ment the whale and subsequently track and obtain data from it was designed and manufactured by Ocean Applied Research Corporation, San Diego, California. Hugh Martin and Romaine Maiefski, both from this organization, actively participated in the attachment of the instrumentation to the animal and the initial stages of tracking. J. S. Leatherwood, J. Hall, Bruce Parks, and L. McKinley, of the Naval Undersea Center, San Diego, California, and the Commanding Officer of the RV *Cape* and his crew were directly instrumental in the success of this project. The radio contact with the instrumented whale on 5 May 1972 was accomplished by Paul Sebesta, NASA Ames Research Center, Moffett Field, Calif., using equipment supplied by the author.

POSTSCRIPT

During the period 2 January 1973-21 March 1973, the author investigated 37 reported resightings of Gigi. Although most of these reports did not check out, on 5-6 January, a Captain Paul Roth, USN, and a Mr. and Mrs. Sherwood of San Diego independently described behavior of a 9-10 meter California gray whale sighted inside the kelp off the Sunset Cliffs area of Point Loma, San Diego, California. In both cases the whale, light in color, approached close to small vessels less than 10 meters, rolled, and frolicked around. On 15 March we received a report from the MV *Long Beach Prince* that a whale of similar size and with white tail flukes (see Figure 3) and a 60 cm × 60 cm square white scar behind the blow hole was sighted frolicking around the vessel by 178 whale watchers. The location of this sighting was 3-4 miles off Point Fermin. This latter sighting is especially interesting since on 6 March 1972, one week prior to release, Gigi II was branded using cryogenics with a 60 cm × 60 cm mark, midline on the back just posterior to the blow hole. This form of marking, called "freeze branding," results in a white scarring due to the destruction or displacement of melanin in the epidermis of the area treated.

LITERATURE CITED

Eckman, S. 1953. Zoogeography of the sea. Sidgwick and Jackson Ltd., Lond., 417 p.

Evans, W. E. 1970. Uses of advanced space technology and upgrading the future study of oceanology. AIAA 7th Annual Mtg. and Tech. Display, Houston, Tex., Pap. No. 70-1273, p. 1-3.

———. 1971. Orientation behavior of delphinids: Radio telemetric studies. Ann. N.Y. Acad. Sci. 188:142-160.

———. In press. Radio telemetric studies of two species of small odontocete cetaceans. *In* W. E. Schevill (editor), The Whale Problem. Harvard Press, Cambridge, pp. 385-394.

Martin, H., W. E. Evans, and C. A. Bowers. 1971. Methods for radio tracking marine mammals in the open sea. IEEE Eng. in the Ocean Environ. Conf., p. 44-49.

Wyllie, J. G. 1966. Geostrophic flow of the California Current at the surface and at 200 meters. Calif. Coop. Oceanic Fish. Invest. Atlas No. 4, xiii + 288 charts.

MFR Paper 1058. From Marine Fisheries Review, *Vol. 36, No. 4, April 1974. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*

MFR PAPER 1059

Capture and Harnessing of Young California Gray Whales, *Eschrichtius robustus*

KENNETH S. NORRIS and ROGER L. GENTRY

ABSTRACT

This paper reports on the details of capture, harnessing, tracking, and harness release for three suckling gray whales. These tests are the first steps in a program to develop new means of data acquisition and recovery from whales during their migrations. It is hoped by these means to develop new information about population routes and hence population numbers to assist management. Capture was by tail noosing and head netting from a fishing vessel equipped with a swordfish plank. The harness, placed on the captive ashore, was held in place over the pectoral fins and back by means of a pair of metal plates held together by a soluble magnesium bolt. Tracking was by radio.

INTRODUCTION

Informed whale management requires adequate knowledge of population numbers. Uncertainty about migratory pathways and population mixing makes determination of such numbers uncertain for some whales such as the humpback (*Megaptera novaeangliae*), the blue whale (*Balaenoptera musculus*), the fin whale (*Balaenoptera physalus*), and the minke whale (*Balaenoptera actorostrata*). Thus precise information on migration routes of these and other marine mammals would materially assist in the development of sound management practice (Anonymous, in press).

In spite of decades of work with Discovery and other tagging methods (Clarke, 1957) our knowledge of whale migration remains highly incomplete. Because such information is needed for some protected species, new tag-

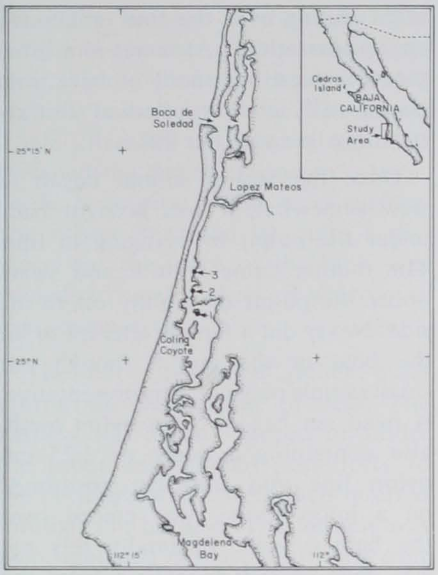

Figure 1.—Map of capture locality. Numbers indicate the capture sites for the three harnessed animals.

ging methods that do not require killing are now required. These methods seem to fall into two categories: (1) those involving the capture of whales, placement of harnesses and equipment on them, tracking along the whale's route, and subsequent release and recovery of data packages; and (2) those involving placement of data or telemetering packages on whales without capture, followed by tracking.

The first method will allow data collection from a few animals, while the latter will presumably allow less complete data collection from more animals and from those species that cannot be captured. The tests described here are of the first sort; that is, they involve capture and harnessing. The experiments of Evans (this number of *Marine Fisheries Review*) with Gigi are also of this sort, though surgical attachment rather than harnessing was used.

We chose our subject, the California gray whale, because large numbers of suckling calves are available in their Mexican breeding lagoon during January and February of each year and because the calm working conditions in the lagoon would assist these preliminary tests. We expect that the majority of results obtained on this relatively well-known animal will be applicable to more oceanic species. Our tests were restricted to capture, harnessing, and very short term tracking, since we expected that our results would require harness redesign prior to long-term tracking. This proved to be the case.

We attempted to capture suckling animals only because of the obvious dangers and seamanship problems presented by adult whales. The rationale supporting this choice is that a suckling calf, harnessed and instrumented, should keep station with its mother and, hence, give a true migratory route.

To our knowledge five baby gray whale captures or handlings have been reported. Eberhardt and Norris (1964) report working with a stranded baby gray whale in Scammon's Lagoon. Robert Elsner (pers. comm.) detailed a capture of a baby gray whale in Scammon's Lagoon from a small catamaran by use of a superficial harpoon followed by netting. David Kenney (pers. comm.) directed the capture of Elsner's animal and the capture and transportation of Gigi, the gray whale calf caught in Scammon's Lagoon and held for 12 months in Sea World. The latter whale was captured with a tail noose from a small fishing vessel equipped with a bow plank. The ship was reportedly damaged slightly by the mother when the baby was brought alongside. Theodore Walker (Cousteau, 1972) is shown manipulating a stranded baby gray whale in circumstances much like those discussed by Eberhardt and Norris (1964). Spencer (1973) reported on the drug-assisted capture of adult whales in Scammon's Lagoon.

THE STUDY SITE

We chose northern Magdalena Bay, Baja California Sur, Mexico, near Boca de Soledad for our work because of an abundance of whales living in a system of shallow bays and rather narrow channels and because

Kenneth S. Norris and Roger L. Gentry are associated with the Coastal Marine Laboratory, University of California, Santa Cruz, Santa Cruz, CA 95064.

the Mexican government has recently declared the better known Scammon's Lagoon (Laguna Ojo de Liebre) a whale reserve. Headquarters were established in the small government cannery town of Lopez Mateos, which fronts on the main lagoon channel 8 km southeast of Boca de Soledad (Figure 1).

In this region the channel is about 800 m wide and averages 11 m deep in mid-channel. To the west a low ridge of dunes separates the lagoon from the sea. The shore along the dunes drops precipitously into deep water. The eastern bank is typically bordered with dense mangrove thickets often cut by shallow bays and channels. The shore along the mangrove coast usually shelves gradually over a broad tidal flat to the main channel. This difference in bottom contour proved crucial to capture and harnessing.

While whales were found throughout the deeper parts of the channel, one concentration occurred just inside Boca de Soledad and another occurred at a broad expanse of water just north of Colina Coyote (see Figure 1). It was here, or somewhat closer to Lopez Mateos, that our captures took place. Our counts showed approximately 86 whales in residence in the entire channel system. Most were mothers and young, but a few males were present, as indicated by copulations observed inside the channel.

WHALE CAPTURE AND HARNESSING

Capture of suckling gray whales proved to be rather simple, once the basic techniques were established. Four whales were netted in 3 days (27-29 January 1973). One was released because it was clearly too large for our harnesses. The other three were successfully harnessed, released to their mothers, and tracked. Capture was performed from the swordfish boat *Louson*, a 15-m vessel equipped with a 11.5 m welded aluminum pipe pulpit projecting from its bow. During capture Captain Tim Houshar occupied the basket at the end of the pulpit, while the helmsman steered from a remote station atop the crow's nest. The vessel was maneuvered behind a whale pair, attempting to place the netman in the pulpit over the animals as they surfaced to breathe. At the same time another crewman in a speedboat zigzagged around and in front of the animals in an attempt to direct and distract them. This attempt succeeded often enough that surfacing whales rather regularly allowed the pulpit to pass over them. The tendency to surface beneath the pulpit varied rather widely from pair to pair and seemed most consistent in mothers with small young.

Once a pair surfaced under the pulpit a noose of 1.25 cm nylon line was placed over the small animal's head by means of a large metal hoop cut through at its outer margin and held together inside a piece of plastic tubing (Figure 2). The rather slow speed of the whales (usually less than 7 knots) and the relatively long time they spend at the surface during respiration make this a reasonably simple process.

At this point the nylon noose which was tied to the metal hoop with light twine was pulled loose. The hoop separated over the animal and was pulled away, leaving the noose to slip back to the tail stock of the little whale. Another crewman on the pulpit pulled the noose tight over the tail stock. The noosed young took out a modest amount of line, usually less than 100 m, before the line was belayed around a Samson post. The young did not dive for extended periods (less than 1 minute) but towed the vessel for a time in this position. The mother always stayed in close attendance, often sliding over the line or coming up underneath it. At times she lifted the young on her snout or back, and occasionally she thrashed at the restraining line with her flukes.

Once the young animal began to slow somewhat, it was brought back under the pulpit by bringing in line. The mother came with it and swam under the pulpit or slightly off to the side. Never did a female attempt to hit the boat or the pulpit, though our small sample may not be representative. A head net bag of 5 cm nylon mesh, also containing a noose of 1.25 cm nylon line and similarly positioned on a hoop frame, was placed over the baby's head. Optimally this net was deep enough to extend from the tip of the snout to just posterior to the pectoral flippers. In practice our nets were too small for all but one animal and placed the noose anterior to the pectorals. Even so, the noose did not slip loose.

With lines fore and aft the young animal was severely hampered and could be pulled in rather easily by hand. During this time the boat and skiff had been maneuvering the pair toward the east bank and its shallow shelf.

Two plastic trash barrels containing the coiled head and tail lines were lifted into a waiting skiff and payed out to the restrained whale until the shallow shelf was reached. Then the lines were taken ashore and the men, usually four to six, pulled the baby sideways onto the shelf. Usually the mother's efforts were strenuous at this time, and occasionally she looped the line over her body or tail giving an irresistable pull, but always she rapidly slipped free and the baby could be towed in again. The baby was beached in about 0.7 m of water, 10 m or so from the shelf edge. The mother was unable to enter such shallow water, though she did patrol the shelf edge, and in one case partially stranded herself, seemingly in an attempt to reach the baby. Thus protected from the obvious ire of the mother, it was rather simple to

Figure 2.—Capture of the baby whale. Note hoop and noose being placed over the baby. Note also the swordfish plank which is maneuvered over the mother-young pair.

place the harness on the baby. The danger from the mother was made clear when a crewman began working within a few meters of one. The female whale lifted her tail, bent it back and thrashed the flukes around in a semicircle, horizontal to the water surface. She missed the man by quite a distance but the force of the blow was enough to send a sheet of water over everyone nearby.

The baby remained rather quiet during the harnessing process. The harness was usually slipped on under the snout and worked posteriorly to the pectorals which were then inserted through the harness. The harness was then tightened in place until snug over the baby's body. At this point, timing for harness release began as a corrosible magnesium bolt which held the release mechanism began to corrode away in salt water.

Three or four men pushed the baby back into deep water over the shelf taking care to avoid the mother. In all but one case she was nearby and quickly took up station with her offspring. In one case the mother left before the baby was launched and was a kilometer or so down the bay shore when the baby began to swim in deep water. This baby cruised quietly for a short time and then, when about 300 m from the mother, turned as if on a signal and raced toward her. The mother did the same, turning toward the baby and beginning to swim rapidly. Once they were near the mother circled the baby, thrashing the water with her flukes. It was probable that an acoustic recognition signal was involved. This young animal had been emitting short low frequency signals while stranded. Even if the young did become separated from the mother by some distance, chances for reunion remained excellent because of the restricted channels available for swimming.

In all cases the presence of the harness had no visible effect on the behavior of the mother-young pair.

HARNESS DESIGN

The harness was constructed of four layers of one-way stretch Lino 241,[1] commonly used in fabricating girdles and corsets, that permitted expansion and contraction around the whale's circumference. The two legs of each harness half (Figure 3) were attached together ventrally by "D" rings to a timed-release mechanism. Dorsally they were bolted to a curved metal plate holding the radio transmitter. Horizontal rows of grommets 5 cm apart in the heavy plastic-impregnated nylon reinforcing band at the dorsal ends of the harness legs allowed adjustments to animals of different circumferences and allowed the harness to be secured under different degrees of tension. We pulled the harnesses snug on our animals, which prevented flutter from water passing around the swimming animal and kept the harness in place during dives (the harness was 40 cm wide and 112 cm long).

The strength feature of the harness was a 2.5 cm wide by 0.6 cm thick woven nylon strap in the leading and trailing edge of each harness half. These straps, held in sewn folds of the harness, were sewn to the harness only near the ventral "D" rings, thus permitting harness and straps to be adjusted independently to the whale's circumference. The grommeted ends of both the harness itself and the strengthening straps were attached to bolts on the dorsal plate by means of knurled nuts.

A plastic cup on each side by midbody simulated an instrument housing, and a polyvinyl chloride rod sewn across the harness above the pectorals acted as a batten, preventing bunching of the harness in the anterior-posterior direction.

The timed-release mechanism consisted to two aluminum plates held together by a central spring-loaded magnesium bolt. One plate had four tapered corner posts that fit into four receptacles on the other plate. The "D" rings of the harness legs slipped over the posts and over four strong springs that assisted in forcing the plates apart during jettisoning. All tensions of the harness and nylon straps were exerted against these posts. The magnesium bolt bore only the vertical strain of a spring between the two plates.

The wall thickness of the magnesium bolt determined the interval between submergence in seawater and the time of breakage. When the bolt broke the springs forced the two plates apart and released the "D" rings from their posts. Corrosion of the bolts was insured by a central copper sleeve that promoted rapid electrolysis.

The dorsal plate to which the harness attached was constructed of 5 mm curved aluminum, designed to fit over the body contour of a baby whale. An Ocean Applied Research Model PT-202 radio transmitter was secured to the center of this plate, and a painted yellow cap moulded of high density polyurethan foam was fitted over the transmitter for flotation. Foam neoprene sheeting was glued to the ventral surface of this plate to prevent chafing the whale's skin.

To fasten the harness around the animal, the two halves, connected ventrally to the timed-release mechanism, were slid under the animal and the pectoral flippers inserted through the harness. The radio, float, and plate were placed on the dorsal midline, and each harness half was pulled tight; the appropriate rows of grommets in the harness were fitted over bolts in the dorsal plate and the nuts tightened down. Then the excess rows of grommets were cut off with a knife and the heavy nylon straps secured in place and similarly trimmed. Finally straps from the float were attached, and the calf was ready to be launched to its mother. Figure 4 shows the harness and radio in place as the released calf joins its mother.

[1] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

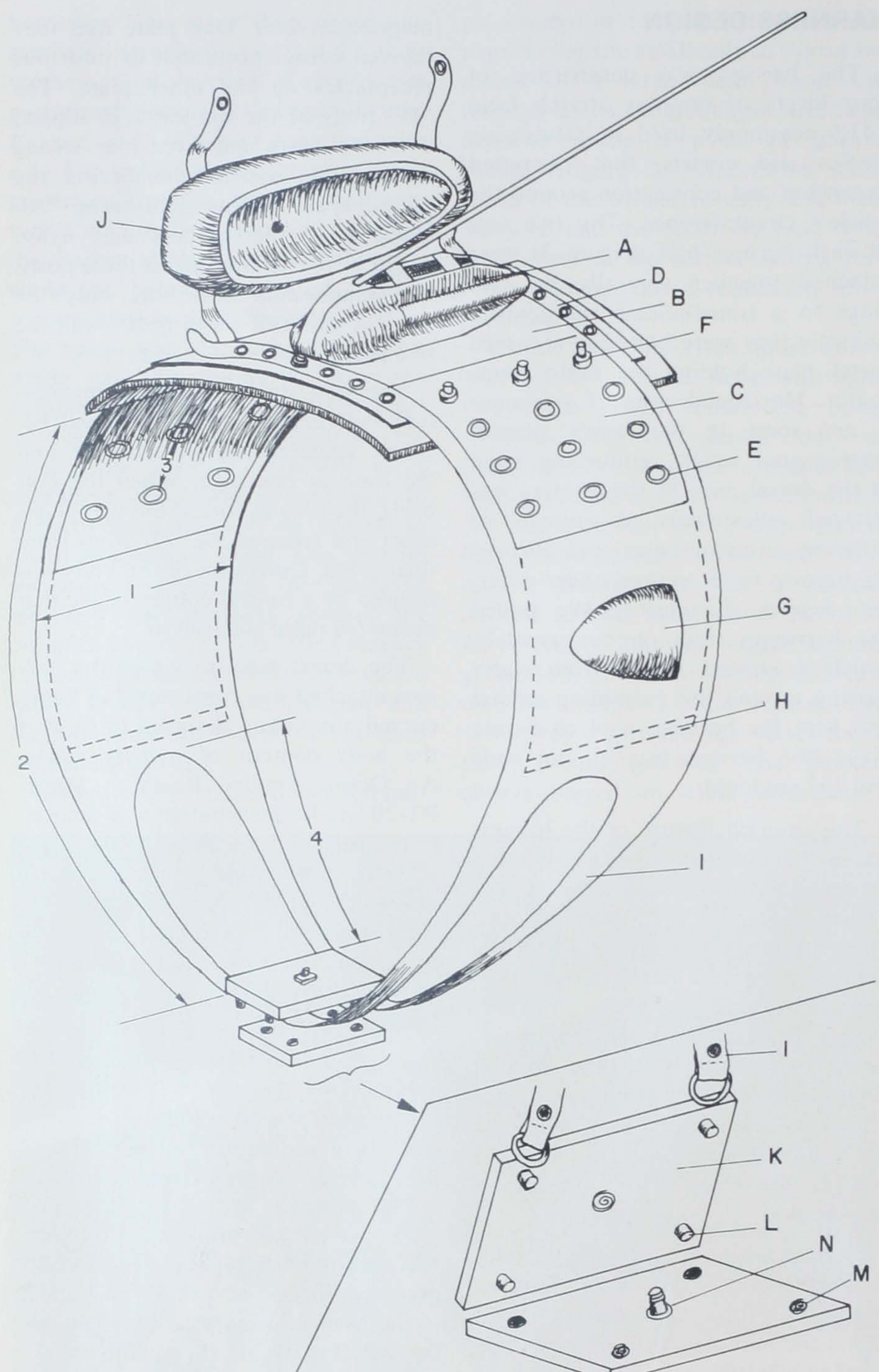

Figure 3.—The harness, radio transmitter and timed release mechanism: (A) OAR PT-202 radio transmitter (B) 5 mm curved aluminum dorsal plate (C) Plastic-impregnated nylon reinforcing sewn on harness of Lino # 241 material (D) Nylon reinforcing strap sewn into harness and bolted to dorsal plate (E) Rows of grommets (F) Knurled nuts holding harness to dorsal plate (G) Instrument housing (H) Polyvinyl chloride batten (I) Harness legs with "D" rings (J) Polyurethan flotation device attached by straps to dorsal plate (K) Timed-release mechanism (L) Aluminum corner posts to which "D" rings of harness legs attach (M) Receptacles for above posts—spring loaded (N) Magnesium bolt passes through spring loaded hole in top plate and secured with a nut.

Dimensions: (1) Harness width 40 cm (2) Harness length 112 cm from timed—release mechanism to first row of grommets (3) Distance between each of five rows of grommets = 5 cm (4) Length of harness legs 40 cm (5) Timed release mechanism 10 × 15 cm.

TRACKING AND HARNESS RECOVERY

The three harnessed whales remained within a few hundred meters of their release points (see Figure 1). Visual tracking in daylight was greatly assisted by the bright yellow float and upper harness which were visible even a foot or two underwater.

In the first release, after some time in the water, the calf swam purposefully toward the *Louson*, turned on her side, and rubbed the harness against the hull and keel of the boat—breaking the float partly loose, releasing one "D" ring, and snapping the fiberglass radio antenna. Transmission of radio signals immediately ceased. This damage could have been prevented by our maintaining a greater distance from the harnessed animal. The timed-release mechanism contained a 5-hour bolt which had not released by the time darkness fell. The harness was recovered 2 days later in vegetation along the channel edge, about 2 km from the release point.

The second release, timed for somewhat less than 5 hours, went flawlessly, including radio tracking and harness release.

The third release was planned for 20 hours, with tracking overnight from the *Louson*. To assist after dark should the radio malfunction, a waterproof lifejacket light was fixed to the float. Though both radio and light functioned at release, they failed before

Figure 4.—Mother and young swimming with harness and radio in place.

dark, and the animal was lost during the night. However, shortly after dawn the released harness was found floating within 60 m of the vessel. Details of these releases and trackings are presented in Table 1.

Table 1.—Harnessing and tracking of gray whale calves.

Date	Animal number and name	Sex	Girth (m)	Length (m)	Planned bolt life (hr)	Netting to beaching (min)	Beaching to release (min)	Tracking
1/27/73	(1) Carl(a)	F	2.41	4.80	5 ±	30 ±	37 ±	4 hr, 45 min track, release time uncertain
1/28/73	(2) Lee	M	2.17	4.20	5 ±	18 ±	14 ±	3 hr, 16 min
1/29/73	(3) Baja	F	2.51	5.16	20 ±	28 ±	8 ±	17 hr, 23 min to harness recovery. Time to release uncertain.

DISCUSSION

The capture methods described here for suckling gray whales are remarkably effective and simple. Except when the mother is under the pulpit or at the edge of shallow water, the methods seem relatively safe. Given enough shipboard power the noosing methods would work with larger animals, though the sheer bulk of an adult would make any movement by the whale, purposive or not, dangerous. This would certainly be a prime consideration in any attempt to affix a harness on an adult.

The harness described here would, with minor modifications, serve nicely for short-term tracking and instrumentation of small gray whales. Because a whale attains 66-72 percent of its adult size in the first year (Rice and Wolman, 1971), growth during the first months is extremely rapid. Harnesses for periods of more than a week must therefore include a device that allows for growth but also keeps a constant tension and locks if the animal rubs the harness against underwater obstructions.

Another concern on any long-term track is abrasion of the harness. The purposive rubbing of whale No. 1 against the capture ship and its mother caused damage to the radio antenna and serious abrasion to the lower harness legs. On whale No. 2 the abdominal legs of the harness were abraded through the girdle fabric and into the flat nylon strap in several places, even though the animal wore the harness for only 3 hours, 16 minutes. Behavioral observations suggest that much harness wear results when the baby rubs against the barnacle-covered back of the mother and slides to one side as she surfaces. None of these problems was more than very minor in these tests. But clearly long-term tracking with increased exposure to obstacles along the migratory path will exacerbate these problems greatly. More durable materials, such as metal or the strongest fabric, and more resilient radio antennae will be needed for successful long-term tracking.

The release mechanism dependent upon magnesium bolt corrosion worked adequately, but variations in water temperature and salinity could unpredictably alter release time. Long release times (more than a week) may require a new system, such as the use of electroexplosive or electronic release mechanisms that might allow an operator to release the harness upon command.

Harnessing is probably the least injurious means of attaching instruments to cetaceans, and harness placement around the pectoral flipper area is probably optimal. Pectoral placement insures maximum exposure of the antenna, minimal body movement during swimming, and relatively little change in girth during diving. Further, when physiological data are to be taken, most important vital areas (lungs, heart, brain) are nearby.

In our opinion package volume could be relatively high, providing it is weight compensated until nearly isostatic. A baby whale might well carry 15-20 kg of instruments properly housed and shaped to reduce drag. Instrument placement is probably best just above or between pectorals where it would cause the least disequilibrium. In these positions it would be most difficult for the whale to rub the instruments loose. Any such package, of course, would have to be strongly protected from impact and abrasion.

The harness used here was designed with a float at the top to suspend the antenna with the harness hanging below so that when cast off it rode easily with the antenna in the vertical position for good transmission.

In conclusion, the first steps of whale capture and instrumentation have been taken, but much remains to be done to transfer the methods to (1) long term trackings, (2) other species which must be caught and handled at sea, and (3) adult whales.

ACKNOWLEDGMENTS

Permission to study the gray whale came from both the Mexican and United States governments, and many people helped. Prominent were Carl L. Hubbs of Scripps Institution of Oceanography; George Gross, U.S. Fisheries Attaché, U.S. Embassy, Mexico City; and Philip Roedel and Robert Miller of National Oceanic and Atmospheric Administration, U.S. Department of Commerce. We thank our willing and skillful field crew: Captain Tim Houshar and the crew of the *Louson*, Richard Pierce, Kenneth Balcomb, and Thomas P. Dohl of the University of California, Santa Cruz; Gerald Kooyman of Scripps Institution of Oceanography; Robert Gibson of the Franklin Institute Research Laboratories, Philadelphia; José Castelló of the Consejo Nacional Ciencias y Tecnologĩa, Mexico City; and Jaime Domĩnguez and Mario Camparán of the Escuela Superior de Ciencias Marinas, Ensenada, Baja California Norte, Mexico.

We thank Frank Brocato for consultation on whale capture and for constructing much of our gear.

We are especially grateful to Edwin Janss and Richard Wheeler of the Janss Foundation for support of the field study. A National Aeronautics and Space Administration subcontract No. 23196 (NASA NAS2-6860) allowed harness preparation.

LITERATURE CITED

Anonymous. In press. Report of Working Group on Bio. and Nat'l. Hist. *In* W. E. Schevill (editor). The Whale Problem. Harvard Press, Cambridge, pp 5-10.

Clarke, R. 1957. Migrations of marine mammals. [In Engl. and Norw.] Nor. Hvalfangst-Tid. 46:609-630.

Cousteau, J. Y. 1972. The whale. Mighty monarch of the sea. Doubleday & Co., Garden City, 304 p.

Eberhardt, R. L., and K. S. Norris. 1964. Observations of newborn Pacific gray whales on Mexican calving grounds. J. Mammal. 45(1):88-95.

Rice, D. W., and A. A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). Am. Soc. Mammal., Spec. Publ. No. 3, 142 p.

Spencer, M. P. 1973. Scientific studies on the gray whales of Laguna Ojo de liebre (Scammon's Lagoon), Baja California, Mexico. Natl. Geogr. Soc. Res. Rep., 1966 projects, p. 235-253.

MFR Paper 1059. From Marine Fisheries Review, *Vol. 36, No. 4, April, 1974. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.*

Opposite.—Gigi II, with transmitter affixed to back, awaits release at sea off San Diego. Photo by J. S. Leatherwood, courtesy of Naval Undersea Center, San Diego, Calif.

☆GPO 799-418