BEHAVIOR OF CALIFORNIA GRAY WHALE, *ESCHRICHTIUS ROBUSTUS*, IN SOUTHERN BAJA CALIFORNIA, MEXICO

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ABSTRACT

Mother-young pairs of the California gray whale, *Eschrichtius robustus*, have been studied by a variety of means, including direct observation in calving lagoons from shore and ship, from aircraft, and by attachment of jettisonable instrument packages to calves. Instrumented whale pairs were tracked inside the lagoon, and one pair was followed for 63 h as the animals left Magdalena Bay and moved southward along the Baja California coast 213 km at a traverse rate of 3.4 km/h.

Mother-young pairs far back in the calving lagoon were found to move toward the deepest nearby water available on the outgoing tide, returning again after low water had passed. Aerial behavior consisted of breaching and spying out. In a breach the leaping animal rose two-thirds or more of its length from the water, falling back on its side. In our observations breaching seemed associated with the presence of males. Spying out was much more leisurely and often seemed to involve an animal with its flukes on the bottom, forcing its head out of the water. Contact between mothers and calves was very common; the calf often slid over the body of the mother and was lifted by the mother in conditions of stress. Floating whales seemed to be supported by inflated lungs which spread the loose rib cage apart producing a very flat cross-sectional profile. The spout was of seawater and it is speculated that part of its volume comes from water entering the nostrils as they open. Whales were observed grubbing in the bottom both in and out of calving lagoons, but feeding was not definitely confirmed. Mating was concentrated at lagoon mouths but some sexual behavior was noted inside lagoons. Female whales were found to be aggressive when their calves were disturbed, thrashing sideways with flukes at intruders, or attempting to hit a vessel with the flat of the flukes. Resonant clicks and loud broad band claps were recorded from calves as they were released to their mothers.

Pacific Mexican lagoons frequented by calving and breeding California gray whales, *Eschrichtius robustus* (Lilljeborg), are easily accessible by road and ship. Even so, information regarding the behavior of adults and young in these lagoons remains fragmentary. This paper describes behavior studies performed in January-February 1974 and 1975. Several methods were used. Observations of undisturbed whales were made from shipboard and skiff. Behavior was noted during capture sequences of nine young whales. Aircraft surveys were made. A set of sequential observations, principally of mother-young pairs, was made from a large dune (Colina Coyote) set on the edge of a major nursery channel. Finally, behavior of mother-young pairs was observed during radio tracking sequences on three animals. Data on diving depths and profiles, and water temperature, were also gathered during these tracks.

Captain Scammon's initial forays into Laguna Ojo de Liebre (Scammon's Lagoon) to capture whales resulted in the first record of the California gray whale from these lagoons, though the nature of his work certainly imposed disturbances that masked much behavior. Little was added for nearly a hundred years. Initial population counts were begun for the entire eastern Pacific population by Hubbs (1959), extended by Gilmore and Ewing (1954), Gilmore (1960a, b), Hubbs and Hubbs (1967), and Rice and Wolman (1971) and finally by Henderson (1972) and Gard (1974). Gilmore et al. (1967) added information about calving along the Sonora coast.

These studies revealed information regarding distribution of age-classes in the calving lagoons and features of behavior such as respiration, diving, swimming speeds, and aerial behavior.

Other studies have touched on several aspects of gray whale life. Huey (1928) and Wyrick (1954) gave field descriptions of behavior. Acoustic studies in Laguna Ojo de Liebre have been made by Eberhardt and Evans (1962), Poulter (1968), and Spencer (1973), while more general studies of mother-calf behavior have been made by Walker

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(1962) and Eberhardt and Norris (1964). Studies by White and Mathews (1956) and Spencer (1973) have given some information about physiological functions of the whales.

Henderson (1972) has reviewed historical data on the eastern Pacific gray whale fishery and speculated about previous distributions of numbers in the breeding population.

The capture of the suckling gray whale calf, Gigi, and her subsequent captivity and release revealed several new aspects of young gray whale behavioral and physiological biology. The various studies performed on Gigi were collated and edited by Evans (1974a).

Rice and Wolman (1971) have summarized data from all parts of the migratory path and their studies of 316 whales captured off San Francisco provide the best information on reproductive cycles and what might be called the migrant procession. They described the sequence occupied by various age and sex classes in the migratory column (see also Sund et al. 1974 and Leatherwood 1974).

The study reported here will draw from these works and add further information on feeding on southern grounds, mating, aggression, mother-calf relations, aerial behavior, respiration, and tidally related movement.

MATERIALS AND METHODS

During 1974, capture and tracking exercises were carried out using the 45-foot swordfish boat *Louson* under the direction of Captain Tim Houshar. In 1975, captures were performed from the *Orion* (Captain Peter Zimmerman) and tracking performed on the Scripps Institution RV *Dolphin,* a 95-foot motor vessel.

Tracks were performed using Ocean Applied Research (OAR) tracking radios, model PT-219, equipped with lithium batteries that generate a pulsed 50-ms/s signal each time the antenna rose above the surface.[4] Because the whip antenna had been broken on one radio when a young whale rubbed against the capture vessel during 1973 work, a flexible antenna equipped with a spring base was substituted in 1974. This minimized such antenna damage. Signals were processed with an OAR automatic radio direction finder and plotted on a strip chart recorder. In 1974, a multichannel sensing and digital recorder system developed by the Biotechnology Laboratory of the Franklin Institute, Philadelphia, Pa., was used to record water depth (pressure) and water temperature.

In 1975 a pressure recorder (TSK depth recorder, 0-1,000 m model) was used to record maximum dive depth.

Harnesses used in both years consisted of a stretchable nylon fabric harness, reinforced at appropriate points with heavy nylon straps. This material was fastened to a curved aluminum back plate which was protected beneath with neoprene sheeting to minimize abrasion to the animal (see fig. 3, Norris and Gentry 1974). Instruments and the tracking radio were mounted on the plate. A syntactic polyurethane foam float was molded to fit over these and painted bright yellow to aid visual sighting. This float provided about 0.5 kg of positive buoyancy to float the harness after jettisoning.

Release was achieved by two means. First, soluble machined magnesium bolts were used to give timed release of up to 6 days duration. One release during the 1975 expedition used a crystal timed explosive bolt system backed up by a soluble magnesium nut. The timing circuitry, which used a serially charged capacitor bank, released early because of a faulty magnetic switch.

The 25-m sand hill of Colina Coyote provides a fine site for observation of undisturbed whales. From it an observer can see a stretch of channel approximately 5 km long. Often animals within the area could be identified individually by scars and marks. Details of behavior such as spying out, respiration, and other features were observed (Figure 1).

This dune appears to be just north of the southern limit of most whale movement in the Boca Soledad area. A moderate number of animals passed the dune and swam a kilometer or so south toward the north end of Devil's Bend, a narrow winding channel flanked by tidal flats that ultimately connects to upper Magdalena Bay. During our observation period, we sighted no whales swimming into the narrow channel itself.

The channel in front of Colina Coyote is approximately 1,200 m wide, is bordered on both sides by tidal flats of variable width, and has a central channel of rather uniform depth, varying from about 8 to 10 m. Various landmarks were named by our observation team to permit easy notation and reference and are noted in the inset of Figure 1. A camp was established behind a small

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

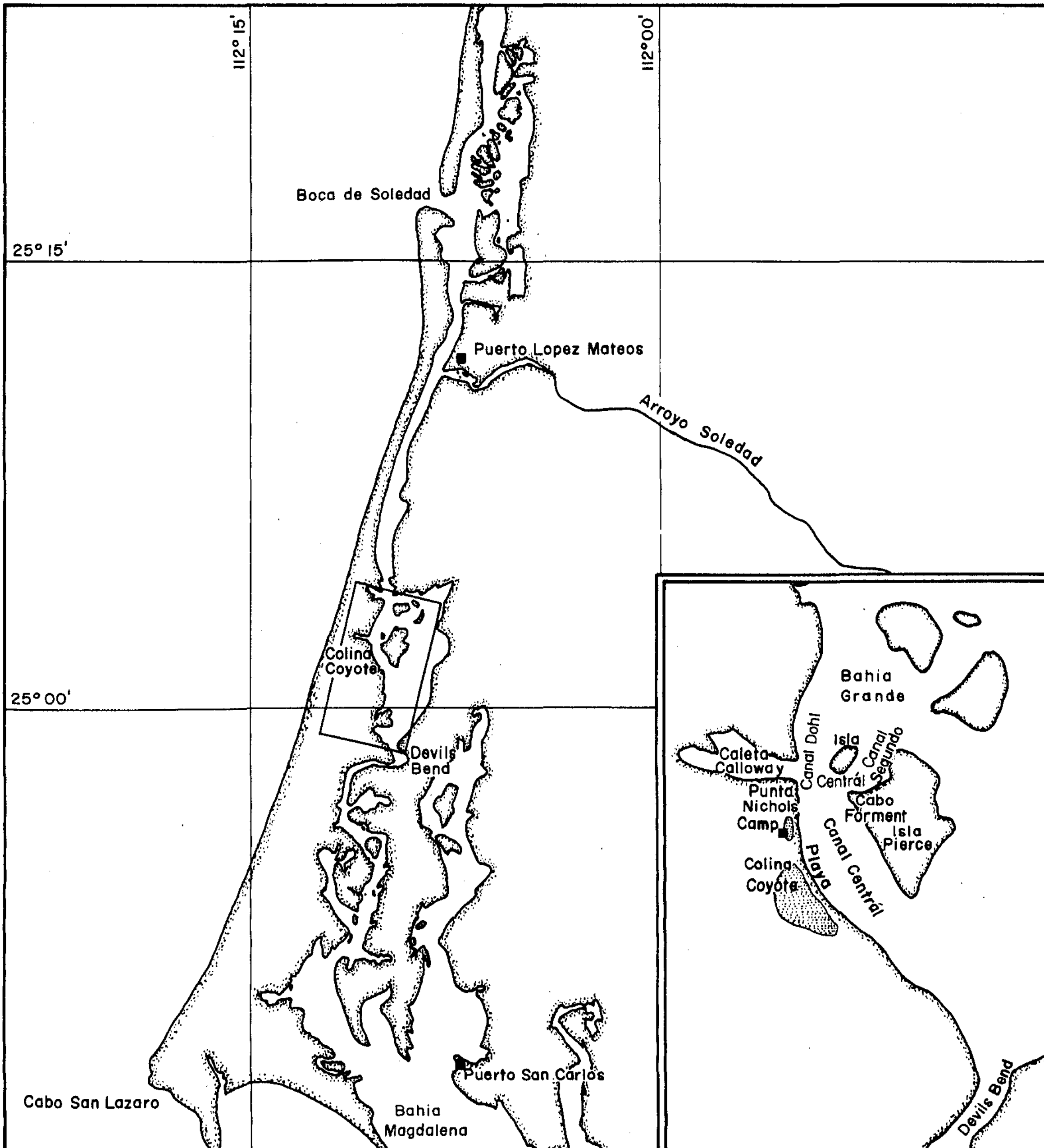

FIGURE 1.—Chart of the capture and study areas in Magdalena Bay area of Baja California Sur, Mexico. Calves were captured in the channel off Puerto Lopez Mateos, at Colina Coyote, and at Puerto San Carlos. Inset map shows area around Colina Coyote, where most observation was done, with names of topographic features given by the study team.

sand hill nearby to prevent undue disturbance of whales in the adjacent channel and to allow easy access to the top of the dune.

A standard assemblage of telephoto-equipped still and moving picture cameras, a spotting scope, binoculars, and watches was used in recording. Nighttime observations were assisted by use of a Zoomar image intensifying night vision scope.

Watches were kept with two observers each and daily observation of tidally related movements and other features were made. Observations of aerial behavior, sound, respiration, and the relationship between mother-calf pairs were made. The sound recording system consisted of an Atlantic Research Corporation LC 32 hydrophone, with a response of ±4.0 dB over 0.1-100 kHz, a Hewlett-Packard 466A amplifier, and a Uher 4400 Report Stereo tape recorder with an upper flat frequency response of approximately 20 kHz at 7.5 ips. Signals recorded above 20 kHz are, at best, nonquantitative indications of energy at these levels and may also be instrumental in nature (i.e., the result of ringing in one or more parts of the system).

Counts of whales and their distribution were made both from shipboard and from aircraft.

RESULTS

Tracking Studies

Tracking experiments were designed for a maximum of 6 days and were intended primarily to test logistic systems and instrumentation for longer tracks. Nonetheless, examination of the data provides some insights into behavior in and out of the calving lagoons. Two animals were equipped with radio packs and the depth/temperature tape recorder units in the 1974 test series. (Details of the data system are in preparation and will be reported elsewhere.) The first whale calf (a 5.6-m total length male) was caught in Bahia Grande south of Lopez Mateos on 31 January 1974. During capture, its mother repeatedly rose beneath the captive which slid to either side off the rising body of the larger animal. The adult made no attempt to entangle the restraining line, nor was there any aggression noted toward the collecting vessel, which sometimes approached within approximately 15 m of the struggling pair. The animal, restrained by a single head noose that had cinched tight anterior to the pectoral fins, proved to be extremely strong and required 25 min of concerted effort by eight men to beach it. The harness was attached and the animal was quickly returned to the mother who patrolled in the nearby channel. This pair stayed in the lagoon for approximately 4 days. They first moved northward toward Lopez Mateos and then turned and swam southward through Bahia Grande, past Colina Coyote, and into the narrowing channel area north of Devil's Bend. They, however, did not enter this narrow (approximately 50 m wide) channel. Aboard the tracking vessel, we noted that the animals were effectively in a cul-de-sac, and that they would probably have to move northward to leave the lagoon via Boca Soledad. The vessel was therefore moved northward and moored near the fishing village of Lopez Mateos. During the night, the whale pair swam from Devil's Bend to Lopez Mateos (22 km) and passed the anchored vessel, stopping at a moderate-sized bay just inside Boca Soledad. The next day the animals returned downchannel past the vessel disappearing into the region of Bahia Grande where radio contact was lost. It was correctly assumed that they would not pass through Devil's Bend, but instead would remain in these southern channels. The collecting crew then caught a young female whale and instrumented it. This calf and its mother immediately moved northward out of the lagoon, through Boca Soledad, and began an ocean traverse southward just offshore of the barrier dunes. The crew was able to follow the pair by shipboard direction finder over the intervening dunes of Isla Magdalena for approximately 33 km south of Boca Soledad when contact was finally lost. That night the first cow and calf again came upchannel and passed the anchored vessel at Lopez Mateos moving toward the entrance at Boca Soledad. It is surmised that somewhere in this region the calf's harness cast loose, since a continuous signal was intermittently received. Only when the vessel moved into the Boca itself, clear of intervening sand hills, was the signal reacquired fully. Directional signals indicated that it was located approximately in the middle of the Boca, and probably washing back and forth with each tide change. It was later recovered on the beach 3 km north of the Boca, its instruments intact and operating.

For the 1975 tracking study a 5.3-m male calf was captured directly in front of Puerto San Carlos in upper Magdalena Bay, stranded on the beach south of the main pier, harnessed and released there. When released at 1105 h on 5 February, mother and calf reunited quickly and began moving rapidly toward the main part of Magdalena Bay. The pair skirted along the 20-m contour of the main bay until deeper water at the bay entrance (along Punta Redondo at the north tip of Santa Margarita Island) was reached at 0200 h, 6 February. The pair went directly into deep water past the point, out at least to the 100-m contour before curving back toward shore again at 0600 h. The depth recorder on the calf later showed that the animals dove to or near the bottom during this traverse (maximum recorded depth 110±10 m). The impression given by the track at this point is that the animals were navigating to some extent by diving to the bottom and when the water deepened they turned for shallower inshore water. This is similar to the findings of Evans (1974b) for the instrumented whale Gigi released off San Diego which also dove to near the bottom and reached a maximum depth of 170 m.

Once near shore they skirted Punta Tosco at the southern tip of Santa Margarita Island, moving directly up the Rehusa Channel to a point off the middle of Isla Cresciente in quite shallow water at 1400 h. The animals remained there for 2 h and stayed almost constantly at the surface. Much rolling and throwing of pectoral flippers and flukes could be seen. We speculate that this interlude could have included a nursing sequence following the concerted swimming effort immediately after capture (Figure 2). After milling in the general area of Isla Cresciente at 0900 h, the pair began to move southward again, staying close inshore. At 0200 h the following night, the radio signal changed from the intermittent signal typical of a swimming and periodically surfacing animal to a constant signal, indicative of harness release. The harness was retrieved successfully at 0930 h. The track had covered 213 km in 63 h, for a traverse rate of 3.4 km/h, or 1.8 knots (2.1 knots excluding 20 ± h of quiescence) and had travelled 159 km southeast directly past the last calving lagoon on the Baja California coast.

One may speculate why the two instrumented animals that left the calving lagoon went south rather than in the expected northerly direction. The normal path at the beginning of northerly movement is not known. First, it seems possible that initial movement from the lagoon may incorporate some milling or nondirectional movement before migration begins. Second, the driving force which motivates and directs the northern migration may be involved. Is it hormonally stimulated, and timed by parturition and nursing? If so, what is the equivalent change in the male and how are these hypothetically related hormonal events related to path direction as well as to initiation of the migration itself? That is, does an animal have a general southward tendency of movement at one period that changes to north before normal migration back to Arctic latitudes? Third, could the attachment of instruments produce an initial direction aberration in path? In view of our observations of instrumented mother-young behavior within the lagoon itself, this appears unlikely, but further study of

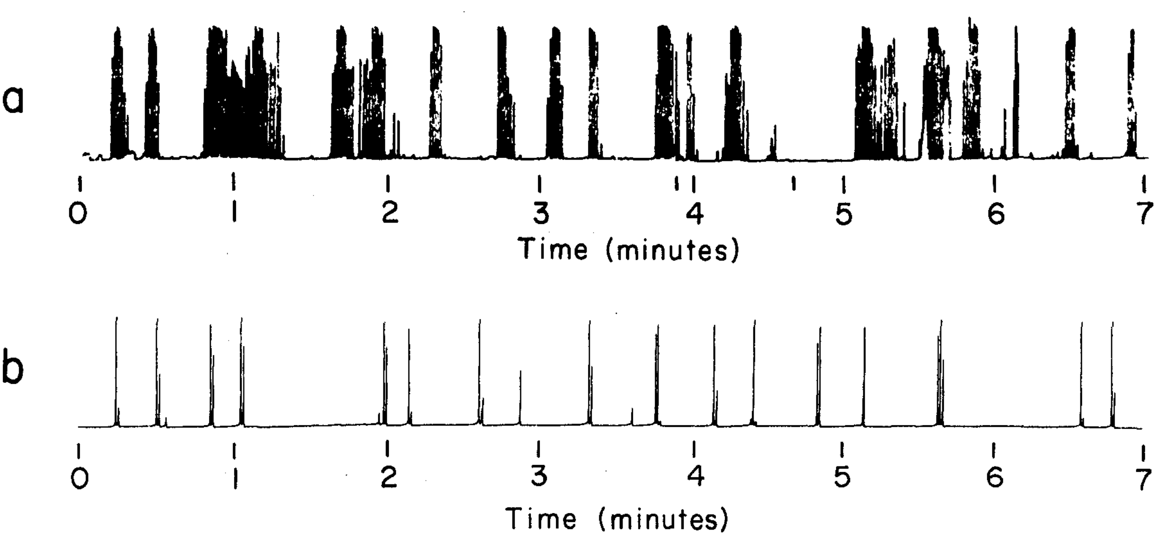

FIGURE 2.—Respiratory patterns of (a) a quiescent and (b) a swimming calf. The record in (a) was recorded off Isla Cresciente at the entrance to Almejas Bay, Baja California Sur, Mexico. This is the southernmost calving lagoon on the peninsula. The mother-calf pair lay at or near the surface in shallow water for 2 h. The repeated bouts of surface activity may represent nursing sequences. Each spike represents a radio transmission from the calf. These transmissions were given every second when the antenna broke the surface, and indicate an average of 16 s/min surface time. Amplitude of spikes varies with transmission efficiency. Time is in minutes. The record in (b) is for the same pair during normal swimming and indicates an average surface time of 3 s/min.

the initial southerly movement of both noninstrumented and instrumented animals appears in order.

Observation Studies

Behavior of Instrumented Animal — 1974

The depth record of the lagoon track of the male calf showed patterns quite different from those we have come to expect from cetaceans during radio tracking. The most striking difference was long periods (up to 3 h) when the calf apparently was at or very near the surface. Although instrumentation circuitry functioned properly in pre- and post-track tests, we prefer to wait for replicate tests to check the validity of these curious observations before reporting the results in greater detail.

Tidal and Water Depth Relations

Whales observed from Colina Coyote responded to the changing tide every day. Each time the high tide turned and while it was still high, many mother-calf pairs swam slowly northward into the extensive deeper water of Bahia Grande. Sometimes well before the tide was very low most animals would be gone from in front of Colina Coyote, with most stragglers travelling in the deepest water available (see Figure 3). The return movement began in similar fashion with the beginning of flood tide. The variation in arrival was so great that some animals did not appear until approximately high tide. Casual observations in channels in upper Magdalena Bay suggest that similar behavior may occur there, though in the deeper and broader waters of that open bay some whales were present throughout the tidal

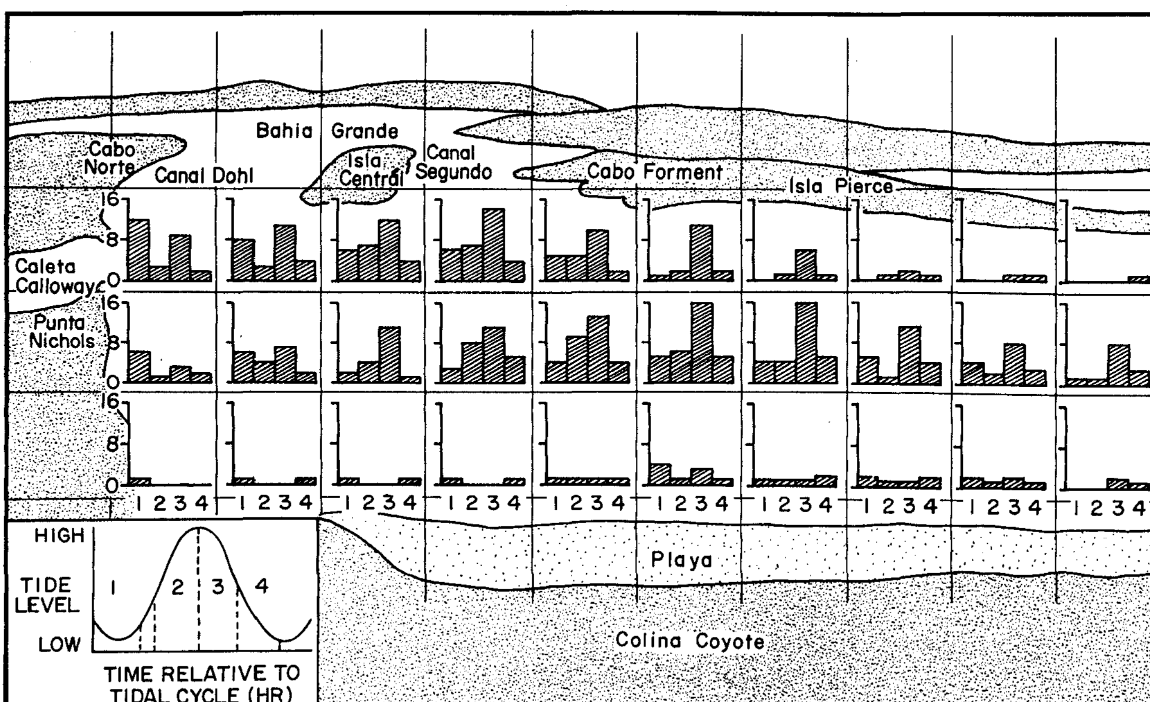

FIGURE 3.—Tidally related movements of adult gray whales in the calving lagoon at Colina Coyote, Baja California Sur, Mexico. Sketch map of waterways in front of Colina Coyote observation post showing tidally related movements of adult California gray whales. Data were acquired visually and recorded on a base map without the grid marks, as tracks against time. The grid was superimposed and an enumeration of sightings per square made for the time period involved. Animals entered or left on the turning tide, thus low tide (1) shows a concentration of animals in Canal Dohl, but also some deep in the Canal Centrál. The latter represent animals that entered the area soon after the change to incoming tide. Bars for high to 2 h after high tide (3) and 2 h after high to mid-low tide (4) reveal first a high concentration of animals coming up channel toward Bahia Grande and passing Colina Coyote, and finally a few stragglers making this passage before low tide. Animals seen in the period from medium rising to high tide (2) represent the more or less static population of animals that milled slowly in the channels in front of Colina Coyote before tidally related movement began.

cycle regardless of tide. Probably such behavior is an important means of avoiding stranding in the complicated shallower channels of calving lagoons.

Whales seldom leave the fairly deep channels, even at the highest tides. Much travel occurs along the channel edges but the animals seldom venture over tidal flats or sand bars, even those covered with 2 or 3 m of water. Occasionally, whales will venture over the edges of such flats when avoiding other whales or a pursuing vessel. The usual reaction to pursuit, however, is to seek deep water. An exception was produced by what we suppose were the pursuits of female whales by males. These chases, often involving three animals, sometimes went into water so shallow that the whales were nearly stranded. Very narrow channels are, however, avoided; we seldom saw whales traverse areas narrower than 130-140 m in width. Because the channel south of Colina Coyote in Devil's Bend is both narrow and sinuous and because we never saw whales there, we suspect it is not used and thus whales in Magdalena Bay are a separate group from those off Colina Coyote that use the Boca Soledad entrance to the sea.

Aerial Behavior

A controversy has long existed over the functions of the various kinds of aerial behavior exhibited by the gray whale (see, for example, Gilmore 1961, 1969; Walker 1962).

In our observations breaching is very different behavior from the much more leisurely spying out behavior (see also Walker 1962), and the two occur in quite different contexts. We use the term breaching to indicate a partial leap, often until two-thirds or more of the animal is free of the water, usually terminating with a rolling turn that causes the animal to reenter backward or on its side with a large splash that can often be seen for several miles. Breaches usually occur in sequences, often of three, and usually with decreasing vigor through the sequence. Gilmore (1961) reported seeing 11 breaches in a single sequence. A breach is vigorous, even violent behavior. We have watched many breaches and cannot report any being made by a cow with a calf, though Gilmore (1961) reported that mothers and calves sometimes breach. Instead, they seem to be made predominantly by rapidly moving animals that may be males or females in the company of males. It seems possible to us that such leaps represent sexually related displays, perhaps not unlike the breaches of such forms as humpback and male killer whales.

We have seen breaching most commonly at sea or in the seaward parts of lagoons where mating was common, although it was seen on three separate occasions in the deepest part of the Boca Soledad in front of Colina Coyote. On these occasions, it was performed by a swift-swimming unaccompanied animal that entered and caused some chases and agitation among the otherwise placid mother-calf pairs. Because of this creation of agitation among the nursing females, and because of its relatively small size, we suspect that it was a male.

In sharp contrast, a spy out is a leisurely event in which the animal raises its head slowly out of the water, often nearly to or slightly beyond the level of the eyes, and then slips back into the water as gravity causes it to fall slowly out of equilibrium. In shallow water, we believe spy outs are performed by an animal with its tail pressed against the bottom, and that flexing of the back forces the head out. Cows with calves often spy out, though single animals also exhibit the behavior. At Colina Coyote, spying out most often occurred in a rather tightly circumscribed sector at the edge of the channel from the middle of Isla Pierce north past Cabo Forment, Canal Segundo, and Isla Centrál, though it was seen occasionally in the middle of Canal Centrál (Figure 4). Soundings in this area showed a rather uniform depth of 8 to 10 m.

The eyes of the animals spying out were often below the waterline, and hence aerial vision was not always involved. Further, spying out was observed at night off Cabo Forment by use of a night vision scope. The observation occurred on a clear moonlit night. It is our strong impression that this kind of spy out is not related to viewing surrounding terrain or objects in air but is usually performed by nearly quiescent animals that may simply be making comfort or postural movements. We could not determine if it had any relation to nursing though we did see calves circling spying adults which suggests that nursing was not necessarily involved since the teats of the mothers were at least 6 m below the surface. The reverse behavior was occasionally seen, especially in Bahia Grande, in which an animal extended its tail into the air for a few seconds before subsiding back into the water, as if its snout was resting in the bottom mud.

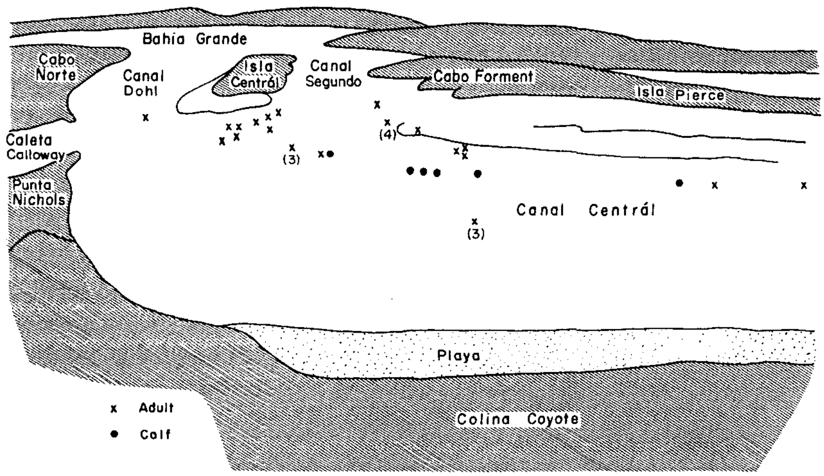

FIGURE 4.—Distribution of spy outs by adults and calves as noted from the Colina Coyote observation station.

Individual spy outs sometimes extend for rather long periods, another evidence that the animal is touching bottom at the time most of them occur. Nineteen examples ranged from 4 to 17 s duration with a mean of 7.6 s. In the longest, the animal rose from the water above the eyes, subsided until only the tip of its snout showed, and rose again to about the angle of the gape before slipping back again.

Occasionally spy outs occur in deeper water where a whale cannot be expected to touch and then the whale subsides very rapidly, just as would be expected of an unsupported animal in water.

Some spy outs do seem to involve aerial vision as has been suggested by Gilmore (1961). When an adult whale and calf are pursued, the adult may sometimes stop her flight and spy out. In one such case, the animal rose slowly and we could see its eyes. After such a spy out, the whale pair typically resumed avoidance behavior.

Of 52 spy outs recorded at Colina Coyote, 3 involved water coming from the corners of the whale's mouth. In two cases, off Cabo Forment, the released water was muddy. In one case, while the observer watched through a telescope, the whale rose with muddy water cascading out of the corner of its mouth. A similar instance was noted at Punta Tosco at the entrance to Àlmejas Bay in which an animal rose near the observer in a drifting skiff, its back toward the boat. As it rose, clear water gushed a foot out from the head from both lower mouth corners (Figure 5).

Thigmotaxis

One of the most striking behavioral attributes of mother-young pairs is nearly constant bodily contact in resting or passively floating animals. The contact seems to be solicited by both partners since the young often swims over the mother and is lifted as she raises head, body, or tail under the baby. Babies may slide over the mother from her head to her tail stock. In the course of such contact, the baby may roll onto its side or back, throwing its pectorals into the air. Lifting by the mother may force the baby calf out of the water even in a relatively quiescent pair.

In frightened animals, the lifting continues on a more violent scale as this excerpt from field notes (Norris) shows. "February 2, 1974. 1300: Bahia Grande. A calf was noosed and the line cinched tight around the pectorals. The calf was accompanied by a large barnacle-encrusted whale and shortly by another adult. They were the most violent consorts we had yet encountered, thrashing their tails and rolling over, repeatedly supporting the baby partly out of water. An attempt was then made to place a head net over the calf by inching the vessel's plank over the thrashing trio. Suddenly one flailed sideways sending a sheet of water over the bow. The head net was successfully placed and line slacked off, all three animals moving 50 m or so from the bow. Then one adult heaved its body into an incredibly powerful thrash of the tail, calf on top, causing the young animal to fly completely free of the water. Both head net and noose flew free."

On 1 February 1974 a young whale was captured and shortly after it was netted, the accompanying adult disappeared. Because we did not want the young animal to lose its parent altogether we released it as soon as it could be

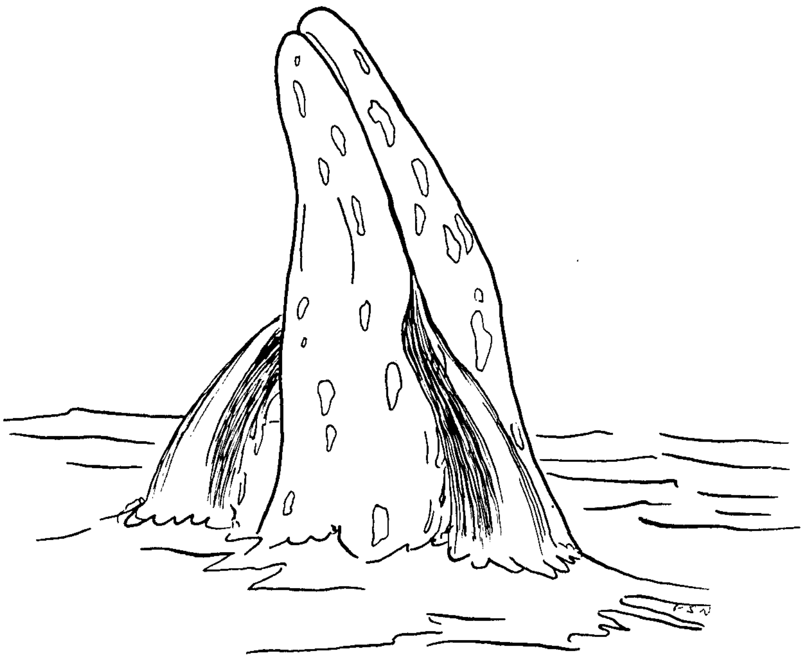

FIGURE 5.—An adult gray whale spying out at the Rehusa Channel adjacent to Punta Tosco, Baja California Sur, Mexico. Note clear water gushing from both posterior mouth corners.

brought alongside, but it refused to leave the vessel. In fact, it pressed itself up against the hull, sometimes sliding under the stem or taking up station alongside the overboard discharge from the main engine. Every attempt to push it away with oars or brooms failed until the ship was finally backed in an arc away from the animal, leaving it following in our wake. Shortly, to our considerable relief, the adult was seen surfacing alongside the young animal. This thigmotactic behavior is strikingly reminiscent of that reported by Norris et al. (1974) for a humpback whale, *Megaptera novaeangliae,* baby in which a released young also refused to leave the side of the collection ship.

From time to time mothers with calves are engaged in rather violent chases with other adults which we speculate to be males. We observed one such chase near Lopez Mateos about 3 km inside Boca Soledad. These chases can be violent with much rolling and thrashing and long high speed sequences in open water, fast enough that the animals produce bow waves of some size. In one such chase we observed a baby racing along attempting to keep station with three adults. The next day in the same area a lone baby, perhaps the same animal, was noted partially stranded. This baby, apparently completely unharmed, swam ashore until its belly touched the sloping sand of the beach. We launched it repeatedly back into deep water without avail. It circled back into the shallows despite all our attempts and did so in both directions (and because it circled in both directions we did not feel it had a middle or inner ear orientation problem). Our impression was that the baby was seeking contact and thus stranding.

Buoyancy and Respiration

Passively floating or slowly moving adults in the calm lagoon areas allowed close inspection of some of the mechanics of respiration and of the formation of the blow or spout (see Kooyman et al. 1975). In such adults, breaths were sometimes taken with a few inches of the back exposed or with just the nostrils protruding. The area anterior to the nostrils swells before air is released, and adults often seemed to straighten or arch the back slightly causing a slight upward movement of the head prior to expiration. This did not always occur as sometimes an animal seemed simply to rise slightly prior to a blow and to subside after it.

Sometimes when a wholly quiescent whale blew, it raised its head slightly with the breath and slid backwards slightly just after it. In such quiet animals there seemed to be some internal mechanism by which the animal trimmed its buoyancy. It sometimes sank slightly after a breath or seemed to bounce slightly, rising a few inches to a new resting level.

Some breaths were released underwater both in the lagoons and out, and by both adults and young, usually causing a strong boil.

The gray whale spout is obviously double if viewed in front or behind the whale and may appear single from the side. It varies from a low "mushy spout" in breezy conditions to a fairly slender column perhaps as much as 2.5 m high in very calm air.

The spout is dense throughout its height from its initial exit point at the animal's nostrils to the top of the blow, and one can occasionally see the column of rushing air "tear" at the surrounding seawater entraining it into the blow as a ragged sheet. Most times the blow seemed to start just as the animal's nostrils rose to the surface and such adjacent seawater was obviously a considerable part of the blow. Occasionally, however, a floating animal did not sink down before a blow and a spout was sometimes not produced. It is our impression that in the calving lagoon most or all of the spout involved either water entrained in the column of rushing air from the sides as the animal's nostrils broke water or from a small amount of water pooled on nostrils, or perhaps more likely from the seawater that had entered the uppermost part of the nostrils just prior to the blow. Condensation is clearly an important part of the blow of whales breathing into cold air, as in more polar latitudes, but was not in our observations within calving lagoons. Neither whales that did not submerge between blows nor stranded calves spouted.

While spouts were taller and more evident in calm morning air, they were present throughout the day and at sea. Our impression is that visibility is affected by such changing conditions but that the mechanism of spout production in this latitude (25°N) remains the same. That is to say, wind may shorten the spout and make it harder to see but most respirations at sea produce spouts regardless of time of day.

Baby whales during swimming tend to toss their heads upwards when they blow, unlike adults, and as a result respiration breaks the smooth course of their swimming. This movement is extreme enough that one can sometimes see their lower jaws rise free of the water during respiration. Adults always seem to remain more deeply submerged with eyes and lower jaws well below the surface during spouting.

Patterns of respiration are quite different in mothers and young. One young animal observed moving slowly with an adult took 88 breaths/h while the attending adult took 58 breaths/h (Figure 6).

During what we suspect might be nursing sequences by an instrumented calf, surface times were considerably longer than otherwise, averaging 16 s/min as opposed to 3 s/min in travelling young.

During steady swimming the respiratory pattern becomes more regular, generally with a sequence of closely spaced blows followed by a longer period of apnea, with this sequence repeated over and over (Figure 2) (see also Wyrick 1954).

Often, adult whales were encountered floating absolutely passively in the calving lagoon. The back from about the nostrils to the base of the tail was often exposed. In such instances we were impressed by the very broad curve of the exposed back, as if the chest of the animal had a huge

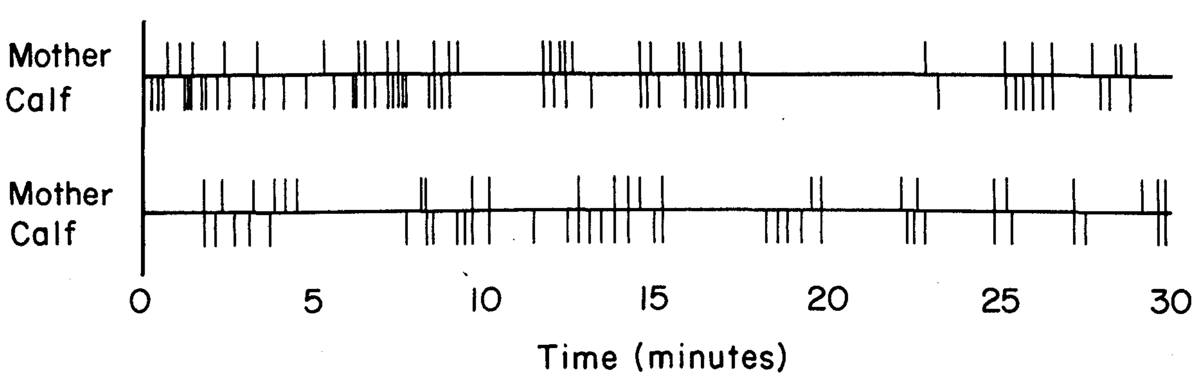

FIGURE 6.—Respiratory patterns of a California gray whale mother and calf pair swimming slowly off Colina Coyote, Baja California Sur, Mexico. Adult respirations equal 58/h; calf 88/h. Note that while initial respirations of a breathing sequence were sometimes simultaneous indicating surfacing together, often the calf surfaced first while the adult swam out of sight below the calf.

diameter. This broad abdomen narrowed immediately to the tail which seemed to be of normal diameter. In rapidly swimming animals the back often seemed much less broad. Our supposition is that in the passively floating animals the loose articulation of the rib cage allows the buoyant lungs to press the ribs outward, flattening the floating animal.

Feeding

Uncertainty exists with regard to the amount of feeding gray whales perform outside the Arctic feeding ground and especially in or near the calving lagoons. Both Gilmore (1969) and Rice and Wolman (1971) emphasized that nearly all migratory whales that have been examined had empty stomachs, while a few contained small quantities of gastropod opercula, wood, polychaetes, sand and gravel, ascidians, and hydroids. Matthews (1932) reported observations of gray whales feeding on shoals of *Pleuroncodes planiceps,* an anomuran swimming crab, or "red crab," off Magdalena Bay. Even so, Gilmore (1969:15) stated "one authoritative opinion holds that gray whales enter lagoons *primarily* to feed. The whales allegedly plow the lagoon bottoms in long furrows, exhausting first one section then another of the rich beds of eel grass and invertebrates. This opinion also asserts that the whale's high, vertical thrust of its head out of water—long considered a visual 'spy-hop'—is gravity swallowing, necessitated by his non-protrusible tongue."

Our observation of a whale spying out with mud cascading from the corners of his mouth at Colina Coyote is difficult to interpret (Figure 5). Surely the animal had grubbed in the bottom mud, but this does not assure that feeding had occurred. Nonetheless, at times we saw patches of muddy water around whales that were diving and spying out, indicating that much bottom grubbing was not isolated and perhaps common.

A more convincing observation was made by our flight observation team of Thomas Dohl and John Hall. They reported seeing 20 whales in shallow greenish water 75-300 m off the beach between Boca Animas and Boca Santa Domingo. Six of these animals were travelling slowly leaving muddy trails behind them. The trails were solid spreading wakes of muddy water and some of them were curved. They saw one whale surface and blow while continuing to trail such a wake, probably indicating that muddy water was issuing from its mouth. Their strong impression was of whales grubbing in the bottom producing the trails as they swam along. Once again we cannot be sure that these animals were feeding, but it is fair to say that probably with reasonable frequency whales in or near calving lagoons grub in the bottom mud or sand and take at least some of it into their mouths. Perhaps it is "pseudo feeding" as Gilmore (1969) suggested, but it is also possible that limited feeding does occur in or near the calving lagoons.

Population Segregation

We can confirm the long standing observation (Gilmore 1961) that at lagoons population segregation of a marked sort takes place. Mother whales with newborn young are indeed confined largely to inland waters within the lagoon systems. Single animals are rather uncommon there. Aggregations of whales without calves are common at or near entrances and in the nearby offshore waters. A considerable percentage of these animals is found in groups of two to six animals and much rolling, fluking, throwing of the pectorals, and bodily contact can be seen. Occasionally a protruded penis was noted as a whale rolled on its back and more often the perineal sheath of the male could be seen in such circumstances. Groups at bay mouths typically contained many moderate size animals, which we estimated at 10-12 m long. It seems probable that both yearling, juvenile, or young adults of both sexes and older males were involved.

All whales found south of the southernmost calving lagoon at Almejas Bay seem to represent this mixed group of males, yearlings, or nonparturient animals. The large group of animals seen around Cabo Falso and Cape San Lucas was of this type with no small young of the year being noted.

Aggressive Behavior

Gray whale aggression has been the subject of some controversy. Hand whalers reported aggression toward whale boats from animals harpooned in the lagoons (Scammon 1874). Later, some research workers have had boats damaged in encounters with whales. Nonetheless, suspicions existed that these encounters were due to the thrashings of a very large innocuous beast in shallow water. Gilmore (1969), for one, reported no aggression from unprovoked whales during his work in the calving lagoons. We can lay these suspicions to rest. Female gray whales separated from their young are apt, indeed, to be vigorously aggressive. But like Gilmore, we have never seen aggression from unprovoked whales. Two examples from our field notes will suffice.

During capture the female stays in close attendance with the young, often placing herself between the baby and the shore line party. She sometimes pressed against the young, literally yanking the line from line handlers. These thrashings increased in intensity as the baby neared the shelf and it is our opinion that the mother was very dangerous at this time. We have always taken care to work with the baby 20 m or so into shallow water where the mother could not come. She patrolled the shelf edge at this time in water just deep enough to allow her passage and she even partially stranded herself. When the baby was taken into very shallow water or far over a flat, the mother sometimes wandered away. We presume this to indicate a loss of effective acoustic communication.

During one capture a line handler allowed himself to come within a few meters of the shelf beyond which the mother patrolled. She reared up, swung her flukes laterally just at the water's edge, with sufficient force that a sheet of water was sent over the entire work party. The blow missed the nearby line handler by a couple of meters but none of us doubted that it would have done serious injury if it had hit him.

On another capture, a young animal was stranded and the scientific party had worked on harnessing the animal for perhaps 20 min when the mother wandered away. The collection vessel had been given the task of keeping the mother close to the shore party by maneuvering around her. The ship was standing by 1 km to the south and about 0.5 km off the channel edge during stranding and then moved up to within about 100 m of the shore party to herd the mother whale while we harnessed the calf. The adult disappeared below the surface for about 45 s and came up under the stern of the vessel, hitting the hull so hard that the vessel was lifted up about a meter and heeled over 25°-30° to starboard. The whale's tail swung up in the air astern, with the broadside of the flukes toward the ship and approximately 2 m of the tail extended above water. The captain put the ship full speed ahead at about 12 knots and attempted to elude the whale. The whale followed below the vessel and three times rose to hit it, swinging her flukes up above water astern even though in full chase. The vessel ran in broad circles and finally swung over fairly shallow water, and at the same time threw seal bombs into the water (firecrackers used to disperse sea lions from fishing nets). The whale moved away at this point, after a chase of 5 to 7 min. The ship was largely undamaged except for a slightly bent propeller blade. The captain felt that the fast maneuvering prevented serious damage to the vessel.

Phonation

Evidence has been accumulating in recent years that the gray whale produces a number of different sound signals, including grunts, pulses, clicks, moans, bubble-release sounds, knocks, and rasping pulses. These sound records have been reviewed by Poulter (1968) and by Fish et al. (1974), and the latter workers recorded the sound of the yearling captive gray whale Gigi. These authors suggest that the metallic pulses recorded from Gigi may have been associated with the internal flow of air bubbles, since no air was released during the sound emission. They also reported click trains released by feeding gray whales, which consisted of clicks with principal energy from 2 to 6 kHz and duration of 1.0-2.0 ms, with a click repetition rate of 9.5 to 36.0/s. Similar click trains have been recorded by us in the channel near Lopez Mateos. In addition, we can directly attribute two kinds of sounds in whale calves since both were heard or recorded directly from these animals as they lay partially out of water; these were repeated low pulses and a very loud bang or intense click.

Low resonant pulses, which were not recorded, were emitted by a stranded calf on 27 January 1973 during harnessing. Each was a second or less in duration, emitted each 2-3 s, and concurrent with such emission one could see slight movement of the animal's body surface behind the head on the lateral body surfaces. No air was released during emission. This young animal was emitting pulses when reintroduced to the bay. The mother had wandered off some 300 m down channel by this time and as the baby swam across channel, the mother was seen to throw her flukes twice and then swim directly toward the distant baby. As they met, the mother slashed the water rather violently with her flukes, circled the baby and the pair swam off together. Because of the distance involved at reentry of the calf and the rapid reunion, we assume acoustic communication was involved, perhaps the pulses mentioned above.

The sharp clicks were made by two male calves, on 2 and 5 February 1975, as they lay stranded at Puerto San Carlos, upper Magdalena Bay. Prior to click production the blowholes were pursed, giving the impression the animal was about to blow, but it did not, and no air was released. Instead it tossed its head slightly upward causing the slightly opened jaws to clap closed quickly (movement of the throat also seemed involved), at which point the click was produced. These signals were very intense and could be heard for long distances underwater; Bartley Gordon, who recorded the sounds for us, could hear them very clearly at least 500 m from the stranded animal. In each case, as the calf was released, clicks were heard before the mother and calf rejoined. Low pulses or grunts were also recorded from one animal.

In the 5 February release, the mother whale swam approximately 500 m southwest of the point at which the young was released. The baby swam resolutely down channel and the mother was noted taking up a collision course. Until the moment of contact sharp clicks were recorded, and then, as the whales met in a flurry of lunges partway out of water, the clicks ceased altogether.

These clicks vary from those recorded by Fish et al. (1974) in that we noted no long trains of closely spaced clicks, but instead sporadic signals given at a maximum rate of 2/s, but more often alone. The signals we recorded seemed to be of much higher intensity and of much broader band character than those noted by Fish and his colleagues. Further, their duration was about 0.25 s as opposed to 1-2 ms. In the sound spectrogram shown in Figure 7, a very intense broad band signal is portrayed, perhaps of frequency range extending well above the flat response band of our instrumental system (0.1-20 kHz). One wonders if these clicks bear any relation to the "earthquaking" reported by Ray and Schevill (1974).

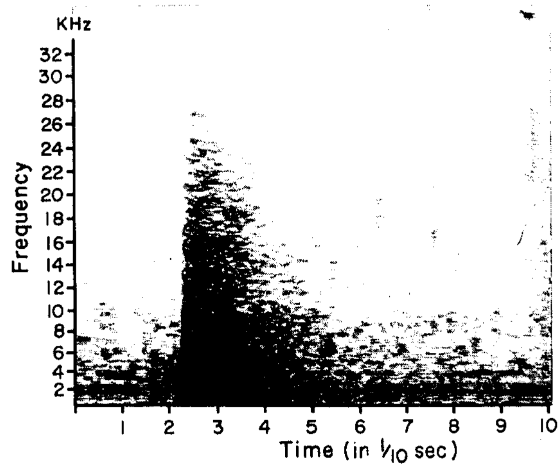

FIGURE 7.—Intense broad band "clack" emitted by a stranded gray whale calf at Puerto San Carlos, Baja California Sur, Mexico, on 5 February 1975. Effective analyzing filter band width is 45 Hz. Due to the limits of the recording system (about 1-20 kHz flat response) the signal recorded above 20 kHz indicates only some energy in that region, not its amount.

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