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GROUP BEHAVIOR OF COMMON DOLPHINS *(DELPHINUS DELPHIS)* DURING PREY CAPTURE

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RESUMEN

De 1983 a 1987 se observaron 54 asociaciones mixtas de alimentación, formadas por delfines comunes *(Delphinus delphis)* y aves marinas, al alimentarse sobre cardúmenes de peces en aguas del Golfo de California. Se realizaron cuidadosas observaciones sobre la superficie del mar y bajo el agua, para contar el número delfines y de aves marinas que forman estas asociaciones. Se tomaron muestras de las especies presa y se obtuvieron datos ambientales. La evidencia sugiere que los cardúmenes son "pastoreados" por los delfines, presionándolos contra la superficie en donde éste se vuelve vulnerable para los delfines, lobos marinos y aves marinas. Las sardinas, anchovetas y macarelas, constituyen la presa principal en esta relación oportunista, lo que se evidenció, obteniendo la regurgitación de los bobos (*Sula* spp.) y por las muestras tomadas en medio de las asociaciones de alimentación. Estas asociaciones ocurrieron en verano y otoño, de acuerdo con las zonas de surgencia y los cambios en la temperatura superficial del mar que presenta el Golfo de California.

Palabras clave: delfín común *Delphinus delphis*, comportamiento durante la alimentación, aves marinas, lobos marinos, asociaciones de alimentación, especies presa, Golfo de California.

ABSTRACT

From 1983 to 1987, 54 feeding associations between common dolphin *(Delphinus delphis)*, and seabirds were observed while feeding on shoals of fish in the Gulf of California. Careful observations were conducted above and below water; observing the number of birds and dolphins that formed these associations. Collection and identification of samples of prey species and environmental data were also taken. Evidence suggests that fish schools are actively herded by dolphins and driven towards the surface where the fish schools becomes easy prey tor the dolphins, as well as sea lions and seabirds. Sardine, anchovy, and mackerel were the main prey in this opportunistic relationship, as evidenced by regurgitation of ingesta collected from boobies (*Sula* spp.), and by samples taken in the middle of the feeding swarms. These associations ocurred during summer and fall, closely related to the changes in upwelling zones and associated surface water temperature that takes place in the Gulf of California.

Key words: common dolphin *Delphinus delphis*, group feeding behavior, seabirds, sea lions, feeding associations, prey species, Gulf of California.

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INTRODUCTION

Prey capture associations between seabirds and marine mammals (locally called "bochinches" or "big fiesta"), are getting widespread attention by scientists. These associations seem to be a very beneficial way for both seabirds and marine mammals to search for food. In the Gulf of California it is almost impossible to see feeding marine mammals without accompayning seabirds. This relationship is a form of commensalism as defined by Martin (1936), but appears to be more opportunistic than commensal. In the first stages, it is impossible to tell which group is the trigger of these large assemblages, due to the fact that either group may act as an "information center", that calls the attention of the other (Ward and Zahavi, 1973). Underwater this frenetic activity alerts the attention of other large predators such as Scombridae and Carangidae fish, and sharks.

The behavior of several species of dolphins sheds some light on the behavior of large predatory assemblages. It is well known that dolphins *Tursiops truncatus* and *Lagenorhynchus obscurus)* catch fish in a cooperative way (Würsig and Würsig, 1979, 1980; Gallo, 1983a), and assuming that the observations presented here are not incidental associations. Therefore, it is not feasible to assume that this behavior occurs incidentally. As Evans (1982) noted, "seabirds (and sea lions) benefit the most by this association because they are able to acquire food opportunistically during a feeding swarm".

MATERIALS AND METHODS

Nine cruises were conducted using Mexican Navy vessels, and the Instituto de Ciencias del Mar y Limnología ship R/V El Puma, from May 1983 to January 1987. The cruises were done in May 1983, August and November 1985, and February 1986 to the "Midriff" area in the Gulf of California; in June 1983, to the northeastern pacific of Baja California; in April 1986, to Isla San Pedro Nolasco; June and November 1986, and January 1987 to the southern Gulf of California (Fig. 1).

Observations were made from 10 m high above the water surface on the ship's bridge or in the bridge catwalk, using 8×40 and 8×50 Tasco binoculars. As soon as an active group was observed the ship was headed to join the assemblage. When possible, a 22 foot fiber-glass boat was lowered to the sea in order to follow the movements of the entire group. Fish were collected using pole nets and by snorkeling. During the observations, surface water temperature, current heading, turbidity, depth, exact location, distance to islands or coast, weather and wind direction and velocity were recorded.

Numbers an species of dolphins, sea lions and seabirds were recorded.

RESULTS

Fifty four prey capture associations or "feeding swarms" (as named by Wells *et al.*, 1981), were composed primarily of common dolphins *(Delphinus delphis).*

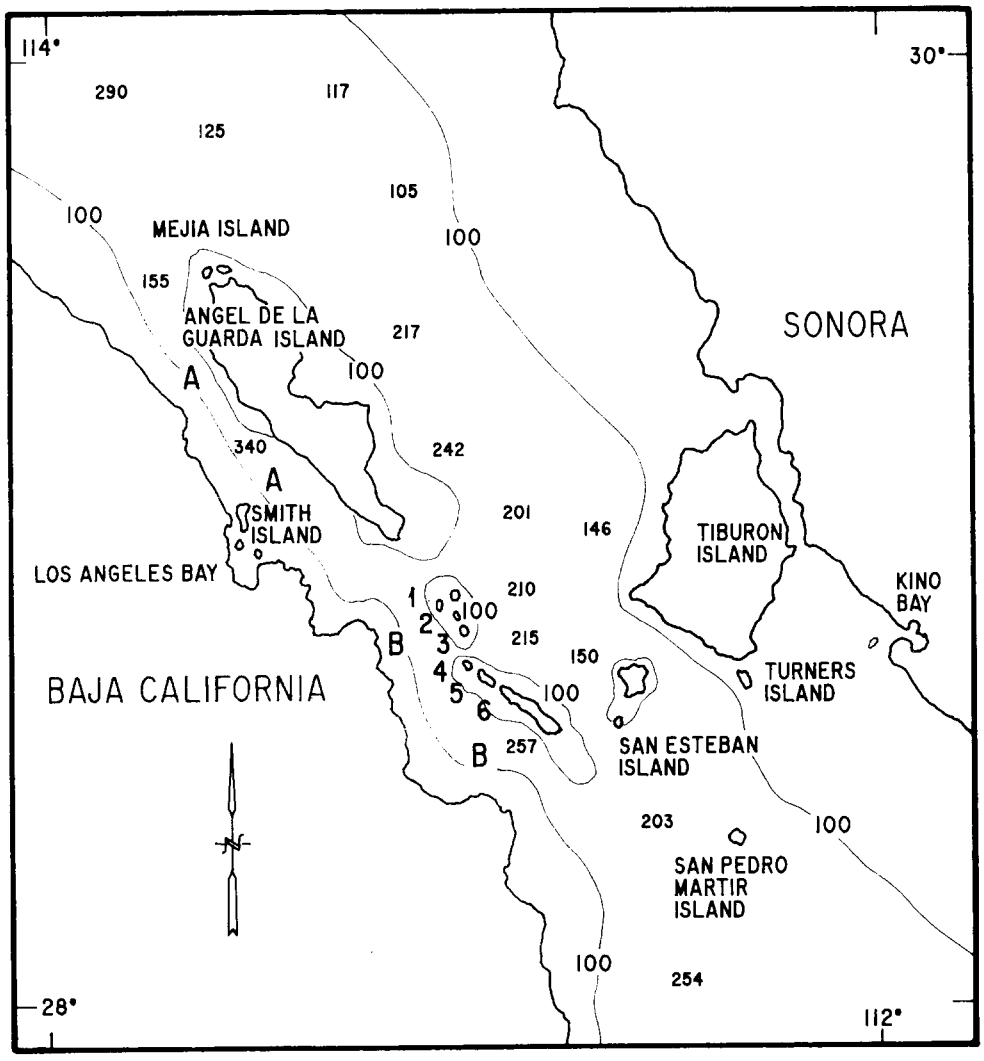

Fig. 1. The Midriff Region of the Gulf of California.

The feeding swarms ranged in size from 30 to 120 dolphins and were classified by group size: small (20-40 dolphins), medium (120-250 dolphins), large (1000-5000 dolphins). Also detected were schools of monterey sardines *(Sardinops sagax caerulea),* threadfin herring (*Opisthorema* spp.), japanese sardine *(Etrumeus teres),* anchovy *(Cetengraulis mysticetus),* Pacific mackerel *(Scomber japonicus),* and hake *Merluccius productus).* Other species involved were fin whales *(Balaenoptera physalus),* California sea lions *(Zalophus californianus),* brown and blue boobies *Sula leucogaster* ans *S. nebouxii),* brown pelicans *(Pelecanus occidentalis),* cormorants *(Phalacrocorax penicillatus* and *P. auritus),* red necked phalaropes *(Phalaropus lobatus),* petrels *(Oceanodroma melania),* parasitic jaegers *(Stercorarius parasiticus*

and *S. pomarinus),* terns *(Sterna maxima* and *S. elegans),* Hermann's gulls *Larus hermannii),* yellow footed gulls *(Larus livens),* California gulls *(Larus californianus),* large Scombridae fish *(Euthynnus lineatus),* large carangid fish *(Caranx caballus),* and sharks.

Cormorants, boobies and pelicans have an active role in these feeding associations. They dive and swim underwater to forage on the fish, competing with the dolphins, other seabirds like gull had roles less active, mainly waiting for floating chunks of fish.

Representing diet samples were obtained from neighboring nesting colonies of boobies at San Pedro Martir Island, immediately after the feeding swarm was dissolved, by causing regurgitation of the boobies, we found monterey sardines with lengths of 17 cm, and Pacific mackerels with lenghts of 22 cm; the monterey sardines catched with pole nets presented lenghts from 16 to 19.5 cm, threadfin herring presented lenghts from 15.8 to 19 cm, and Pacific mackerels presented lenghts from 21 to 27 cm, showing that boodies had a marked preference for smaller prey. The bulk of the feeding of common dolphins as observed in 54 feeding swarms, were composed primarily by monterey sardines, in second place by Pacific mackerel, followed by threadfin herring, anchovies and hake (Gallo, 1984, 1989c).

Of the 15 feeding associations observed in Salsipuedes Channel, 13 were engaged in feeding activity and two were forming by the addition of small groups (12 to 20 dolphins). One swarm was observed as it formed in May, 1983. On 8 August 1985, we observed the largest swarm composed of 5000-10000 dolphins and several thousand seabirds, on the south of Tiburón Island. On 16 November 1985, we observed one swarm from its beginning, composed of 1500-2000 dolphins; later the same day we observed the formation of another feeding swarm with 100-150 dolphins, however, the ship cut the swarm in half, causing it to disband within minutes. It is noteworthy that in 26 of 54 feeding swarms the dolphins detected the fish far away and approached them swimming at high speed and performing high jumps. Once the school of fish are located, the leaping stops and a spread formation is adopted in accordance with the behavior noted by Würsig (1979). In my observations the spread formations was an "U" shaped parabola, presumably utilized for acoustically scanning a major are and localizing the schools of either sardine, anchovy, or mackerel as has been observed by Gallo (1984).

Partridge (1982) described a similar parabolic formation made by Atlantic bluefin tuna *(Thunnus thynnus)* to increase their visual range and localize their prey, suggesting that they hunt in a cooperative manner to drive shools and surround them for feeding. Würsig and Würsig (1979) observed a 25 m separation between individuals in Atlantic bottlenose dolphins during a spread formation. I observed common dolphins in a small group, separated by 1-7 m in the "U" formation. Three subgroups joined the formation, making a medium sized group of 80-90 dolphins.

This parabolic formation could be utilized by common dolphins to acquire an optimal sonic reinforcement point (just as it happens stereophonically) of the ultrasonic sounds they emit for echolocation. This parabolic pattern would also permit a better reception of the echoes rebounding from the detected prey school, thus

enhancing the amplitude of a major tridimensional area. This would suggest a better concept of the fish spatial position and quantity, before it could be detected by the dolphins visually.

Morris and Mohl (1983) suggested the possibility that odontocete species may be able to debilitate their prey with an ultrasonic pressure wave capable of studing them and making them easy to capture. If this hypothesis is true (Zagaeski, 1987), a parabolic formation will be more effective for detection, location and orientation toward the fish school and gain in pressure and energy levels of sound in order to stun prey. In this pattern, information will be picked up more easily than in the spread patterns used by *T. truncatus,* described by Würsig and Würsig (1979). Compared with "echelon" formations, hydrodynamically, the "U" parabolic formation is disadvantageous for high speed swimming, because it generates greater turbulence in the water column while the dolphins are getting close to the fish school. Nevertheless all the dolphins observed advanced rapidly and the "U" formation lasted until the enclosing of the school. The dolphins also seemed to organize and accomplish the approach strategy to make the fish school surface, keeping it densely packed against the surface in order to obtain the maximum benefit.

A typical feeding swarm is described as follow (field notes, Salsipuedes Channel, May 22, 1983): "Common dolphins are likely to be encountered close to deep high relief areas like channels or islands, usually swimming in spread formations. Once the dolphins had detected a school of fish and are near to it, they increase their speed and the formation acquires a parabolic shape, some of them dive (at both extremes of the parabolic formation and in the center), immediately followed by the rest and reappears at 50-70 m from the point at which they initially submerged. (Murchinson (*in* Norris and Mohl, 1983) found a range of detection with a high background noise to be about 73 m in *Tursiops* sp.). The dolphins surrounds the schooli rapidly in a clockwise and counterclockwise manner, driving the fish to the surface (Fig. 2, a, b, and c). Others leap continually, head forward, and dive beneath the packed school. This activity is performed until the predator formations acquires the shape of a purse seine net. It was noticed that a subgroup composed of cows and calves remained near of the "U" formation and entered the swarm when the fish were completely surrounded (as has been described by Würsig and Würsig (1980) for *Lagenorhynchus obscurus*). Now, some fish (apparently mackerel) are seen leaping out of the water, such behavior is indicative of foraging activities by the dolphins. No "ensonifying" (after Norris and Mohl, 1983) posture could be noted due to the excessive turbidity and aggitation of the water. Minutes later a group of 16-20 California sea lions comes from the south and joins the swarm.

It seems that the sea lions were waiting for the dolphins to bring up the fish school to take advantage of their cooperative capture schooling techniques, but without collaborating in the detection or herding of the fish. (This behavior resembles that observed for Southern sea lions, *Otaria byronia,* in relation to the swarms formed by the Argentinian dusky dolphins, *L. obscurus,* as reported by Wells *et al.* (1981)).

When the fish are completely surround seabirds starts to dive toward the packed school. Boobies are hurling from altitudes of 25-30 m, falling with great speed into the center of the feeding frenzy. Pelicans are also diving. No evasive

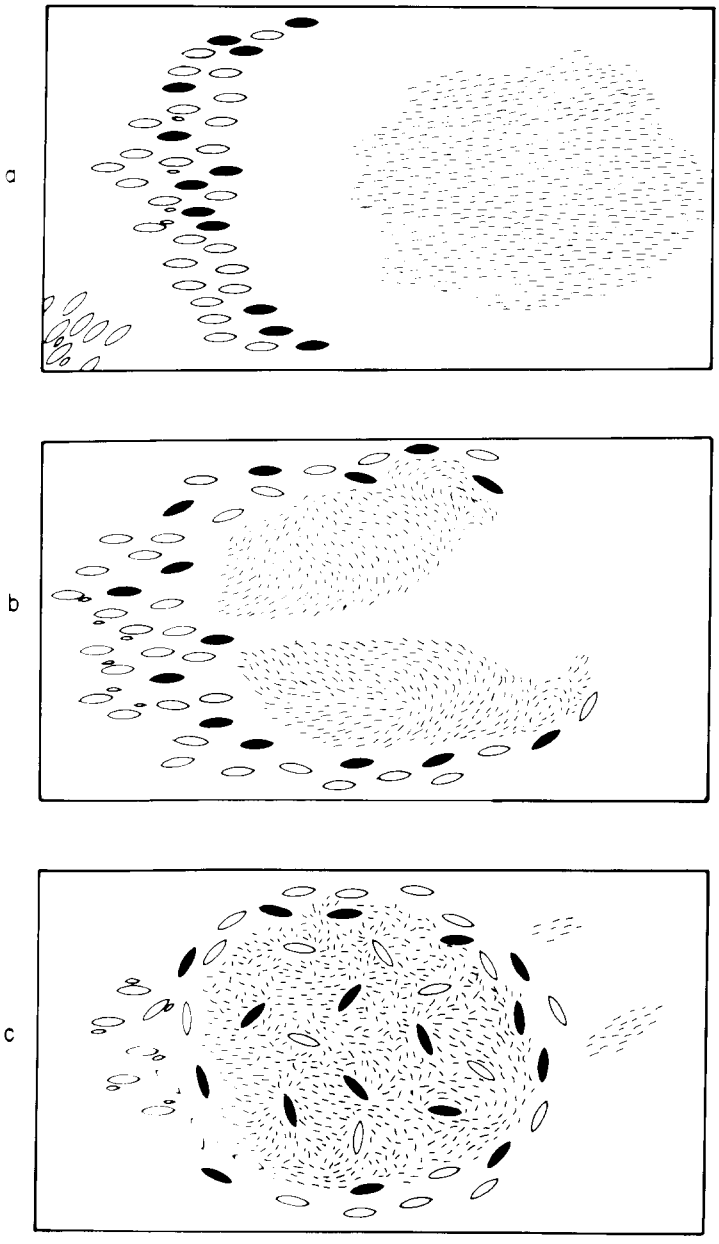

Fig. 2. Common dolphins in their advance and approach to the fish school. Shaded ovals represent diving dolphins, hollow ovals represent surfacing dolphins. 2a. Parabolic formation utilized by common dolphins for detection of fish schools. Note the approaching familiar group that will join the larger one to cooperate in herding the scholl. 2b. The school of fish try to avoid the approaching dolphins by dividing and subdividing, doing a fountain effect and performing flash expansions to outmaneuver the dolphins. (The same was noted by Norris and Mohl. (1983), in a test conducted with spinner dolphins, *Stenella longirostris* and a school of akule, *Trachurpsis crumenophthalamus)*. 2c. Finally, when the fish are surfacing, densely packed, the foraging starts.

action is taken by the birds to avoid crashing into dolphins, sea lions, or other birds. Some cormorants are continually diving. Gulls are the least active and chase the boobies making them release their prey in midair and feed upon the dropped pieces of fish. No aggresive action is shown by dolphins towards sea lions, seabirds or large fish.

After 15 minutes the swarm became quiet (similar to the feeding swarm described by Wells *et al.* (1981)), and the dolphins rested and swam at a slow pace in circular pattern. The sea lions also rested, some on their backs, with their hind flippers extended out of the water. The pelicans, boobies, cormorants and some Hermann's gulls rested on the water surface. It is possible to see fish chunks and feathers floating on the sea surface. In this assemblage no fish could be collected for identification. No reactivation of the swarm ocurred and after several minutes, participating dolphins slwoly departed in small groups".

These feeding swarms seem to have a very important ecological role as there were many different species foraging upon the same resource, including the large finback whale *(Balaenoptera physalus)* that was circling the swarm without prolonged dives and breathing slowly, but nor showing evidence of feeding.

DISCUSSION

These swarms are a model of a complete food chain as it implies the great phytoplankton and zooplankton productivity of the midriff region, with nutrient-rich water. Gilber and Allen (1943) as well as Zeitzschel (1969), agree that the phytoplankton of the midriff region is distinctly more abundant than that of the more southerly regions. The upwelling system of the Gulf of California have a well marked seasonal ocurrence: summer-fall in the eastern Gulf, and winter-spring in the western Gulf (Roden and Groves, 1959; Roden, 1964). Plankton-filtering fish are likely to be found on the nutrient-rich upwelling areas, and therir movements are closely followed by common dolphins, which numbers also varies seasonally, the larger groups were found in summer-fall, in the eastern Gulf, and the smaller groups were found in winter-spring, in the western Gulf (Gallo, 1989c).

Sardine, anchovy, and mackerel play an importan role in the ecology of this region of the Gulf of California because they represent the largest resource for the marine mammals with coastal-pelagic habitats like *D. delphis* and *Z. californianus,* and for seabirds (Anderson, 1976; Wells *et al.,* 1981; Balcomb *et al.,* 1979; Gallo, 1989c). The size of the California sea lion population in the Gulf of California numbers 20,000 individuals (Le Boeuf *et al.,* 1983). Aurioles *et al.* (1981) stated that 59% of the Gulf of California sea lion population lives in this region. Gallo (1989b) estimated the population around the midriff islands at 7237 sea lions. Fiscus and Baines (1966) related that sea lions are important predators of sardine, anchovy, hake and squid. These fish also are an important source of food to other marine mammals with pelagic habitats, such as the finback whales, which are residents in this region (Wells *et al.,* 1981; Balcomb *et al.,* 1979).

In accordance with Würsig and Würsig (1980), a cooperative feeding strategy requires complex social signs and language repertory to communicate with nearby

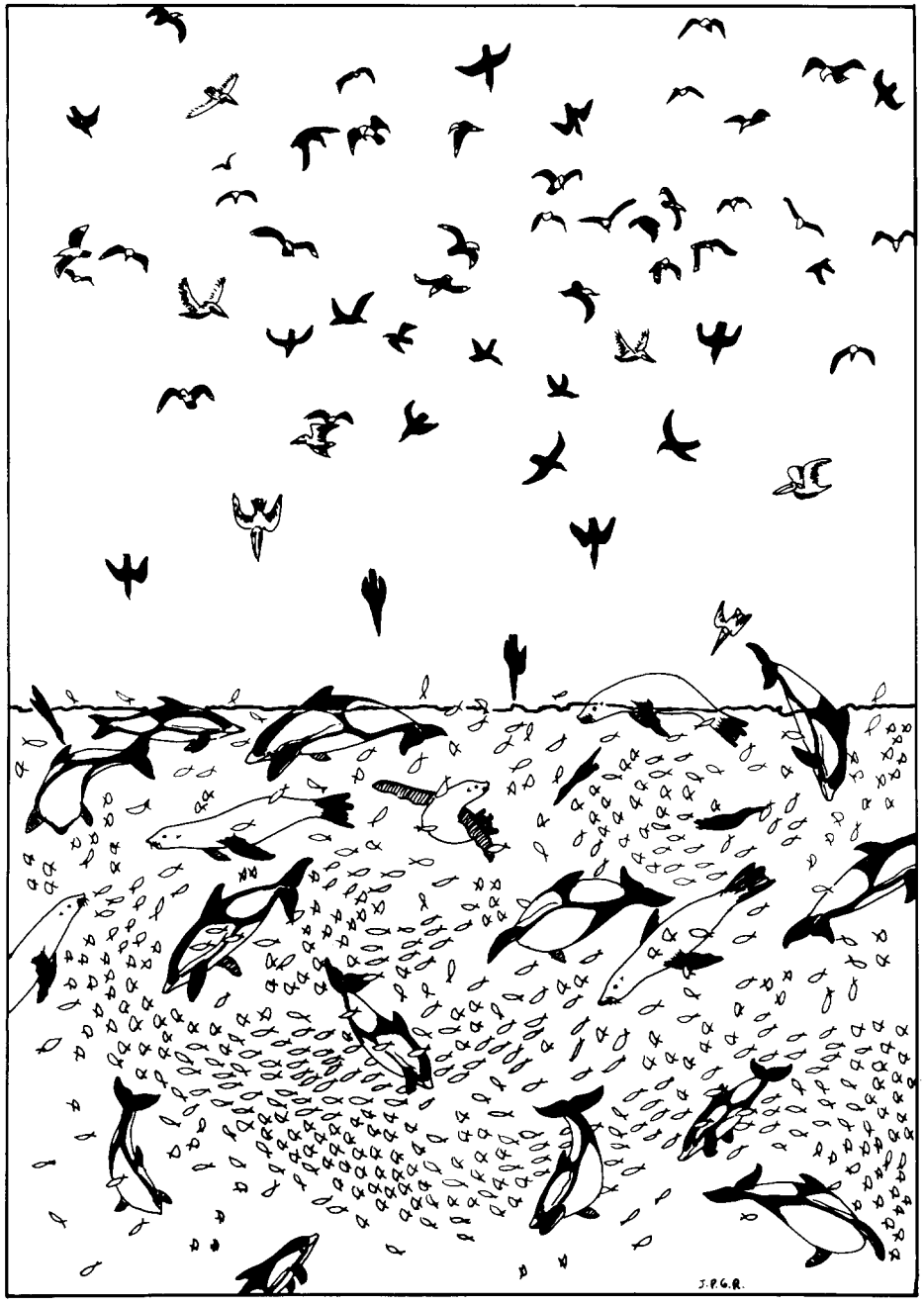

Fig. 3. A complete "feeding swarm" divided in three trophic strata (in order of importance): the first occupied by the top predators, dolphins, herding, and eating fish, and the sea lions chasing and devouring fish; the second, occupied by diving seabirds (cormorants, boobies, pelicans) and large fish; and the third, occupied by more opportunistic predators and carcass eaters like the gulls and frigate birds, waiting for chunks of fish.

conspecifics. The forms of communication used could be: noisy leaps, underwater sounds or vocalizations, and high leaps, to visually locate the swarm. This also requires a good knowledge of several items including prey aggressive and defensive behavior, habitat and seasonal movements, the depths and bottmon configuration, and neighboring land masses.

Feeding swarm formations and related dolphin behavior have been recorded for several oceans, in example the dusky dolphin and the bottlenose dolphin in the South Atlantic (Würsig and Würsig, 1979, 1980); and Atlantic spotted dolphins *(Stenella plagiodon)* associated with Cory's shearwaters *(Calonectris diomedea)* around the Azores Islands (Martin, 1986). In the Gulf of California, this behavior occurs mainly on summer and fall, I have observations of this behavior on winter and spring, but the quantity of participating dolphins are significatly small, due to the movements of plankton filtering fish and their predators (Gallo, 1989c). Villa (1976) related something close to a feeding swarm, composed of common dolphins and sea lions in the proximities of Angel de la Guarda Island. Gallo, in March 1980, sighted a feeding swarm in the proximities of Cerralvo Island, composed of common dolphins, white sided dolphins *(Lagenorhynchus obliquidens),* sea lions, boobies, pelicans, gulls and frigate birds *(Fregatta magnificens).* It was estimated to have 200 common dolphins, and 78 white sided dolphins (Aurioles *et al.,* 1980). Maravilla (February 1982, *pers. comm.*) witnessed a feeding swarm composed of 50-60 white sided dolphins, sea lions, pelicans, cormorants and gulls in the vicinity of Ballena Island in the Bay of La Paz. Wells *et al.* (1981), saw nine of these associations with common dolphins in the Gulf of California. On the Pacific side of Baja California, Norris and Mohl (1983) described a feeding swarm on the San Benito Islands, involving white sided dolphins, feeding on anchovies (*Engraulis* sp.) which were pressed against the surface where larger fish and seabirds also fed. Leatherwood *et al.* (1983), mentioned that these feeding groups (called by them "balls") of common dolphins could be found during dawn or in the evening, feeding in small groups with gulls, preying on small unidentified bait fish, seemingly to be hake, squid, sardine and anchovy which form the greatest percentages in the stomach contents of common dolphins. I found it mainly on evenings (Gallo, 1989c).

The described group behavior of common dolphins (and other dolphin species) reported here, is likely a cooperative feeding strategy that minimizes capture effort and gives great benefits to all species involved.

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