession. This pattern was repeated over and over though the clicks were sometimes omitted. The blowhole was never opened during the sound production by this animal. However, with the production of each sound the semicircular palp or valve of the blowhole was flattened and spread laterally.

The pattern of sound production was somewhat different in the other captive, a female 10 feet, 4 inches long. Once again the chirping was made on inflation of the nasal sacs without passage of air through the blowhole. A higher and more prolonged squeak was made by this animal by expressing air through an anterior corner of the blowhole. A sound, much like the siren noise noted earlier, was made by this animal also by forcing air out of a corner of the blowhole. The palp or valve of the blowhole was extremely mobile and was markedly flattened and spread during production of these latter sounds. It was not evident that air was being forced into the nasal sacs during production of these sounds, unlike the obvious expansion noted during the production of chirps.

Jaw clapping is apparently used as a warning signal by Pacific pilot whales as well as by bottlenose porpoises (McBride and Hebb, 1948). It has been directed toward divers attempting to feed newly captured pilot whales underwater (Brown, 1960). The sound is graphically described as the noise made when a wet trunk is slammed closed. It was not noted by Kritzler (1952) in a captive immature male.

MORTALITY AND DISEASE

Strandings.—Wherever *Globicephala* is found it seems subject to mass stranding more frequently than any other genus of cetaceans (Moore, 1953; Gilmore, 1959). We have information on two mass strandings on the Pacific coast of North America.

On May 25, 1959, a group of twelve pilot whales was found stranded at Simonton Cove, San Miguel Island, California, by California Fish and Game Patrol Captain E. C. Fullerton. It was estimated that the animals had been stranded for two days when first found. The animals were spread down the beach for approximately a half a mile. They were estimated to vary between 15 and 18 feet in length.

On May 12, 1959, a group of sixty-one stranded pilot whales was observed on a gradually shelving sandy beach, 3 miles north of La Paz, Baja California, Mexico, by George Mann (pl. 35, *a* and *b*). The animals were blowing and could be heard squeaking as they lay in the shallow water. There was one main group, with a few stragglers stranded in both directions for several hundred yards. As has been commonly reported, animals led offshore into deep water returned to the stranded herd. Mr. Mann reported that when one animal thrashed its tail others would also begin to thrash.

Usually one or more individual pilot whales strand on Pacific coast beaches yearly. For example, on November 26, 1957, a subadult pilot whale stranded on Huntington Beach, Orange County, California. It was without external wounds but in a very weakened condition and unable to struggle against the surf. On June 12, 1958, an 18-foot, 3-inch male pilot whale stranded itself on Torrance Beach, Los Angeles County, California (pl. 32, *b*). Marineland personnel attempted to hold the animal in the surf until trucks and equipment arrived but the animal was too powerful and returned to sea, only to strand again about an hour later, in King Anchorage, a short distance to the north. The animal drowned during attempts to raise it from the water. Autopsy showed that it had not eaten for a considerable length of time. The intestine was empty, except for bile pigments, and was greatly distended with gas.

On June 25, 1959, an adult pilot whale stranded at Belmont Shores, Long Beach, California. The animal was very battered, probably from rolling in the surf, and was very weak. When towed out to sea a short distance, it turned shoreward and stranded again. Finally the animal was towed by the tail a considerable distance offshore, released, and not seen again.

While attempts to maintain captive pilot whales taken from the mass strandings have not met with much success, the animals in these groups apparently are not usually sick.[2] Stranded pilot whales roll onto their sides in very shallow water and even slight wave action fills their blowholes with a mixture of salt water and sand and the animals quickly die. In one instance (Kritzler, 1949) a small male of *Globicephala macrorhyncha* was successfully maintained in captivity after having stranded. However, pilot whales that strand alone nearly always give indication of being sick.

On May 1, 1960, a group of Pacific pilot whales, including two adults and one 7-foot young, was encountered a short distance north of the Isthmus of Santa Catalina Island. These animals were swimming about a mile away from a larger group of the same species. All three were obviously diseased. The young animal was in the worst state. It was covered with pinkish-white blotches about the size of a silver dollar, which were most numerous over its dorsal surfaces and around the base of its dorsal fin. The two adults were also afflicted, but to a lesser degree. The cause of this affliction is completely unknown to us.

PARASITISM

The only ectocommensals we have noted on Pacific pilot whales are the peculiar whale barnacles, *Xenobalanus globicipitus* Steenstrup (pl. 34, *a*). These odd, purplish, fleshy barnacles sometimes fringe the edges of the pectoral flippers and dorsal fins of young animals; occasional individuals can sometimes be found on the flukes of these whales. Larger pilot whales generally have fewer or none of these commensals.

HARBOR PORPOISE
Phocoena phocoena (Linnaeus)

DISTRIBUTION

Range.—Along the west coast of North America, the harbor porpoise ranges from Point Barrow, Alaska (Miller and Kellogg, 1955), to the San Pedro Channel, southern California (Norris and McFarland, 1958). The species is uncommon south of Monterey Bay, California.

[2] Strictly as a speculation, we would like to advance a possible partial explanation of these mass strandings. Perhaps, for any number of reasons, a single animal in a school becomes stranded and begins to emit distress calls. The social behavior patterns of pilot whales, particularly those concerned with mutual assistance, seem unusually strong, and these may lead others of the school into shallow water, where they in turn become stranded and begin to emit distress signals. This could ultimately lead to the stranding of the entire school, and could also explain the return to the beach of stranded animals that are towed a short distance to sea and released. It may be possible to perform crude experiments to test this hypothesis. First of all, during a stranding it is important to note whether the animals are producing audible calls. Of course the distress calls may be in frequencies inaudible to human ears. Then, if a single animal can be isolated until calls from the school seem to have ceased, and then released close by in water of adequate swimming depth but out of sight of the stranded animals, it should not return to the beach, if the theory is correct. Or if a stranded animal can simply be towed out of hearing distance of its distressed schoolmates its tendency to strand should be removed. Do animals that are escorted into deep water return to their school, or merely to the nearest beach? Such tests would not provide conclusive evidence but they would add suggestive information to that already on hand.

CAPTURE OBSERVATIONS AND SIGHTINGS

On December 6, 1958, Homer Moore, captain of the fishing vessel *GM*, captured six specimens of this species in Morro Bay, San Luis Obispo County, California. All were drowned in a sea bass gill net set on the bottom in 15 fathoms of water. A few days earlier four other harbor porpoises were caught by the same man, off Pismo Beach, San Luis Obispo County, California, also in 15 fathoms of water. Weights were estimated to vary from 50 to about 90 pounds. All were discarded except for an 89¾-pound male that was brought to Marineland. Mr. Moore reported that all the animals turned several shades darker after a few hours exposure to the air. He stated that he saw no harbor porpoises on the surface in the area nor had he heard reports of their presence. Roest, Thurmond, and Montgomery (1959) have recently reported on a specimen of *P. phocoena* from Pismo Beach.

MORPHOLOGY

Morphometrics and anatomy.—The only feature of the Marineland specimen which appears significantly different from that reported on by Roest, Thurmond, and Montgomery (*op. cit.*) or that reported on by Boolootian (1957) from Pebble Beach, Monterey County, California, was the presence of six small tubercles on the leading edge of the dorsal fin near the tip. These tubercles apparently are of intermittent occurrence in *P. phocoena*, but always present in *P. spinipinnis* (Allen, 1925). A specimen of *P. phocoena* with prominent tubercles prompted Gray (1865) to describe the species *Phocoena tuberculifera* for the aberrant specimen. Measurements and proportions are given in table 9 for the Morro Bay specimen.

GULF OF CALIFORNIA HARBOR PORPOISE
Phocoena sinus Norris and McFarland

DISTRIBUTION

Range.—This species ranges from the upper Gulf of California probably as far south as the Tres Marías Islands and Banderas Bay, Jalisco, Mexico (Norris and McFarland, 1958).

CAPTURE OBSERVATIONS AND SIGHTINGS

No entire specimen of *Phocoena sinus* has yet been described by a biologist. Therefore any detailed sight records are of considerable interest. Ian McTaggert Cowan, of the University of British Columbia, observed what was probably this species in the harbor at Topolobampo, Sinaloa, Mexico. He says in part: "On several occasions during the second week in March of 1959 they were within six or eight feet of my outboard motor boat, and on two occasions I was right over them and looking down their backs. They did not strike me as particularly small; I would say five to six feet long. They were dull lead grey in color with a slight brownish cast. No white showed from above. There was no discernible beak. The water in which they swam was very shallow." What was presumed to be this species was previously reported from Topolobampo Bay by Norris and McFarland (1958).

On January 24–25, 1958, the senior author spent several hours observing the

TABLE 9

MEASUREMENTS AND PROPORTIONS OF *Phocoena phocoena*

Measurement	December 6, 1958 W. of Cayucos, San Luis Obispo Co., Calif., in 15 fathoms of water Male; 89¾ lbs.	
	Cm.	Proportion[1]
Total length—snout to fluke notch	139.5	.....
Snout to eye	15.8	0.112
Snout to end of mouth crease	10.5	0.074
Snout to anterior origin of flipper	29.2	0.209
Snout to center of blowhole	16.7	0.120
Flipper (left)—anterior origin to tip	19.7	0.140
Flipper (left)—axilla to tip	14.6	0.103
Flipper (left)—greatest width	6.4	0.045
Flukes—depth of median notch	4.4	0.030
Flukes, spread—tip to tip	33.0	0.236
Median notch of flukes to dorsal fin at deepest point of posterior curve	64.8	0.463
Dorsal fin—length of base	25.4	0.181
Dorsal fin—height	8.9	0.063
Dorsal fin—anterior origin to deepest portion posterior curve	17.8	0.127
Dorsal fin—anterior origin to center of blowhole	44.4	0.318
Blowhole—width	2.8	0.020
Girth—at anterior origin of flippers	70.5	0.503
Girth—at anterior origin of dorsal fin	93.0	0.665
Girth—at level of anus	49.0	0.349
Anus to reproductive aperture	29.2	0.209
Anus to median notch of flukes	68.0	0.485

[1] Proportions expressed in one-thousandths of total length.

little harbor porpoises from the deck of a Mexican shrimp trawler in the vicinity of San Felipe Bay, Baja California Norte, Mexico. The animals were very wary. Usually two were seen together. When the boat pursued them they took a short breath, arched their tail stocks, and dived without showing their flukes above the surface. They then disappeared for rather long periods of time, coming unobtrusively to the surface in unexpected locations. They never seemed to pursue a straight path under water, but circled and swam long distances to avoid being sighted again. Their dorsal fins seemed to be much more acute than is normal for *Phocoena phocoena*. In one instance an animal was seen whose dorsal was quite high and had a somewhat curved posterior contour.

Fortunato Valencia, the Yaqui Indian skipper of the shrimp trawler, had had several experiences with the little animals. He had netted them when fishing for totoaba (*Cynoscion macdonaldi*). He described them as lead gray above grading to white below, without any black line from eye-to-mouth crease, as far as he could remember. He estimated them to be somewhat over 4 feet long. The animals were called "vaquita," or little cow. Previously it had been reported that the species was called "cocinita" by the Mexicans (Norris and McFarland, 1958) but this name seems to refer to a dolphin that travels in large dense schools, and is probably *Delphinus*. Señor Valencia had taken vaquitas in a small lagoon about 7 miles north of San Felipe. They were trapped at a low tide in nets stretched across the entrance. He also mentioned taking them in a shrimp trawl and in gill nets set for totoaba in the estuary of the Río Colorado at the head of the gulf. His recollection was that he had seen vaquitas with young in May and June. The young were described as being somewhat under 2 feet in length. He mentioned the story of a fisherman who was working near a small lagoon at Aqua Charlie, near Punta Estrella, south of San Felipe, who found a mother and her baby stranded by the dropping tide. The gulls had picked one eye from the baby, but when both mother and baby were lifted over the bar they swam off together into the gulf.

Another fisherman told the senior author that the vaquita was sometimes considered to be a "duende." This word is used to describe a creature inhabited by a supernatural spirit. This fisherman did not believe the myth but thought it had arisen because of the little porpoise's habit of rising to the surface, puffing, and then disappearing completely.

Dall Porpoise
Phocoenoides dalli (True)

DISTRIBUTION

Range.—Phocoenoides dalli (True) ranges from at least as far south as 39° N. in Japan (Wilke, Taniwaki, and Kuroda, 1953) northward to the Sea of Okhotsk and the western Aleutian Islands (Miller and Kellogg, 1955), southward on the west coast of North America at least as far south as southern California.

Seasonal movements.—The Dall porpoise is a regular winter visitor in southern California waters. Our most southerly record is over Fourteen Mile Bank, off Newport Beach, Orange County, on January 12, 1955 (fig. 11). This locality is about 25 miles south of the previous southern record listed by Butterworth (1957), for a specimen taken at Long Beach, California.

We have observed the Dall porpoise in the San Pedro Channel–Santa Catalina Island area at its earliest in the fall, on October 17, 1955, and latest in the spring, on May 4, 1955. Water temperatures recorded at the times of sighting are listed in table 10. The highest have all clustered closely around 63° F., and only one sighting has been made in waters warmer than this level (64° F.), even though sea temperatures in the area rise above 70° F. occasionally during summertime. It seems possible that the species moves, at its southern limit, in relation to a maximum water-temperature level. However, Lustig (1948) reports seeing a school of twenty Dall porpoises on July 6, 1936, 2 miles off Pyramid Head, San Clemente Island. Water temperatures were not given, but possibly they might have been higher than the maximum we have noted. He also records summer occurrences of the species in the northern Channel Islands, but these islands are in a cool-water area and it is probable that temperatures were below our observed maximum.

CAPTURE OBSERVATIONS AND SIGHTINGS

On February 9, 1956, a school of about thirty Dall porpoises briefly ran the bow of our collecting vessel. One was hooked with the Indian salmon-hook gear described by Brown and Norris (1956). It immediately raced off, followed closely

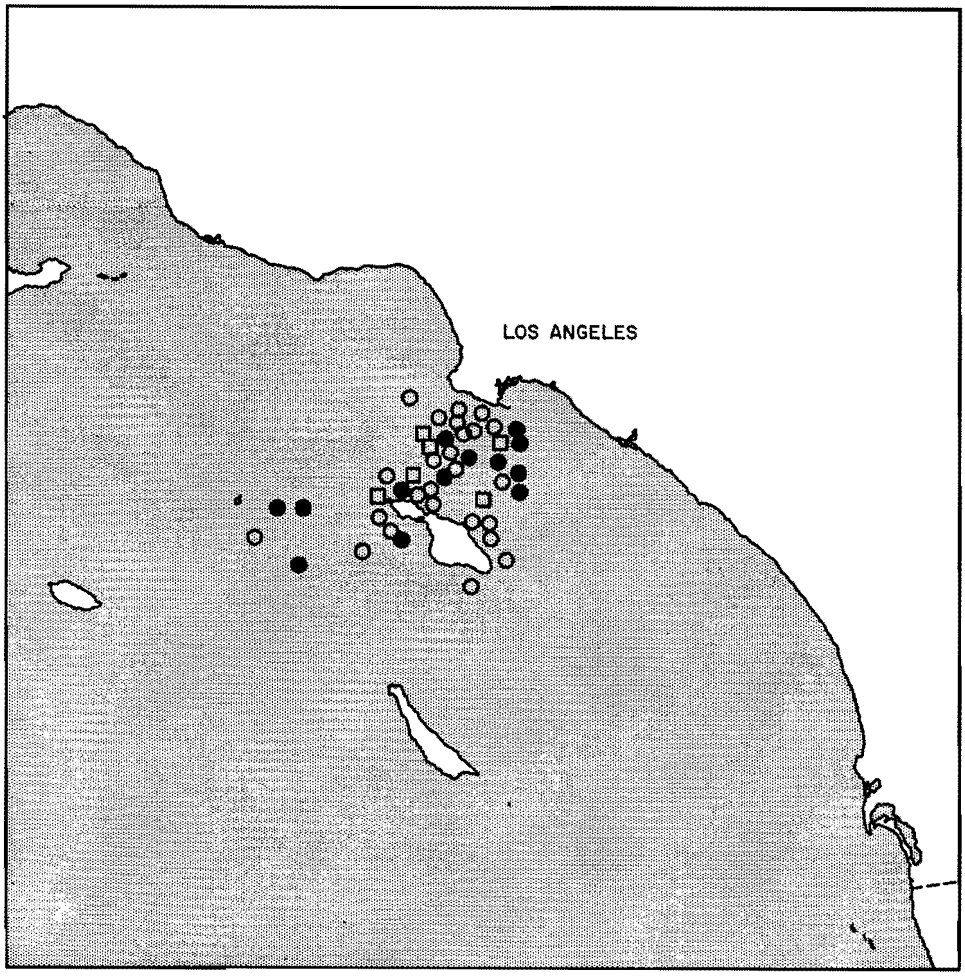

Fig. 11. Sight records and localities of capture of the Dall porpoise (*Phocoenoides dalli*). Open circles, January through March; open squares, April through June; black circles, October through December.

by another adult. As we entered the skiff and moved down the line toward the porpoise, its companion left. Our captive swam about us in a circle, surfacing every twenty-three to twenty-eight seconds for two breaths, seven or eight seconds apart. The blow was sometimes visible as a cloud of vapor and sometimes not. After two hours and thirty minutes the animal was brought alongside and quickly rolled into the skiff. Unlike most captive cetaceans with which we have worked, this individual battered us and the skiff with frenzied beatings of its tail. This same behavior has since been exhibited by every Dall porpoise that has been captured. After taking two shallow breaths, the animal died, exhaling about a half a pint of clear fluid from its blowhole.

TABLE 10

Sea Temperatures and Dall Porpoise Sightings

Date	Locality	No. of animals	Temperature	
			°F	°C.
10 Nov. '54	¾ mile S. of Long Point, Catalina Is., Calif.	4	64	17.8
9 Dec. '54	11 miles W. of west end, Catalina Is., Calif.	12	62–63	17.2
12 Jan. '55	3 miles SE. of east end, Catalina Is., Calif.	12–16	55.5	15.1
4 May '55	9 miles S. x W. of Pt. Fermin, Los Angeles Co., Calif.	6–8	63	17.2
17 Oct. '55	2 miles NE. of Emerald Bay, Catalina Is., Calif.	5	63	17.2
12 Dec. '55	10 miles SW. of San Pedro lighthouse, Los Angeles Co., Calif.	8	59	15
	14 miles SW. x W. of San Pedro lighthouse, Los Angeles Co., Calif.	8–10	59	15
14 Dec. '55	5 miles SW. of San Pedro lighthouse, Los Angeles Co., Calif.	40	59	15
	8 miles SW. of San Pedro lighthouse, Los Angeles Co., Calif.	25	59	15
	14 miles SW. of San Pedro lighthouse, Los Angeles Co., Calif.	25	59	15
15 Dec. '55	5.5 miles S. of San Pedro lighthouse, Los Angeles Co., Calif.	100	59	15
	9.5 miles S. of San Pedro lighthouse, Los Angeles Co., Calif.	20	59	15
	16 miles S. of San Pedro lighthouse, Los Angeles Co., Calif.	20	59	15
1 Feb. '56	.5 to 9 miles SW. of Pt. Vicente, Los Angeles Co., Calif.	100	57	13.9
9 Feb. '56	4 miles S. of Pt. Fermin, Los Angeles Co., Calif.	30	55–56	13.4
	8 miles S. of Pt. Fermin, Los Angeles Co., Calif.	8	55–56	13.4
15 Feb. '56	10 miles S. of Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	4–5	55–58.8	14.8
	4 miles N. of Isthmus, Catalina Is., Calif.	6–7	55–58.8	14.8
	2 miles N. of Isthmus, Catalina Is., Calif.	10	55–58.8	14.8
	2 miles N. of Long Point, Catalina Is., Calif.	4–5	55–58.8	14.8
	4 miles NE. of Avalon, Catalina Is., Calif.	12–14	55–58.8	14.8
20 Feb. '56	4 miles E. of Long Point, Catalina Is., Calif.	4–5	55.5	15.1
8 Nov. '56	9.5 miles S. of Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	9	61	16.2
26 Nov. '56	2 miles S. of Ribbon Rock, Catalina Is., Calif.	15	60	15.6
11 Dec. '56	13 miles SW. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	12	56	13.4
19 Dec. '56	3 miles E. of Santa Barbara Is., Calif.	4	59	15
20 Dec. '56	11 miles E. of Santa Barbara Is., Calif.	6	59	15
2 Feb. '57	12 miles SW. of San Pedro lighthouse, Los Angeles Co., Calif.	2	..	..
3 Feb. '57	1 mile S. of Ben Weston Point, Catalina Is., Calif.	..	57	13.9
	.5 mile S. of Church Rock, Catalina Is., Calif.	3	57	13.9
6 Feb. '57	2 miles N. of Cherry Harbor, Catalina Is., Calif.	50	57	13.9

TABLE 10—*Continued*

Date	Locality	No. of animals	Temperature	
			°F.	°C.
13 Feb. '57	2 miles SW. of Pt. Fermin, Los Angeles Co., Calif.	1	58	14.5
	7 miles S. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	25	55	12.8
	¾ mile W. of west end, Catalina Is., Calif.	8	60	15.6
14 Feb. '57	1 mile SE. of Pebbly Beach, Catalina Is., Calif.	6	61	16.2
	2.5 miles N. of Long Point, Catalina Is., Calif.	7–8	61	16.2
15 Feb. '57	4.5 miles N. of west end, Catalina Is., Calif.	20	58	14.5
25 Feb. '57	1 or 2 miles S. of Ribbon Rock, Catalina Is., Calif.	20–30	59	15
	5 miles SSW. of west end, Catalina Is., Calif.	10	59	15
	2.5 miles WSW. of west end, Catalina Is., Calif.	6–8	59	15
9 April '57	4 miles N. of Arrow Point, Catalina Is., Calif.	3	58	14.5
25 April '57	8 miles SW. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	12–15	60	15.6
11 Feb. '58	5 miles W. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	4–5	61	16.2
12 Mar. '58	12 miles S. of San Pedro lighthouse, Los Angeles Co., Calif.	6–7	59	15
	8 miles SSW. of Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	4	59	15
18 Mar. '58	9.5 miles SSW. of Long Point, Palos Verdes Peninsula, Los Angeles Co., Calif.	9–12	61	16.2
11 April '58	10 miles S. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	20	61	16.2
	10 miles N. of west end, Catalina Is., Calif.	20–25	61	16.2
15 April '58	4 miles NE. of Long Point, Catalina Is., Calif.	6–8	..	..
4 Dec. '58	10 miles S. of Pt. Vicente, Palos Verdes Peninsula, Los Angeles Co., Calif.	3–4	62.5	17
26 Feb. '59	6.5 miles S. of Santa Barbara Is., Calif.	many	61	16.2
1 Dec. '59	16 miles S. of Santa Barbara Is., Calif.	1	62	16.8
20 April '60	5 miles S. of Catalina Harbor, Catalina Is., Calif.	2	..	..
	14 miles W. x N. of west end, Catalina Is., Calif.	10–15	..	..

On December 19, 1956, an adult male was brought into the skiff and a mighty struggle ensued. After seven or eight minutes the animal arched its back, with head up in rigor, emitted a squeal, regurgitated about a bucketful of squid, and died.

Only one living Dall porpoise has been brought to Marineland of the Pacific. This animal was captured on November 26, 1956, off the west end of Santa Catalina Island. Once the animal was brought on board the collecting vessel it lay quietly on its stretcher. Its eyes apparently had been damaged during capture and it battered itself against the walls of Marineland's circular display tank until it was finally removed and floated in a restraining sling in a shallow tank. It was found dead next morning.

MORPHOLOGY

Morphometrics and anatomy.—The external auditory canal of the Dall porpoise does not penetrate to the exterior but passes through the blubber layer as a tiny passage and stops at the base of a pigmented black layer just below the parchment-thin epidermis.

Measurements and proportions are given in table 11.

Color and pattern.—The color pattern of Dall porpoises varies considerably between individuals. Since the initial observation of two Dall porpoises with totally black dorsal fins (Brown and Norris, 1956), no other such individuals have been seen. The upper half of the dorsal fin of all others has been white to lead gray. The black lower part of the fin extends diagonally upward from the insertion of the trailing edge to the mid-point of the anterior edge (pl. 36). The light-colored upper half is variously flecked with black or gray marks.

TABLE 11

MEASUREMENTS AND PROPORTIONS OF *Phocoenoides dalli*

Measurement	February 9, 1956 4 miles S. of Pt. Fermin, Los Angeles Co., Calif. Male; 237 lbs.		November 26, 1956 2 miles S. of Ribbon Rock, Santa Catalina Island, Calif. Male; 291 lbs.	
	Cm.	Proportion[1]	Cm.	Proportion
Total length—snout to fluke notch	198.0	.....	200.3	.....
Snout to eye	21.6	0.109	22.2	0.108
Snout to end of mouth crease	11.4	0.057	12.3	0.060
Snout to anus	132.5	0.669	142.0	0.70
Flipper (right)—anterior origin to tip	20.9	0.105	26.1	0.127
Flipper (left)—greatest width	10.8	0.053	10.2	0.050
Flukes, spread—tip to tip	43.8	0.220	50.8	0.25
Dorsal fin—length of base	29.2	0.147	30.5	0.150
Dorsal fin—height	16.5	0.083	17.8	0.087
Blowhole—width	4.4	0.021	4.7	0.022
Projection of lower jaw beyond upper	1.2	0.006	1.2	0.004
Genital slit—length	11.4	0.057	10.2	0.050
Girth—at anterior origin of dorsal fin	123.0	0.621	133.0	0.658
Intestine—length	1675.0	8.459	2001.0	9.99

[1] Proportions expressed in one-thousandths of total length.

The markings of the tail stock are also quite variable. In one captive (MLP56-5) the ventral surface of the tail stock was speckled with white, whereas in another (MLP56-76) this area was totally black.

Some individuals show a filigree of white markings on the pectoral flippers which to some extent delineate a few of the terminal phalanges (pl. 36).

The large ovoid lateral white patches are continuous ventrally and are mostly bordered rather sharply by black. Black or gray flecks invade these white areas along their anterior margins particularly, to a variable extent in different animals. These flecks, both on the dorsal fin and on the other white areas give the impression of being tiny spots of paint flicked on the animal as it sped past at high speed.

Many such flecks resemble an elongate teardrop in shape, and all are arranged in what might be called "flow patterns" over the animal's body (pl. 36).

REPRODUCTION

No newborn animals have been seen in the southern California area. The smallest individual we have noted was sighted on February 6, 1957, 2 miles north of Cherry Harbor, Santa Catalina Island, and was thought to be about three-quarters grown.

BEHAVIOR

Locomotion.—Speed: It is our impression that the Dall porpoise is the fastest-swimming species of small dolphin or porpoise regularly occurring in southern California waters. This impression is gained from the manner in which these animals race to the ship's bow and cut rapidly away with a striking burst of speed. When they are reluctant to run the bow they often veer about and maneuver away from the ship with great swiftness. We have had a school of Dall porpoise leave our bow while we were cruising at 8.5 knots and take station in front of a nearby submarine, cruising along at a considerably faster pace, probably at between 15 and 20 knots. Some records of the frequency of tail beats in relation to swimming speed are listed in table 12.

TABLE 12

SPEED OF TAIL BEAT IN ADULT *Phocoenoides dalli*

Period of timing (seconds)	No. of beats	Beats/ second	Boat speed (knots)
6	11	1.8	8½
7	16	2.3	8¼
7	16	2.3	8¼
7	13	1.9	8¼
7	15	2.1	8¼

Schooling: On October 17, 1955, five adults were noted swimming single file, very evenly spaced about 100 feet apart, heading easterly down the San Pedro Channel. The animals could be heard venting a distinct whistle each time they blew, which sounded like high-pressure air escaping through a small opening. The spacing of the school members did not seem particularly noteworthy in view of the small size of the school. However, on December 15, 1956, the peculiar behavior was noted again on a much more striking scale. A single-file school was encountered in the San Pedro Channel, 5.5 miles south of San Pedro Lighthouse. This school consisted of an estimated one hundred animals, all adults. All were spaced about 100 feet apart, head-to-tail, proceeding southeastward. The spacing was remarkably constant and the line quite straight. The boat zigzagged through the 2-mile-long file, but the animals never allowed it to come closer than about 200 feet before breaking rank and fleeing. Four miles farther out in the channel another file was met, going in approximately the same direction as the first. This school consisted of about twenty animals, again spaced about 100 feet apart. Still another file was met 2.5 miles farther south. This one was also composed of about twenty adults, again spaced about 100 feet apart, and again proceeding southeasterly. All the files were moving slowly, barely breaking the surface. All the animals were adults with white-tipped dorsal fins. No explanation can be offered for this peculiar schooling habit. It has been noted occasionally since, but the schools have not been as large.

Usually Dall porpoises have been found in small groups of less than a dozen animals arranged in no noticeable order.

Dall porpoises show a remarkable ability to disappear when pursued. After being harried by a boat for a few minutes they are apt to dive out of sight and remain below the surface for rather long periods, perhaps 5 minutes or more. They usually swim several hundred yards under water and then surface very quietly. Even on a calm day it may take great persistence to keep track of a school.

Feeding. Dall porpoises have been seen circling, and presumably feeding, amid schools of sauries (*Cololabis saira*), and as has been noted earlier, a captive

TABLE 13

STOMACH CONTENTS OF ADULT MALE *Phocoenoides dalli* (MLP56–5) TAKEN 4 MILES SOUTH OF PT. FERMIN, LOS ANGELES CO., CALIF.

Species	Remains[1]	Number	Approx. size
Merluccius productus (Hake)................	otoliths and vertebrae	26 otoliths (12 left, 14 right)	3–10 inches
Trachurus symmetricus (Jack Mackerel).......	otoliths and skeletons	4 otoliths in two skulls	10 inches
Loligo opalescens? (Squid)..............	beaks and lenses	13 lower and 12 upper beaks	adults
....	vertebrae and lenses	numerous	?

[1] The porpoise had eaten at least fourteen hake, two jack mackerel, and thirteen cephalopods (probably *Loligo opalescens*).

regurgitated a large quantity of squid (probably *Loligo opalescens*) when captured. The stomach contents of an adult male (MLP56-5) was identified for us by John Fitch, senior research biologist of the California Department of Fish and Game. These data are listed in table 13. The predominance of hake remains in this stomach is interesting since this species of fish does not normally live near the surface in southern California waters, but is abundant at depths of 400 feet or more. Probably the animal had been capturing its food deep beneath the surface. Scheffer (1953) reported the remains of hake, squid, and jack mackerel in the stomachs of six Dall porpoises taken near Monterey, California.

Bathypelagic and deep-water benthic fish and cephalopods have been reported from Dall and True porpoise stomachs in Japanese waters by Wilke, Taniwaki, and Kuroda (1953) and by Wilke and Nicholson (1958). Striped porpoises (*Lagenorhynchus obliquidens*) taken from the same general area showed a markedly different assemblage of species in their stomach contents. The striped porpoises contained mostly myctophid fishes, many of which are notable vertical migrants, plus smaller quantities of anchovies, squid, and mackerel. All of their food could have been caught near the surface.

Respiration.—The Dall porpoise swims with such vigor during rapid locomotion that upon surfacing and plunging again beneath the surface, its head usually causes a hollow cone of water to pass backward over its body (pl. 37, *a*). The porpoise often seems to breathe under this sheet of water, literally beneath the surface.

Sound production.—We have not noted any sound production by captives other than the squealing noise emitted by one animal as it went into rigor and died in the collecting skiff. However, in all captives, inflation of the nasal sacs was seen. This inflation occurred just as we thought the animal was about to vent air through its blowhole. Instead, the blowhole remained tightly closed and the top of the head in the area of the nasal sacs began to swell. The inflation was maintained for two or three seconds, with slight but observable fluctuations in the swelling. No sound was heard. It seems possible that the animal was emitting sounds outside the range of human hearing.

PARASITISM

Large quantities of a nematode (*Stenurus* sp.) were removed from the lateral air sinus of the head, near the internal ear, during the preparation of the skeleton of an adult male (MLP56–5). We wish to thank Donald Heyneman for this identification. The occurrence of this genus of parasites in the air sinus system in odontocetes is apparently widespread (Reysenbach de Haan, 1957).

California Gray Whale

Eschrichtius glaucus (Cope)

CAPTURE OBSERVATIONS AND SIGHTINGS

On January 28, 1959, a female gray whale estimated at 29 feet in length was seen leaping partly out of the water about .75 of a mile from the Marineland collecting vessel in the San Pedro Channel. She breached twice more, each time lifting about three-quarters of her length above the surface. She did not sound upon the approach of the vessel but swam off in a zigzag course about 20 feet below the surface. For an hour she continued swimming at or near the surface in an erratic path toward the southeast, pursued by the collecting vessel. The longest distance she swam continuously beneath the surface was estimated at 900 yards. During the chase she seemed to be swimming at or close to maximum sustained speed and since this coincided closely to the normal cruising speed of the vessel, she was moving about 8½ knots. She did not, or could not, outrun the boat.

After the chase had covered a considerable distance, her behavior changed. In full flight she suddenly circled and stopped close by the vessel, and surfaced. Initially she was in a normal upright position as she stopped. While resting quietly in the water she slowly rolled over, first exposing the anterior portion of her right side, her lower jaw, and one flipper (pl. 37, *b*). The remainder of her body was submerged in an arched position with the flukes about 6 to 8 feet below the surface. She soon righted herself by submerging the exposed anterior portion of her body and rolling over. Later she repeated this pattern several times. Each time the response was quite similar and followed a definite sequence. First she would surface ahead of the boat, blow, circle toward the boat either to the right or left, and then stop. Gradually she would roll over, exposing first one and then both flippers. At this time both flippers and the lower jaw extended into the air.

When in this position her head began to submerge and her entire body became arched. A progressive sinking of her head exposed the ventral surfaces of the abdomen and genitalia. At this point she sank completely and righted herself. Nearly every time before resuming her flight from our boat she flailed her flukes laterally toward the ship. This often created a vortex at the surface when the flukes were submerged several feet (pl. 38). The flailing was apparently directed at the boat, and on one occasion a "spent" blow hit the skiff, which was tied astern, and moved it several feet.

When her genitalia were exposed it was possible to determine that the whale was a female and possibly pregnant. The genital slit was swollen and protruded beyond the normal body contour. Her abdomen appeared exceptionally large, and her mammary glands were also distinctly distended.

On one occasion, when the whale circled back to stop, she collided with the vessel. On this occasion the junior author leaned over the rail to snap a picture of the animal directly below. At this instant she blew. The odor from the expelled breath was almost overpowering and the spray covered a pair of sunglasses to opacity. This spray was allowed to dry on the glasses, and crystals formed that seemed identical with those formed by drying salt water on a glass surface. There was no evidence of oil on the glasses.

BEHAVIOR

Migration.—For two seasons (1955–1956) a whale counting station was maintained atop the Marineland of the Pacific whale stadium. Census data from these counts have been presented to the U.S. Fish and Wildlife Service. A few random observations, not pertaining to this survey, are included here.

During the period from early December to early April gray whales are often quite abundant in the waters near Los Angeles, California. Many animals do not confine their migratory path to the coast line but pass offshore near the inner Channel Islands. This offshore movement seems particularly evident on the return migration from the breeding lagoons in Mexico.

A series of observations was made during the winter of 1954–55 on the habits of gray whales as they crossed Santa Monica Bay. The majority of the animals swam from the northern points of the bay (Point Mugu, Point Dume) across the outer bay, not following the shore line closely, and made their approach to shore again near Rocky Point, on the Palos Verdes Peninsula. Occasional animals, however, did swim close inshore around the shallow margins of the bay. Before the whales reached Rocky Point they passed over the Redondo submarine canyon, which is about 250 fathoms deep in the area that they must cross. In this general vicinity the whales often spent some time diving and leaping almost clear of the water in the maneuver called "spy hopping" (Gilmore, 1958). The dives made at this area were typified by the animals turning head down and throwing their flukes high out of the water. Rapidly traveling whales either do not throw their flukes at all on dives or they lift them out of the water at a slight angle above the surface.

The broaching or spy-hopping behavior that we noted was almost entirely confined to this area, though occasional instances were noted at the tip of Point Vicente, a short distance to the south.

On the west side of the Palos Verdes Peninsula the whales often swam within 200 yards of shore, though many were seen well out to sea. When they reached Point Vicente the usual behavior was for the animal to slow its pace and begin a series of nearly vertical dives around the outer rocks of the point. Once the point was rounded the whales proceeded in a direct course along the south shore of the peninsula, usually heading slightly out to sea. Their pace speeded to about 4 knots and the sounding dives of the animals began to be made again at a low angle, rather than nearly vertically, as had been the case at the point. Occasional animals rounded Point Vicente and began to circle in the small shallow cove on its south side. Sometimes these animals would spend nearly a half an hour circling and blowing in this cove before going out again into deeper water and moving southeastward along the coast. Once they were clear of the cove these animals often swam much closer to shore than the majority of whales until they were well out of sight from our vantage point on the cliffs above.

Several southern California fishermen have told us of encounters with gray whales during gill-net fishing for California white sea bass (*Cynoscion nobilis*). Laurence C. White (personal communication) reported repeated damage to his nets during the months of December, 1954, and January, 1955. Mr. White concentrated his fishing activities off Newport, Corona Del Mar, and Laguna Beach, Orange County, California, during this period. These months are the peak period for the southward migration of gray whales at these localities. The whales passed through his nets, sometimes merely leaving holes in the webbing, and other times dragging parts of a net as far as 10 miles down the coast. Nearly all the damage occurred in water of 15 fathoms depth or less, according to Mr. White. Nets set beyond this depth, on the bottom, were seldom molested. The whales seemed to swim into beds of the giant kelp (*Macrocystis pyrifera*), and also along the edges, as nets set through the beds were sometimes destroyed. Whale barnacles and whale lice and one piece of whale skin were found attached to one of his torn nets. Mr. White made the following interesting observation: "The whales seem to like shallow water and will swim out of their way to stay in these depths when there is deep water close to shore. Where the shallow shelf of Huntington Flats (off Huntington Beach, California) and San Onofre Flats runs farther to sea, the animals stay farther out." H. C. Buckman reported similar occurrences. Most of the damage to his nets occurred in 7 to 12 fathoms of water. Nets set in 14 fathoms and deeper were seldom molested. In both instance the nets used were set on the bottom and stood 12 to 14 feet high. The whales generally hit the nets from 4 to 12 feet from the bottom.

During the 1959 northward spring migration extensive net damage was reported to us by several other fisherman. The damage varied from large tears in the nets to having nets dragged away entirely. In April, 1959, a gray whale was found entangled in one of these nets near Marineland of the Pacific. It had become entangled sometime during the morning, after the fisherman had visited his net. By noon the whale had dragged this net several hundred yards from its initial location. The whale stayed entangled throughout the day, but managed to escape sometime before the following morning. Sam Falsetta told us of having his nets torn by whales when they were set on the bottom in 38 fathoms of water off the

Palos Verdes Peninsula, Los Angeles County, California. The nets stretched upward from the bottom about 4 fathoms when set. We inspected these nets and found whale lice entangled in the meshes 6 to 8 feet above the lead line.

Antonio Perisky, quoted earlier with regard to *Tursiops gilli,* reported seeing a large whale, presumably a California gray whale, enter the Estero de Punta Banda, Baja California Norte, Mexico, during the winter of 1917. He said the whale "was the same kind which still swim in the bay outside" (Todos Santos Bay); it swam up to the first sand bar inside the lagoon, turned, and swam back out to sea.

These observations tend to indicate that the California gray whale sometimes uses landmarks on the bottom, and possibly also along the shore, during its long migrations. Repeated nearly vertical dives are seemingly typical of locations in which the whales must make a decision on a new course, or in locations in which they suddenly lose the bottom. The information from net damage indicates that the whales normally dive to within a few feet of the bottom in their migratory swimming. Unlike the smaller toothed whales, they do not seem to be able to evade nets by means of echo-location, or at least they do not seem to attempt such evasion. They may, of course, actually seek such nets as a means of scraping off barnacles and whale lice. It also seems obvious that the navigation methods of the gray whale are not wholly efficient, since individuals often become disoriented.

Little Piked Whale

Balaenoptera acutorostrata Lacépède

NOMENCLATURE

Cowan (1939) has examined two specimens of the little piked whale obtained in British Columbia waters by the British Columbia Provincial Museum, and has concluded that the Pacific form belongs to the Atlantic species *acutorostrata,* and is probably a subspecific differentiate. Hence it should be considered as *B. a. davidsoni,* utilizing Scammon's (1872) name.

DISTRIBUTION

Range.—In the north Pacific ocean the little piked whale is known to occur from the Bering Sea to Baja California (Hall and Kelson, 1959). The species has seldom been reported from California or Mexican waters. A young individual caught off La Jolla, California, on April 17, 1923, is represented by a mounted preparation in the San Diego Society of Natural History (Abbott, 1930). Fry (1935) has recorded a 10-foot, 5-inch specimen weighing 750 pounds which was lassoed and stranded in Los Angeles Harbor on February 4, 1933. Scattergood (1949) lists all known records up to that time for the eastern Pacific and says: "The paucity of published records results in a false picture of the relative abundance of this whale in the northeastern Pacific. The coastal region between California and Alaska has extensive areas of sea coast which are inhabited by few people. Whales could be stranded in a great many sections of this long coastline and their presence never detected. In addition, few persons are sufficiently interested to identify whales and subsequently report them." These remarks apply very well indeed to the little

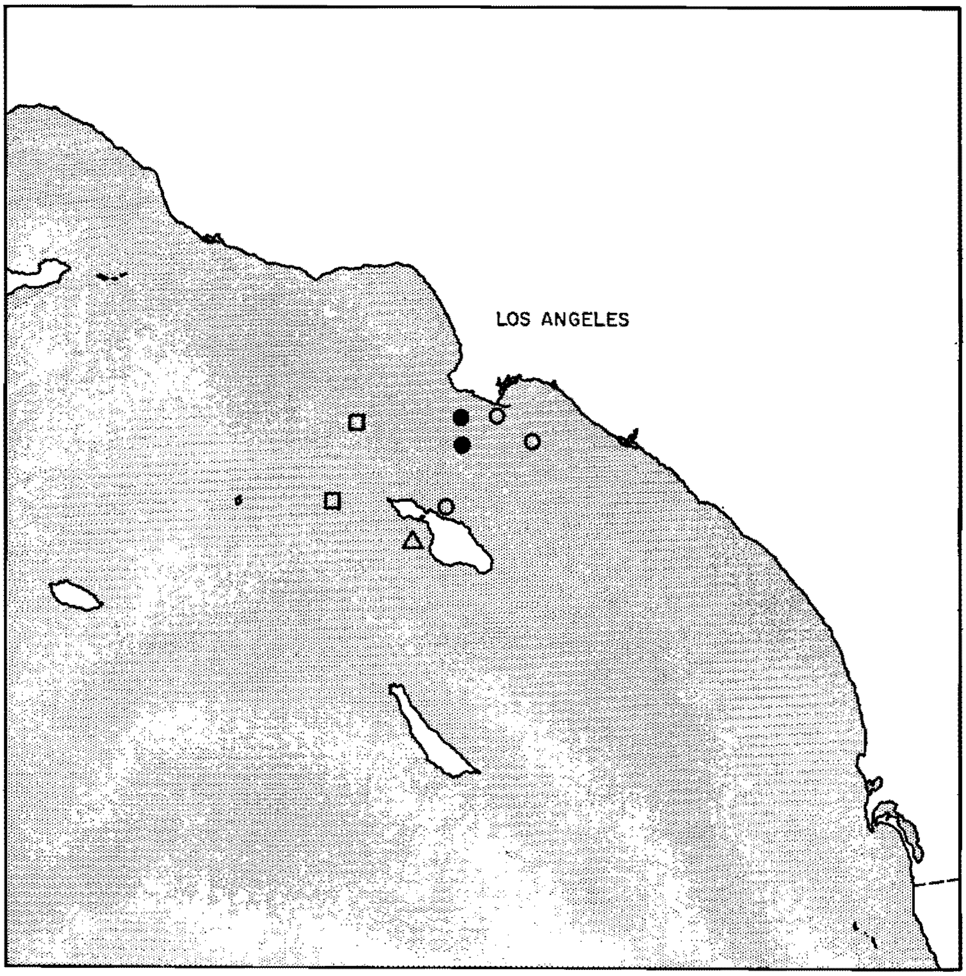

Fig. 12. Sight records and localities of capture of the little piked whale (*Balaenoptera acutorostrata*). Open circles, January through March; open squares, April through June; open triangles, July through September; black circles, October through December.

piked whale in southern California waters where it is a regular visitor instead of the rare animal indicated by the published records (fig. 12).

Seasonal movements.—Records for the species are available for every season of the year in southern California waters. However, like the killer whale (*Orcinus orca*) and the Pacific striped porpoise (*Lagenorhynchus obliquidens*) the preponderance of sightings and specimens have come from the cooler months. This concentration may simply reflect the presence of heavy populations of squid and other food species. The squid, *Loligo opalescens,* gathers in vast numbers at certain localities in southern California waters during the cool months to spawn.

CAPTURE OBSERVATIONS AND SIGHTINGS

On October 16, 1956, two adult little piked whales were sighted 8 miles south of Long Point, Los Angeles County, California. They were apparently feeding in one small area, as they circled and surfaced many times while we watched them from the collecting vessel. Both were about 20 feet long. Their backs were dark gray and the white ventral surface of the chin was plainly seen when one raised its head clear of the water for a moment. The white marking ran along the chin and lower margin of the lips, making the entire ventral surface of the chin white. Numerous throat grooves were evident. We were unable to see the pectoral flippers and hence did not see the diagnostic white band. The dorsal fin was about two-thirds of the way back on the body, and was quite prominent and strongly hooked. The head was very pointed and the nostrils especially prominent, with a very noticeable transverse groove behind them. When one animal raised its head above the water the movement was accomplished by bending only the anterior part of the body. The blow was audible but almost invisible during the period of our observations. Twice we passed behind the creatures as they blew, and although we were 50 yards away, the odor was unpleasantly strong, smelling much like rotting squid.

When the animals sounded after a series of short blows, their tail stocks were arched but the flukes never showed above the surface of the water.

At the time of this sighting a strong red tide, composed principally of a dinoflagellate (*Gonyaulax polyhedra*), was present over much of the channel; the two whales were swimming at the edge of a moderately dense patch of these organisms.

On December 11, 1956, a single little piked whale was sighted 10.5 miles south of Long Point, Los Angeles County, California. The animal surfaced near a school of pilot whales, which was feeding on the abundant spawning squid present in the area.

On June 6, 1957, when 20 miles east-northeast of Santa Barbara Island, California, four little piked whales were seen swimming with a group of pilot whales. As the boat entered the school, two of the little piked whales came alongside, from either side. They approached within a foot or two of the vessel and may even have rubbed against the hull. Captain Brocato threw the engine out of gear to prevent them from being cut by the screw. The boat stopped and the whales turned and swam around her, turning on their backs as they did so. They were seen "standing" vertically beneath the surface of the water under the skiff tied astern. At times, when they were as much as 3 feet below the surface, they blew, and the large bubbles caused a boil at the surface. Directly after such an underwater blow they surfaced, extended their double nostrils, and took in a new breath. When the boat was put back in gear the whales returned to the pilot whale school, but later returned again just ahead of the bow. An unusually accurate sight estimation of length was made by matching the animals against known points on the ship. Each was about 19 feet long. Since the observation lasted about ten minutes and the animals were very close, identification was certain.

On January 7, 1958, a newborn female little piked whale was found swimming feebly 200 yards off the old rock quarry near the Isthmus of Santa Catalina Island.

She was lassoed by the crew of the California Department of Fish and Game vessel *Pompano.* Robert Thompson and Robert Ryan, of the *Pompano,* loaded the 398-pound animal on board and proceeded toward Marineland's pier. The animal was dead on arrival. Blood was seeping from the large umbilical scar, as if the umbilical cord had been detached only recently.

On February 14, 1958, an 18-foot individual was sighted 10 miles south of San

Pedro Lighthouse. The animal was swimming within a few hundred yards of a pod of five gray whales.

On April 13, 1958, three little piked whales were observed and followed for about half an hour, 5 miles west of the west end of Santa Catalina Island, California. One was estimated at 20 feet in length, another at 15 feet, and the third at 8 or 9 feet long.

A 13- or 14-foot little piked whale was seen on August 12, 1958, 4 miles southwest of Catalina Harbor, Santa Catalina Island, California. It was feeding in a school of anchovies (*Engraulis mordax*). The whale was frightened away from the anchovy school by the observer's vessel, but quickly returned. It was seen swimming through the school, turning partly over as it fed.

A newborn female little piked whale stranded on the inside of the Los Angeles Harbor breakwater at Cabrillo Beach on March 21, 1959. The animal was alive when first reached but died before it could be brought ashore. It was extremely emaciated and was covered with lacerations from the sharp rocks of the breakwater.

MORPHOLOGY

Morphometrics and anatomy.—The measurements of two newborn little piked whales are given in table 14.

The newborn female caught on January 7, 1958, had five white hairs widely spaced along the margins of the upper jaw, each about a half an inch in length, fourteen similar hairs arranged in two vertical rows at the tip of the lower jaw, and two hairs situated between the posterior ends of the paired nostrils.

At the median symphysis of the lower jaw, inside the curve of the lip, were two minute hardened white spots that may possibly have been vestigial teeth. Each was composed of a somewhat pliable tube filled with a soft reddish tissue. These tubes extended down through the blubber but could not be traced to the jaw margin.

Color and pattern.—The following is a color description of the same newborn female discussed above. In general, the animal was dark gray dorsally, grading to light gray laterally, and white ventrally, with the following exceptions. A prominent oval lateral black patch extended from over the upper insertion of the pectoral flipper to slightly posterior to the tip of the adpressed flipper (pl. 39 and 40). Two gray, posteriorly directed chevrons marked the lateral surfaces of the tail stock. The diagnostic white band across the pectoral flippers was widest ventrally, narrowing at the anterior flipper edge and grading into the gray of the body along the posterior margin. The dorsal surface of the tail flukes was dark gray and the ventral surface was white with gray margins all around.

REPRODUCTION

Young.—The capture of newborn or very young individuals of the little piked whale in southern California waters probably indicates calving of the species in this area. It is conceivable that these small animals could have traveled a considerable distance from the locality of their birth, but their repeated occurrence in southern California waters makes this seem unlikely. The records indicate that winter is at least part of the season of birth.

TABLE 14

MEASUREMENTS AND PROPORTIONS OF *Balaenoptera acutorostrata*

Measurement	January 7, 1958 200 yds. offshore, 1 mile W. of Empire Landing, Santa Catalina Island, Calif. Female; 398 lbs.		March 21, 1959 Inside Los Angeles Harbor breakwater, Cabrillo Beach, Los Angeles Co., Calif. Female;	
	Cm.	Proportion[1]	Cm.	Proportion
Total length—snout to fluke notch	269.5	.....	284.5	.....
Snout to eye	47.0	0.174	47.0	0.165
Snout to end of mouth crease	.....	.....	50.8	0.178
Snout to anterior origin of flipper	80.0	0.297	82.5	0.290
Snout to center of blowhole	.....	.....	33.0	0.116
Snout to anus	196.0	0.728	.....	.....
Snout to origin of dorsal fin	174.0	0.646	.....	.....
Flipper (left)—anterior origin to tip	41.3	0.152	39.4	0.135
Flipper (left)—axilla to tip	.....	.....	27.6	0.095
Flipper (left)—greatest width	17.8	0.066	11.4	0.040
Flukes, spread—tip to tip	64.2	0.237	58.5	0.205
Median notch of flukes to dorsal fin at deepest point of posterior curve	.....	.....	88.2	0.308
Dorsal fin—length of base	.....	.....	19.0	0.062
Dorsal fin—height	12.7	0.047	12.7	0.044
Dorsal fin—anterior origin to deepest portion posterior curve	13.9	0.051	13.9	0.049
Dorsal fin—anterior origin to blowhole center	.....	.....	141.0	0.495
Blowholes—width	.....	.....	6.4	0.022
Blowholes—length	8.2	0.030	7.7	0.029
Projection of lower jaw beyond upper	3.2	0.011	.....	.....
Genital slit—length	12.7	0.047	.....	.....
Girth—at anterior origin flippers	122.0	0.452	132.0	0.464
Girth—at anterior origin of dorsal fin	.....	.....	104.0	0.366
Girth—at level of anus	.....	.....	83.8	0.294
Intestine—length	.....	.....	1600.0	5.623
Umbilicus to anus	.....	.....	57.2	0.200
Anus to reproductive aperture	.....	.....	21.6	0.075
Anus to median notch of flukes	.....	.....	76.2	0.267
Throat furrows—number	48	.....	.....	.....

[1] Proportions expressed in one-thousandths of total length.

TABLE 15

MEASUREMENTS AND PROPORTIONS OF *Lissodelphis borealis*

Measurement	November 7, 1960 Manhattan Beach, 22nd Street Lifeguard Station, Los Angeles Co., Calif. Female; 110 lbs. (± 10 lbs.)	
	Cm.	Proportion[1]
Total length—snout to fluke notch	218.0	.....
Snout to eye	33.7	0.154
Snout to mouth crease, inside corner	22.1	0.101
Snout to anterior origin of flipper	58.5	0.268
Snout to apex of melon	7.63	0.035
Snout to center of blowhole	31.0	0.142
Snout to anus	160.5	0.736
Flipper (left)—anterior origin to tip	27.3	0.125
Flipper (left)—axilla to tip	19.0	0.087
Flipper (left)—greatest width	10.8	0.049
Flukes—depth of median notch	1.65	0.007
Flukes, spread—tip to tip	37.0	0.169
Blowhole—width	3.18	0.014
Projection of lower jaw beyond upper	1.65	0.007
Genital slit—length	17.7	0.081
Girth—at level of blowhole	67.3	0.308
Girth—at anterior origin of flippers	86.5	0.396
Girth—at midbody	85.5	0.392
Girth—at level of anus	39.4	0.180
Girth—greatest—at tip of adpressed flipper	91.5	0.419

[1] Proportions expressed in one-thousandths of total length.

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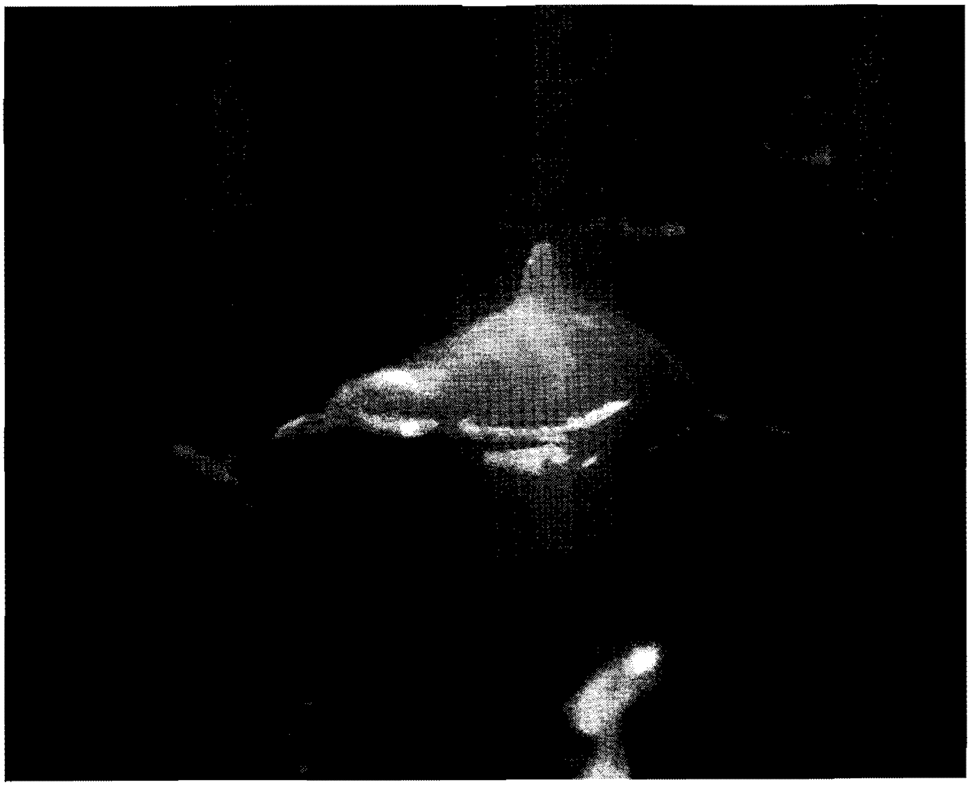
PLATES

PLATE 27

a. A female Atlantic bottlenose porpoise (*Tursiops truncatus*) supporting a dead leopard shark (*Triakis semifasciata*) on her snout. See text.

b. Two Pacific striped porpoises (*Lagenorhynchus obliquidens*) riding the bow of the Marineland collecting vessel *Geronimo*. Note the depressed snout and caudal peduncle of the upper animal. Note also the photographer's reflection. The animals are stationed directly in front of the vessel's stem post.



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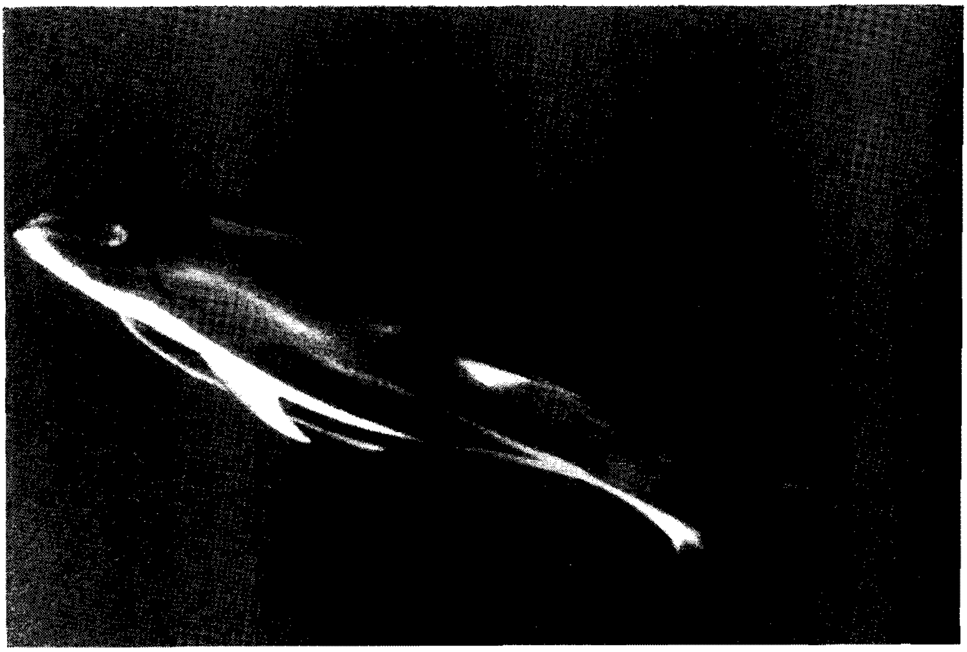

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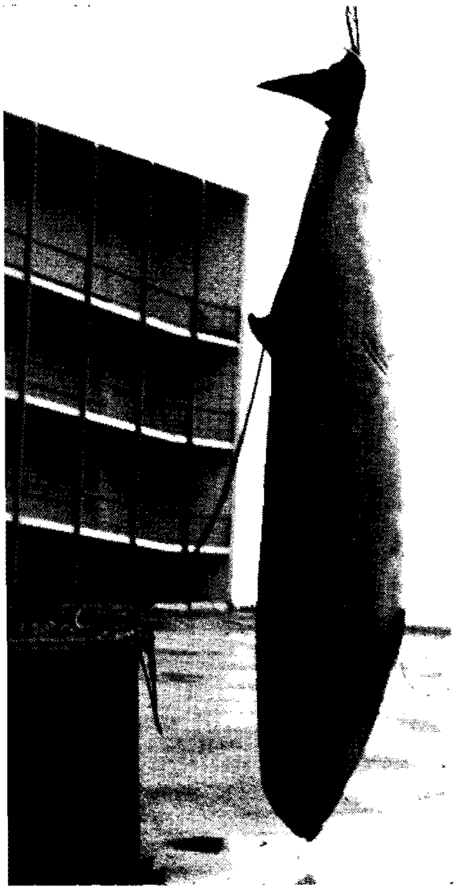
PLATE 28

Body posture during turning in the Pacific pilot whale (*Globicephala scammoni*). Note the slight lateral curve in the caudal peduncle of the adult male swimming away from the observer. Note also the tilted flukes, which are slightly rotated on the longitudinal axis of this animal's body. Photograph courtesy of Peter Stackpole and *Life Magazine*.

PLATE 29

a. Immature female Cuvier's beaked whale (*Ziphius cavirostris*). Note the distinct median notch in the tail flukes and the long double scar on the flanks below the dorsal fin.

b. Immature female Cuvier's beaked whale (*Ziphius cavirostris*). Note the dark coloration around the eye and the pale body color.



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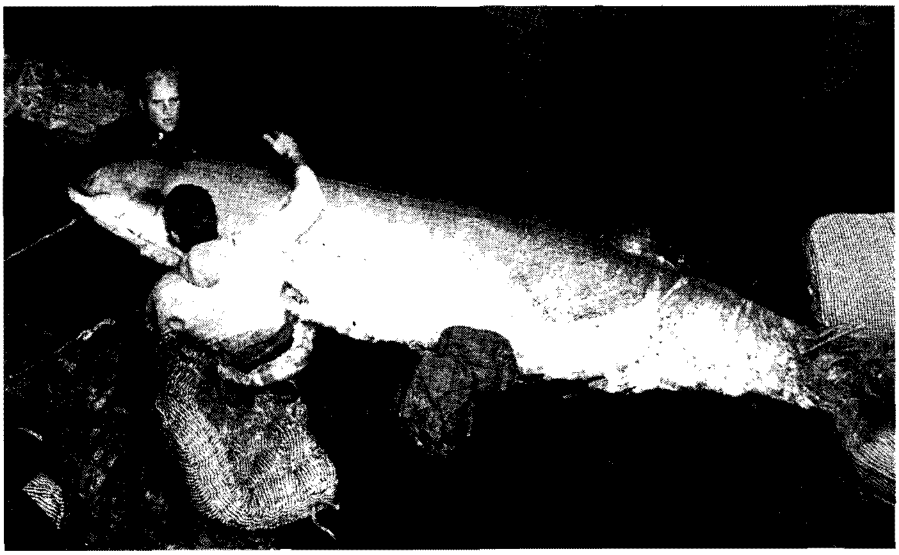

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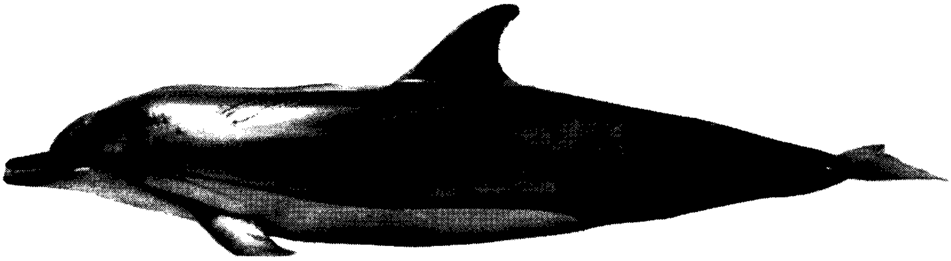
PLATE 30

Morphology and pattern of an adult male Gray's long-snouted porpoise (*Stenella euphrosyne*), taken at Playa del Rey, Los Angeles County, California. *a*. Lateral view. The pectoral flipper is bent by the weight of the animal. *b*. Lateral aspect of head. *c*. Dorsal aspect of head. *b*. Dorsal view of left pectoral flipper. *e*. Dorsal view of flukes.



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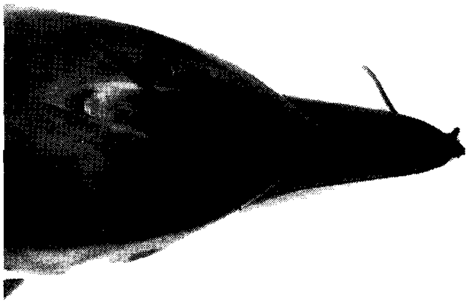

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PLATE 31

a. Play in a captive Pacific striped porpoise (*Lagenorhynchus obliquidens*). This animal is racing off with a diver's air hose. Similar behavior has been noted in this species in which the animal carried pieces of paper or long strands of kelp. Photograph courtesy of Peter Stackpole and *Life Magazine*.

b. Adult female killer whale (*Orcinus orca*) leaping alongside the Marineland collecting vessel *Geronimo*. Note the foam-covered area from a previous leap. Photograph courtesy of Philip Schuyler.

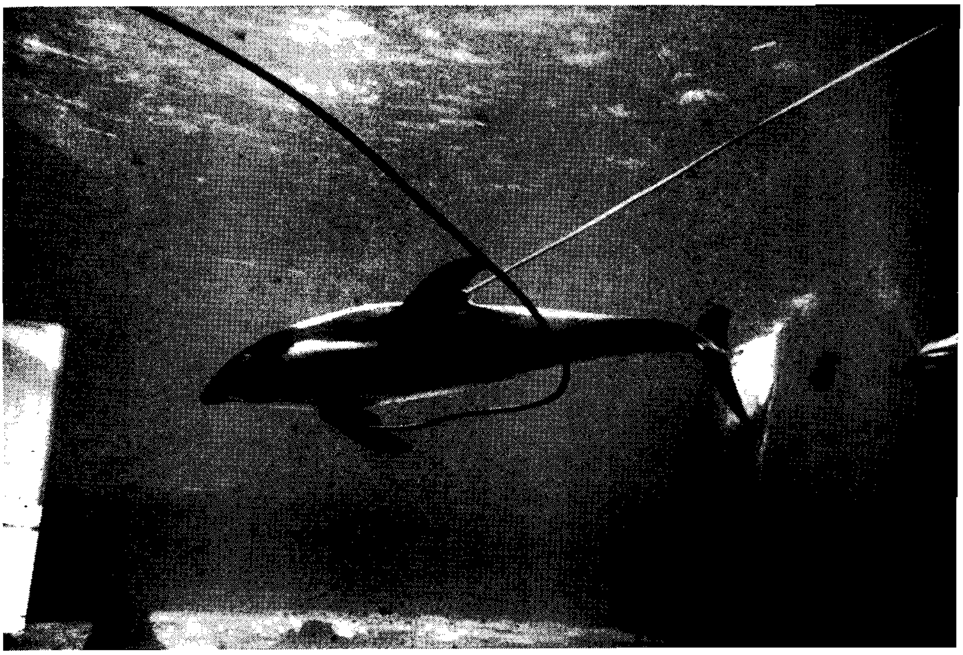

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PLATE 32

a. Adult female killer whale (*Orcinus orca*) swimming near stern of Marineland collecting vessel *Geronimo* off Montecito, California.

b. An 18-foot, 3-inch male Pacific pilot whale (*Globicephala scammoni*). Note the large overhanging melon, the very elongate sickle-shaped pectoral flippers and the deeply keeled caudal peduncle.

a

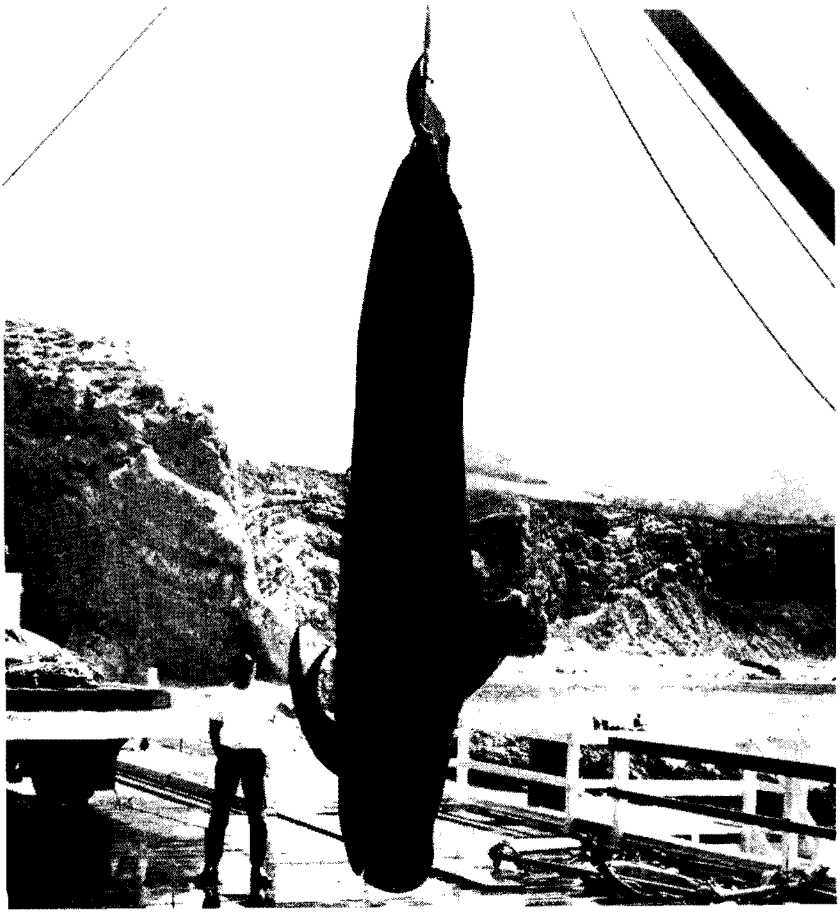

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PLATE 33

a. A 13-foot adult female Pacific pilot whale (*Globicephala scammoni*). Note the moderate overhang of the melon, the fairly short pectoral flippers, the moderately hooked dorsal fin, and the less-pronounced keel of the caudal peduncle, as compared to the adult male pictured in plate 32, *b*.

b. The ventral blaze mark of a 13-foot adult female Pacific pilot whale (*Globicephala scammoni*). Note the extreme mobility of the pectoral flippers. Photograph courtesy of Peter Stackpole and *Life Magazine*.

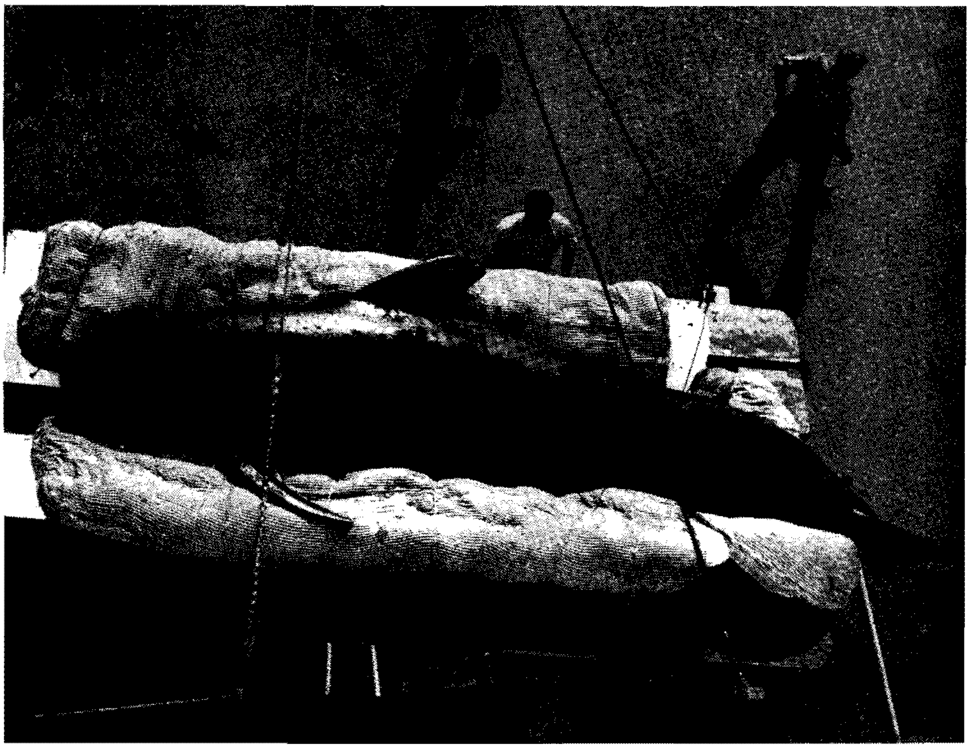

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PLATE 35

a. Sixty-one Pacific pilot whales stranded 3 miles north of La Paz, Baja California Sur, Mexico, on May 12, 1959. Photograph courtesy of George Mann.

b. Stranded Pacific pilot whales at La Paz, Baja California Sur, Mexico. Note how the still-living animal struggles to breathe while the animals on each side have dug into the soft sand and drowned. Photograph courtesy of George Mann.

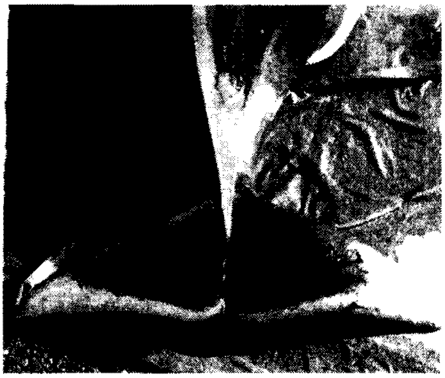
a

b

PLATE 36

Morphology and pattern of an adult male Dall porpoise (*Phocoenoides dalli*) taken 4 miles south of Point Fermin, Los Angeles County, California. *a*. Ventral pattern. *b*. Dorsal aspect of flukes. *c*. Lateral view of dorsal fin and mid-body. *d*. Ventral aspect of flukes and tail stock. Note enlargement of ventral keel. *e*. Dorsal aspect of pectoral flipper. Note delineation of phalanges by white pattern.

a



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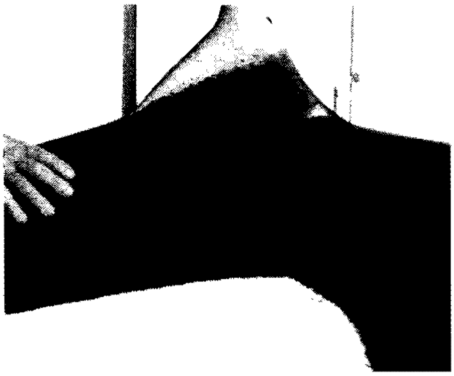

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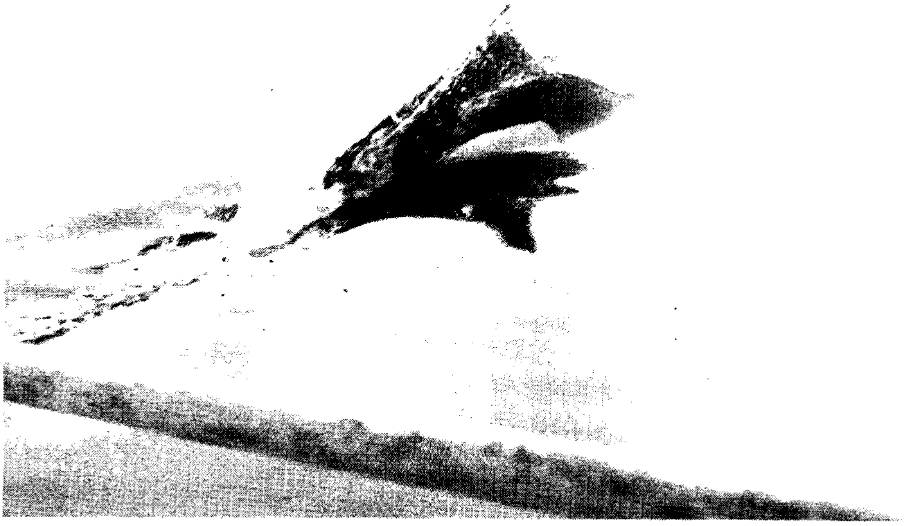
PLATE 37

a. A Dall porpoise (*Phocoenoides dalli*) breathing within a cone of water formed by its own fast-moving body. Photograph courtesy of Donald Hackett.

b. A female California gray whale (*Eschrichtius glaucus*) lying on her back after being pursued by the Marineland collecting vessel.



a

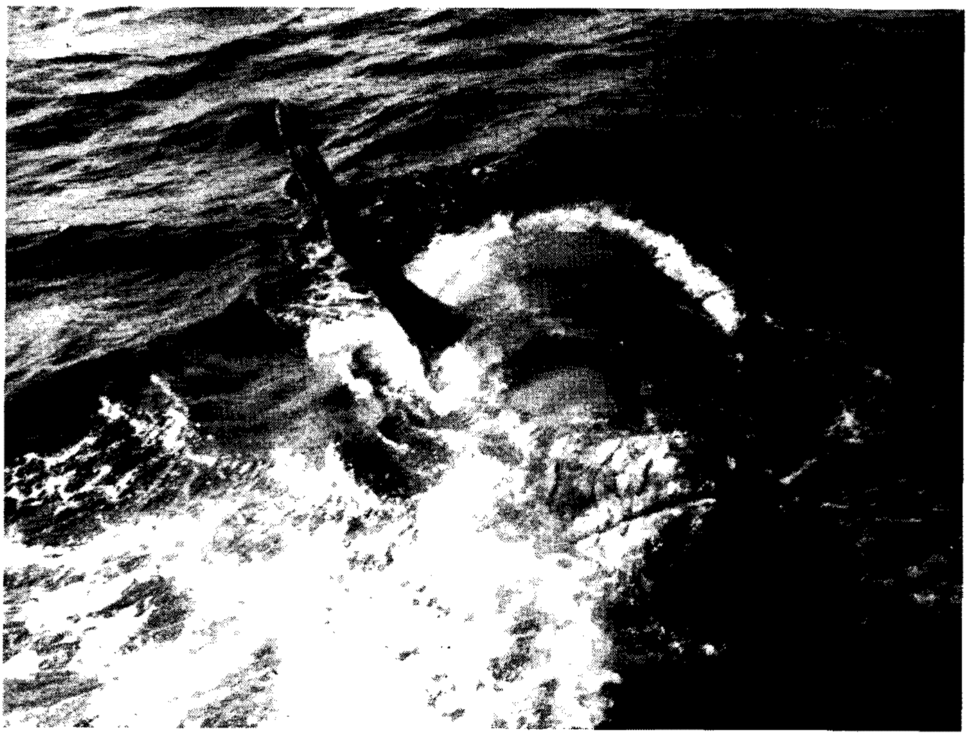


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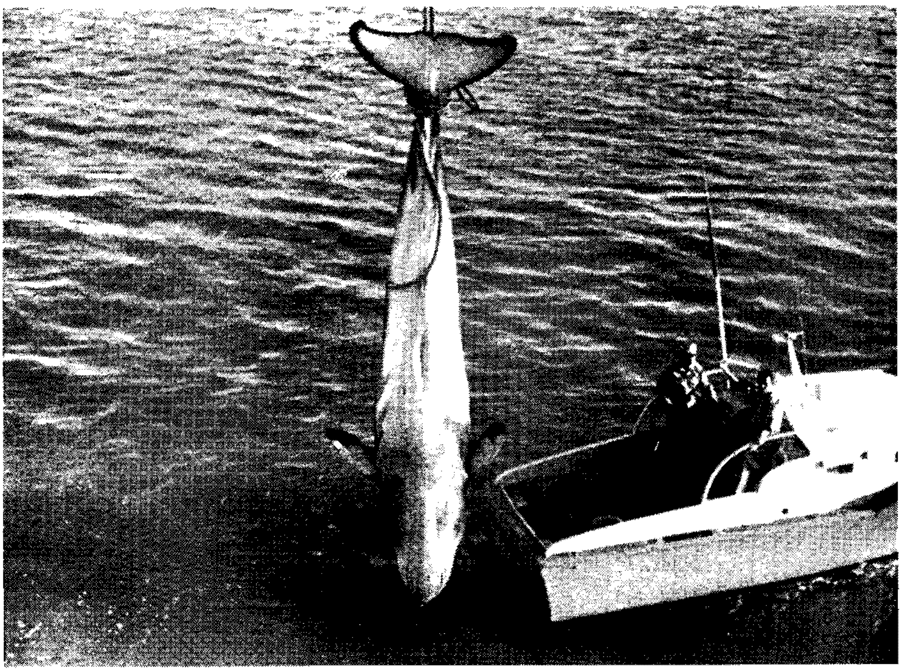
PLATE 38

A female California gray whale (*Eschrichtius glaucus*) striking laterally with her flukes after turning over in the water when pursued. The animal was still belly-up at the time this picture was taken.

PLATE 39

A newborn female little piked whale (*Balaenoptera acutorostrata*) taken near Santa Catalina Island, California, on January 7, 1958. *a*. Lateral view. Note prominent black patch just above pectoral flippers and chevron-shaped marking on caudal peduncle. *b*. Ventral view.

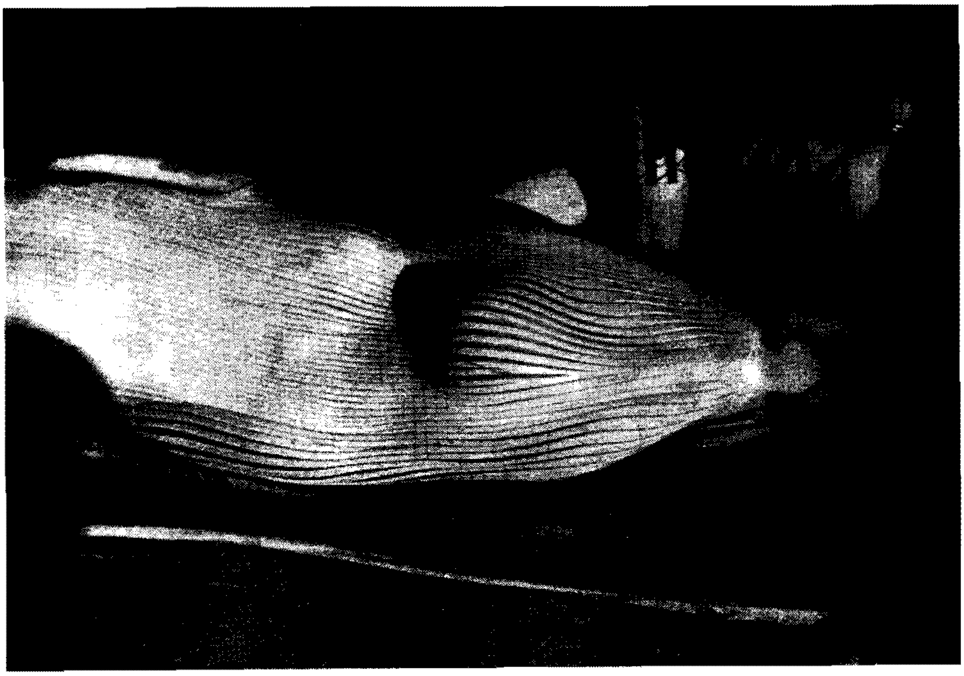
a



b

PLATE 40

A newborn female little piked whale (*Balaenoptera acutorostrata*) taken near Santa Catalina Island, California, on January 7, 1958. *a*. Ventral aspect of head. *b*. Anterior view of head and body. *c*. Dorsal fin.



a

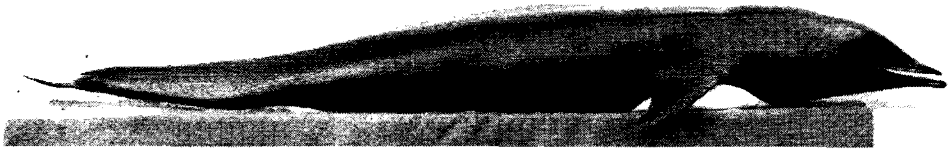
b

c

PLATE 41

An adult female northern right whale porpoise, stranded November 7, 1960, at Manhattan Beach, Los Angeles County, California. *a*. Lateral view. *b*. Ventral view. *c*. Dorsal view. *d*. Ventral aspect of the tail flukes. *e*. Dorsal aspect of the tail flukes.

The heavy venation of the flukes shown in these photographs was not nearly so evident in the animal just after death had occurred. The gray dorsal fluke tips are slightly evident in *c*, but were much more obvious in the newly dead animal.



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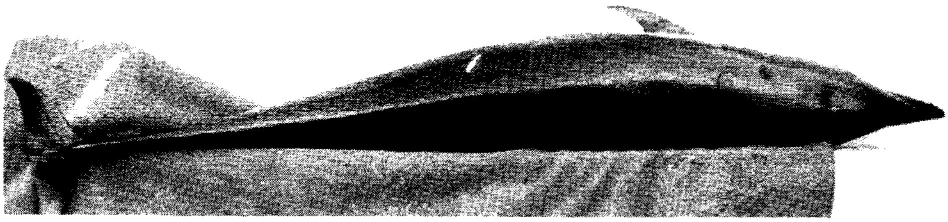

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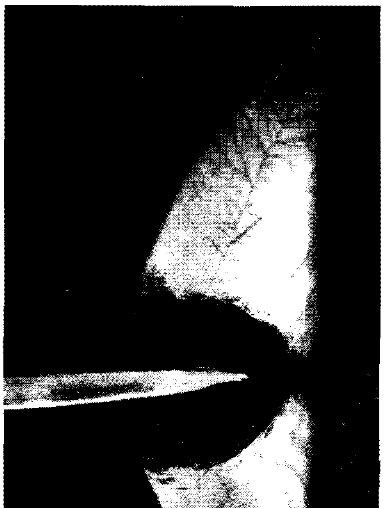

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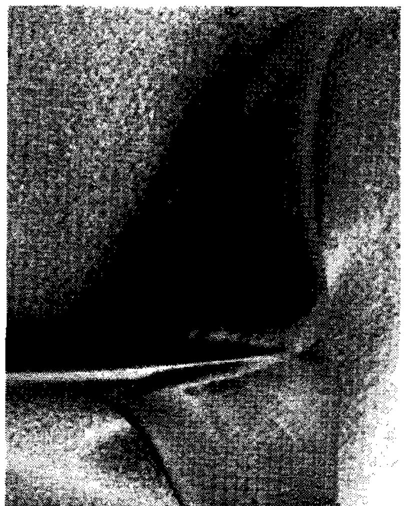

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