Recovery Plan for the Vaquita, *Phocoena sinus*

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13. ABSTRACT *(Maximum 200 words)*
The vaquita, or Gulf of California harbor porpoise, Phocoena sinus, is endemic to the Gulf of California. It is among the smallest and least known of the world's cetacean species. The vaquita appears to be linked ecologically to the sciaenid fish totoaba, Totoaba macdonaldi, and both species are listed as endangered under the Endangered Species Act and included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Vaquitas are caught and killed incidentally in the totoaba gillnet fishery and the species may be adversely affected by other human activities. Recently, the Mexican Government established the Technical Committee for the Preservation of the Totoaba and the Vaquita to organize, evaluate, and coordinate efforts to protect both species. This recovery plan is intended to guide cooperative efforts to rapidly and efficiently attain the goal of the preservation of this highly endangered cetacean species. The success of these efforts will depend on the support and participation of the international community as well as Federal, state, and local governments.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
I. NATURAL HISTORY AND STATUS	2
1. Description of the species	2
1.1. Systematic status, morphometry, and coloration	2
II. LIFE HISTORY	3
2.1. Distribution and dispersal	3
2.2. Population size	4
2.3. Habitat use	4
2.4. Reproduction	5
2.5. Natural mortality	6
2.6. Parasitism	6
2.7. Feeding habits	6
III. ACTUAL AND POTENTIAL IMPACTS TO THE *Phocoena sinus* POPULATION	7
3.1. Incidental mortality caused by fishery activities	7
3.2. Degradation of benthic communities by shrimp trawling	8
3.3. The Río Colorado flow	9
3.4. Pollution	9
IV. CONSERVATION ISSUES	10
4.1. Regulations: Historical review ...	10
4.2. Present and future research	12
V. RECOMMENDED RECOVERY ACTIONS	15
5.1. Goals and objectives	15
VI. IMPLEMENTATION SCHEDULE	24
VII. LITERATURE CITED	29
VIII. FIGURES	34

RECOVERY PLAN FOR THE VAQUITA, *Phocoena sinus*

INTRODUCTION

For thousands of years, the vaquita, or Gulf of California harbor porpoise, *Phocoena sinus*, has been part of the marine mammal fauna of the Gulf of California. It is among the smallest and least known of the world's cetacean species.

The vaquita appears to be linked ecologically to the sciaenid fish totoaba, *Totoaba macdonaldi*, and both species are listed as endangered under the U.S. Endangered Species Act and included on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In addition, the vaquita has been designated as rare and in danger of extinction by the Government of Mexico, and IUCN-The World Conservation Union has classified the species as endangered in its Red Data Book.

Knowledge of the vaquita is limited, in part because it was not formally described until 1958. The initial description of the species was based only on a skull; the post-cranial bones were described years later from a carcass found on the beach at El Golfo de Santa Clara. At that time, vaquita carcasses were of little interest and were discarded.

Vaquitas are caught and killed incidentally in the totoaba gillnet fishery. In the past, vast schools of totoabas were found along the coasts of the Gulf of California. Human exploitation of the totoaba began at the end of 19th century and flourished into the middle part of this century. Exploitation was excessive and nearly brought the species to extinction. The size of the vaquita population before the beginning of the totoaba fishery is unknown. However, as the totoaba fishery grew, apparently so did the incidental take of vaquitas.

In recent years, knowledge of the vaquita has grown, and the scientific community, resource managers, and the general public have become increasingly aware of the problems involving the species. Over the past two decades, this growing international awareness has resulted in important steps to protect and enhance recovery of the species. Recently, the Mexican Government established the Comité Técnico para la Preservación de la Totoaba y la Vaquita (Technical Committee for the Preservation of the Totoaba and the Vaquita), whose purpose is to organize, evaluate, and coordinate efforts to protect the species. The success of these efforts will depend on the support of the international community as well as Federal, state, and local governments.

This recovery plan is intended to guide cooperative efforts to rapidly and efficiently attain the goal of the preservation of this highly endangered cetacean species.

I. NATURAL HISTORY AND STATUS

1. Description of the species.

1.1. Systematic status, morphometry, and coloration.

The species *Phocoena sinus* was described from a carcass found north of San Felipe in the upper Gulf of California (Norris and McFarland, 1958). This species and two others are grouped in the genus *Phocoena* (from the Greek, porpoise = pig). According to Barnes (1985), the status of the vaquita is as follows:

Order Cetacea, Brisson 1762.
Suborder Odontoceti, Flower 1867.
Superfamily Delphinoidea (Gray 1821) Flower 1864.
Family Phocoenidae (Gray 1825) Bravard 1885.
Subfamily Phocoeninae (Gray 1825) Barnes 1985.
Phocoena sinus, Norris and McFarland 1958.

There are two subfamilies in the family Phocoenidae: Phocoeninae and Phocoenoidinae. The latter includes two extant species, *Australophocaena dioptrica* (formerly *Phocoena dioptrica*) and *Phocoenoides dalli*, and the extinct porpoises of the genus *Piscolithax* and *Salumiphocaena* (Barnes, 1985). The genus *Phocoena* includes *P. phocoena* and *P. spinipinnis*, the first from the northern hemisphere and the second from the Atlantic and Pacific waters of South America (Barnes, 1985).

Descriptions of the post-cranial skeleton were provided by Noble and Fraser (1971) and Magatagan *et al.* (1984). External measurements of 13 specimens of *Phocoena sinus* were reported by Brownell *et al.* (1987). The specimens examined ranged in length from 70.3 to 143.5 cm. The three largest females measured 135, 135, and 143.5 cm, and the largest male was 134.5 cm. All were physically mature. Two additional females described by Brownell (1983) were 139 and 150 cm in length. The authors suggested that females may reach a maximum size of approximately 150 cm and males about 140 cm. The recorded weights ranged from 7.8 to 46.5 kg. The vaquita is the smallest of the porpoises (Gaskin *et al.*, 1974).

The typical spade-shaped crown of the teeth of the Phocoenidae exist in the vaquita (Norris and McFarland, 1958). The number of teeth in the maxillary row of nine specimens was 17 to 21 and the mandibular row contained 17 to 20 teeth (Brownell *et al.*, 1987).

In *P. sinus*, the pectoral fins are larger and the dorsal fin is higher, proportional to the body length, than in any other extant porpoise species (Brownell *et al.*, 1987; Silber and Norris, 1991).

The coloration of adult vaquitas is unique. On the dorsal portion, the color is dark gray, the sides are pale gray, and the ventral surface is white with some small pale-gray elongated spots. The porpoise has a large dark eye spot and lip patches that contrast with the gray background. Some individuals have a thin stripe from the mouth to the pectoral fin. In neonates, the coloration is darker than in adults (Silber *et al.*, 1988), particularly on the head and the areas behind the eye; this includes a wide gray stripe that runs from the head to the flukes and encompasses the dorsal and pectoral fins (from Brownell *et al.*, 1987; Villa, in press).

II. LIFE HISTORY

2.1. Distribution and dispersal.

Several authors agree that the geographic distribution of the vaquita is confined to the upper Gulf of California, which represents the most restricted range for any cetacean species (Barlow, 1986; Brownell, 1986; Silber, 1990a; Silber, 1990b; Vidal, 1990; Silber and Norris, 1991) (Fig. 1).

Some records (sightings), however, have been reported outside this region (south of 30° 45' N latitude) (Norris and McFarland, 1958; Norris and Prescott, 1961; Villa, 1976). These sightings were regarded as misidentifications (Brownell, 1986; Vidal, 1990), occasional departures by some individuals (wanderers) from the center of distribution (Silber and Norris, 1991), or temporary extensions in distribution due to climatic changes (*e.g.*, El Niño) (Silber, 1990a; Silber, 1990b; Vidal, 1990).

Of the 306 cetacean sightings in the upper Gulf of California reported by Silber (1990a), 58 (18.95%) were of vaquitas. The majority of the vaquita sightings (96.15%) occurred less than 40 km from San Felipe, Baja California.

This distribution is supported by records of stranded vaquitas recovered from gillnets (Silber, 1990a) and confirmed by an extensive compilation of collected specimens made by Vidal (1990) and Vidal *et al.* (1991). However, as indicated by these authors, most of the censusing effort to date has been conducted in the area off San Felipe, Baja California. The region south of Puerto Peñasco, Sonora, remains insufficiently monitored to

estimate the population size and establish the southern limit of the geographic range.

2.2. Population size.

Accurate estimates of the vaquita population size are difficult to achieve because few data are available. Most authors agree, however, that the population is very small, numbering in the low hundreds.

Villa (1976) estimated the vaquita population at 200-300 individuals, while Barlow (1986) estimated the lower limit of the population at 50-100 animals. These estimates, however, were not based on survey efforts. Surveys were conducted in 1986-1989, in which a total of 3,230 km of boat and aircraft surveys yielded 58 vaquita sightings, representing 110 individuals (Silber, 1990a). From this study, a qualitative population estimate of 300-500 individuals was derived (G. Silber, pers. comm.). All estimates indicate that the vaquita population contains less than one thousand individuals. It is very likely that the population size is not larger than this, considering both the low sighting rate (1.8 individuals/100 km) (Silber, 1990a) and the small geographic range. These factors, coupled with incidental mortality in fisheries and other forms of potential impact, make the vaquita one of the cetacean species most in danger of extinction.

2.3. Habitat use.

There are few studies of the geology and oceanography of the upper Gulf of California. Silber (1990a) provided an excellent review based on the work of several authors (Roden and Groves, 1959; Roden, 1964; Matthews, 1969; Alvarez-Borrego *et al.*, 1975; Alvarez-Borrego *et al.*, 1978; Alvarez-Borrego, 1983; and others). The following paragraphs are intended as a brief review of those aspects that seem relevant to vaquita distribution and habitat utilization.

The northern Gulf of California, that is, the area from the Río Colorado delta to the northern part of Angel de la Guarda Island, can be characterized as having shallow waters (the majority is less that 200 m deep), with high turbidity, high salinity, a large tidal range, and strong currents. In spite of the significant water exchange between this region and the central Gulf, high temperatures and low precipitation levels, particularly in summer, cause high salinities in the upper Gulf (Alvarez-Borrego, 1992). The waters occupied by the vaquita, which range in depth from 10 to 60 m, include the area from Puertecitos, Baja California, to Puerto Peñasco, Sonora (Barlow, 1986; Brownell, 1986; Silber, 1990a; Silber, 1990b; Vidal, 1990; Silber and Norris, 1991). This region is an extensive plane of

sand, silt, and clay sediments deposited by the Río Colorado and runoff from the Mexican mainland (Maluf, 1983).

Resuspension of particulate material, a process enhanced by strong tidal currents and shallow waters, produces an almost permanent turbid water environment. According to Silber (1990a and 1991), this environment provides a habitat for vaquitas in which visual detection by both predator and prey is difficult. Silber (1991) also suggested that acoustic signals produced by *P. sinus*, as well as by other phocoenids, are adapted to detect prey near the sea floor in a turbid water environment by utilizing frequency ranges that minimizes both interference by ambient noise and reverberation from the bottom. The small wavelength signals emitted by vaquitas are above the hearing ranges of both prey and predators such as killer whales and sharks.

The combination of shallow depths, high solar radiation, and minimal precipitation results in water temperatures that fluctuate greatly on daily and seasonal bases (Silber, 1990a). The daily offshore sea surface temperatures in the area may be close to 8° C in winter and 33° C in summer (Alvarez-Borrego, *et al.*, 1975). Silber and Norris (1991) theorized that the unusually large dorsal fin and small body size of *P. sinus* are adaptations to cope with high water temperatures.

The small geographic area inhabited by the vaquita is influenced by dramatic tidal ranges and strong currents and winds. These phenomena drive the upwelling process that occurs, according to Maluf (1983), at the center of the upper Gulf in winter and along the coasts in summer. Silber (1990a) suggested that the occurrence of these conditions around Rocas Consag Island, which itself may cause upwelling, are linked to the presence of vaquitas in the area.

Vaquitas appear to use this region throughout the year, as suggested by sightings obtained in spring and fall in the same locations (Silber and Norris, 1991).

2.4. Reproduction.

Little is known about the reproductive biology of the species. Vidal (1990) reported that three females between 135-150 cm in length and three males ranging from 129-145 cm in length were physically mature. Given the occurrence of calves (as noted by the presence of fetal folds) in sightings at sea and young specimens collected from gillnets, several authors suggested that calving occurs in spring (Norris and Prescott, 1961; Silber, 1990a; Vidal, 1990). If that is the case, it is likely that mating occurs in late spring or soon thereafter (Vidal, 1990).

Judging by the seven neonates reported in the literature (Brownell, 1983; Vidal, 1990; Silber and Norris, 1991), vaquita body length at birth (males and females combined) is probably about 73.6 ± 2.6 cm; the weight of five calves was 10.46 ± 1.55 kg.

2.5. Natural mortality.

Vidal (1990) reported that several shark species feed on vaquitas, but he did not make it clear whether the porpoises were attacked as free-ranging individuals or were taken from gillnets. Shark species mentioned by Vidal were the white (*Carcharodon carcharias*), the mako (*Isurus oxyrinchus*), the lemon (*Negaprion brevirostris*), the black-tipped (*Carcharinus limbatus*), and the thresher (*Alopias supercillosus*). Other potential predators were the tiger (*Galeocerdo cuvieri*) and the hammerhead (*Sphyrna lewini*). Killer whales (*Orcinus orca*) were also mentioned as possible predators; however, they apparently are not frequent visitors to the upper Gulf. Of 306 cetacean sightings in the upper Gulf, which included bottlenose dolphins (*Tursiops truncatus*), common dolphins (*Delphinus delphis*), vaquitas, fin whales (*Balaenoptera physalus*), Bryde's whales (*Balaenoptera edeni*), gray whales (*Eschrichtius robustus*), and killer whales, the latter were seen twice (0.66% of all observations) (Silber, 1990a).

2.6. Parasitism.

Brownell *et al.* (1987) described the presence of the commensal pseudo-stalked barnacle (*Xenobalanus globicipitis*) on the trailing edges of the dorsal fins and flukes of vaquitas recovered from gillnets. Lamothe (1988) reported the trematode (*Synthesium tursionis*) in the middle intestine of a vaquita from El Golfo de Santa Clara. This trematode also has been found in bottlenose dolphins, Risso's dolphins (*Grampus griseus*), and rough-toothed dolphins (*Steno bredanensis*).

2.7. Feeding habits.

Squid beaks and otoliths from a grunt (*Orthopristis reddingi*) and a croaker (*Bairdiella icistia*) were found in a vaquita stomach (Fitch and Brownell, 1968). Silber (1990a) examined stomach contents from two specimens and found squid beaks, numerous unidentified otoliths, a crab carapace, and several whole fish identified as *Anchoa nasus* or *Sardinops* spp.

According to Silber (1990a), food competition could exist between vaquitas and common dolphins and between vaquitas and bottlenose dolphins. He defined the bottlenose dolphin as a

shallow-water feeder and described the niche of the vaquita as turbidity-defined. The abundance of food resources in the upper Gulf may readily support these cetacean species (Silber, 1990a); however, potential competition with California sea lions (*Zalophus californianus*) was not considered. This pinniped feeds on a large variety of prey, including the grunt and the croaker mentioned above. In addition, about 500 California sea lions haul out on Rocas Consag and nearly 3,500 individuals have been counted on Isla San Jorge south of Puerto Peñasco (Aurioles-Gamboa, 1988).

III. ACTUAL AND POTENTIAL IMPACTS TO THE *Phocoena sinus* POPULATION

3.1. Incidental mortality caused by fishery activities.

The incidental mortality of vaquitas in fisheries in the upper Gulf of California has been reported numerous times in the past two decades (Villa, 1976; Barlow, 1986; Boyer and Silber, 1990; Silber, 1990a; Vidal, 1990; Klinowska, 1991; Silber, 1991). There is agreement that incidental mortality is the most serious problem facing the vaquita population. Vaquitas are entangled in nets set for the totoaba, in shark nets, and in shrimp trawling nets (Brownell, 1983; Barlow, 1986; Silber, 1990a; Vidal, 1990). Of 102 confirmed records of vaquitas entangled in gillnets, 72 were caught in totoaba nets (mesh size 20-30.5 cm), 29 individuals in shark nets (10-15 cm mesh), and one specimen in a sierra gillnet (9 cm mesh). Clearly, the totoaba fishery is a major threat to the vaquita population.

The vaquita and the totoaba may be indirectly linked ecologically, *i.e.*, their distributions overlap and they may consume similar prey. The totoaba, also endemic to the Gulf, was exploited beginning at the end of the last century, and its population at that time was abundant (Berdegué, 1955). Initially, the fish was commercially important for its swim-bladder, which was valued in oriental countries; in later years, the fish was also sought for its meat. After 1942, the extensive use of nylon gillnets and the increased fishing effort reduced the catch of totoaba from 2,261 tons in 1942 to 58 tons in 1975 (Flanagan and Hendrickson, 1976). Although the totoaba fishery was banned in 1975, it has continued illegally since that time, further endangering both the totoaba and the vaquita. An experimental totoaba fishery initiated in 1985 exacerbated the problem (Vidal, 1991).

Vidal *et al.* (1991) estimated that a minimum of 95 vaquitas died in gillnets between 1985 and 1990, for an average mortality of 15.3 animals per year. Because not all vaquitas deaths are reported, this figure must be considered a minimum estimate.

Based on interviews with fishermen inhabiting the upper Gulf, Boyer and Silber (1990) estimated that an average of 32.3 vaquitas are caught annually in gillnets. By working with fishermen and recovering gillnet-killed specimens, Vidal (1991) arrived at a similar figure (30-40 individuals per year). If the population totals about 300-500 individuals (G. Silber, pers. comm.), the incidental mortality caused by fisheries alone represents a removal of about 5-10% of the population annually. According to analyses by Barlow (1986), the growth rate for this population is unlikely to be higher than 10% per year, and is very likely below this figure. Clearly, the population cannot sustain this level of incidental loss for many years.

3.2. Degradation of benthic communities by shrimp trawling.

In the Gulf of California, the Mexican Pacific offshore shrimp fishery fleet catches brown shrimp (*Penaeus californiensis*) in depths ranging from 9 to 90 m, and blue shrimp (*P. stylirostris*) and white shrimp (*P. vannamei*) in waters from 9 to 36 m deep. Historically, brown and blue shrimp have been caught intensively along the coast of Sonora from Guaymas to the Río Colorado delta and from this point to the south of San Felipe (Magallon, 1987). The number of boats in the shrimp fishery increased from 800 in 1971 to 1,700 in 1981 with no corresponding increase in catch (Magallon, 1987). Shrimp trawling likely has affected the bottom ecosystem to a degree not yet evaluated, but the effect is probably drastic considering that the shrimp bycatch is many times larger than the take of shrimp.

By the end of the 1960s, the proportion of bycatch in the shrimp fishery was 10.2 times that of the shrimp (Chapa, 1976). At that time, the shrimp fleet in the upper Gulf included 165 boats (85 at Puerto Peñasco, 35 at El Golfo de Santa Clara, and 45 at San Felipe), and the annual shrimp catch was 2,000 tons. By inference, the bycatch of this fishery throughout the decade in the upper Gulf of California may have approached 20,400 tons per year.

Based on the more than 200% increase in the size of the shrimp fleet from the 1970s to the 1980s, it reasonably can be assumed that trawling effort also doubled during that period, resulting in the removal of nearly 40,000 tons of biomass annually from the upper Gulf. This is based on an assumption that the standing stock remained the same during such exploitation.

Unfortunately, 80% of the shrimp bycatch consists of fish (Chapa, 1976; Hendrickx, 1985) that die on boats and are discarded. A portion of this lost biomass could have provided food for *P. sinus* and many other organisms. Another negative effect of the shrimp trawling on the benthic environment is the

disruption of food webs by removing large portions of biomass, which in many cases contains juvenile stages of several fish species (Hendrickx, 1985).

3.3. The Río Colorado flow.

The Río Colorado flow has been reduced for several decades due to water retention by the Hoover Dam and other facilities in the United States. Reduced freshwater flow into the upper Gulf of California may have contributed to alteration of vaquita habitat (Brownell, 1982; Barlow, 1986; Silber, 1990a). Before human intervention, the Río Colorado annually released about 18 billion cubic meters of water (about 50% of the total freshwater input) into the Gulf of California. Additionally, approximately 161 billion kg of sediments and alluvial detritus formerly provided important enrichment to the ecosystem (Schreiber, 1969). Following construction of the Hoover Dam, the freshwater flow was estimated at less than 8 billion cubic meters of water, carrying 12 billion kg of sediments per year (Schreiber, 1969). However, Alvarez-Borrego *et al.* (1973) concluded that there is no surface freshwater input to the Río Colorado delta except for that provided by winter rains.

It is reasonable to assume that, as a result of limited freshwater influence, a drastic change occurred in the ecosystem. For example, a negative estuary at the Río Colorado delta supplanted the estuarine conditions that existed prior to the flow reduction (Alvarez-Borrego, 1992). This change may have caused alterations in food webs and biological diversity, however, there is no information to substantiate this hypothesis. In fact, evidence suggests that the Río Colorado delta behaves as a very fertile coastal lagoon, supporting abundant populations of crustaceans and mollusks (Alvarez-Borrego, 1992), and that substantial numbers of bottlenose dolphins utilize the delta (Silber, 1990a). There is no information to suggest that this apparent richness is different from naturally occurring conditions of the past.

3.4. Pollution.

The Río Colorado effluent is affected by agricultural lands from southern California and the Mexicali Valley. This has raised concern about the concentration of organochlorine pollutants and fertilizing chemicals in the system. Relatively high levels of PCBs, DDT, and DDE have been implicated in reproduction impairment in many marine mammals (Gilmartin *et al.*, 1976; O'Shea *et al.*, 1980; Barlow, 1986).

The presence of pollutants (DDT) in bivalves collected at the mouth of the Río Colorado (Guardado, 1975) confirmed that

these compounds entered the food web of the upper Gulf. However, more recent analyses indicated that the levels of organochlorinated pesticides found in the mollusks *Chione californiensis* and *Modidus capax* taken from the Golfo de Santa Clara and off San Felipe had low concentrations (Gutierrez-Galindo *et al.*, 1988). The authors determined that the concentration values were two orders of magnitude below those considered acceptable for human consumption by the U.S. Food and Drug Administration.

Similar concern exists regarding contaminant accumulation in vaquitas and other organisms that inhabit the delta. However, results obtained from eight vaquita blubber samples (Calambokidis, 1988) suggest that the levels of organochlorine pollutants were lower than in cetacean species from other regions. Villa *et al.* (in press) also found low concentrations of heavy metals in samples of liver, heart, and kidney of *P. sinus*. Although the presence and possible effects of these pollutants in vaquitas cannot be overlooked, their levels at this time appear to be far less than levels found in marine mammals elsewhere.

IV. CONSERVATION ISSUES

4.1. Regulations: Historical review.

Since Berdegué (1955) cited a need to regulate the totoaba fishery, attempts have been made to manage and protect the marine resources of the upper Gulf of California.

On 24 May 1974 the Diario Oficial de la Federación (Official Diary of the Federation) published the following declaration:

> Hereby established as a preserve zone, for all commercial fish species including the totoaba, the area of the Río Colorado delta in the Gulf of California; bordering that area at the north, from an east-west imaginary line, tangential at the south of the Montague and Gore Islands, which extends from the east coast of the Gulf in the Sonora State (Santa Clara 31° 41' 00" N.; 114° 30' 00" W.), to the west coast of the Baja California (31° 40' 42" N; 114° 47' 00" W).

A year later, on 1 August 1975, an agreement was published that prohibited the totoaba fishery in the Gulf of California. The area of prohibition extended from the Río Colorado delta to the Río Fuerte in Sinaloa along the east coast, and from the Río Colorado to Bahia Concepción in Baja California Sur along the west coast (Fig. 2).

Due to lack of enforcement, these regulations had little effect, and the totoaba fishery continued illegally from 1975 to 1985. In 1985, a permit was granted to conduct experimental research fishing. As previously described (section 3.1), this activity probably contributed to depletion of the vaquita population because many fishermen took advantage of the official research permit to fish on their own. Since then, and as a result of claims by Mexican scientific organizations and institutions, the problem has received international attention, and the Mexican Government has taken steps to tighten the control of fishing activities in the area.

On 13 February 1992, another notice was published in the Diario Oficial de la Federación stating that: "Since the uppermost Gulf of California is inhabited by the adults of totoaba from October through May, migrating from the growth areas to the breeding grounds in the Río Colorado delta, sharing the area and season with the vaquita (*Phocoena sinus*), which is a protected species, it is necessary to avoid the incidental catch of both species."

In accord with these resolutions, three Federal Articles to protect the vaquita were subsequently published. They are:

> **Article One:** The use of gill nets, constructed of nylon (bore 36-40) and mesh size larger than 10 inches, and called "totoaberas," is prohibited during the whole year in the area from the east coast of the Gulf of California from Santa Clara, Sonora (31° 41' 00 N; 114° 30' 00" W), to the Río Fuerte mouth in Sinaloa (25° 49' 00" N, and 109° 26' 00 W) and on the west coast from 31° 40' 42" N; 114° 47' 00" W), to Bahía Concepción, Baja California Sur, (26° 50' 00" N; and 111° 54' 30" W) (Fig. 2).
>
> **Article Two:** Those who conduct fishing with the described fishing gear will be prosecuted according with the federal fishing law and further applicable laws.
>
> **Article Three:** With regard to the strict application of the dispositions of the present article, the Secretaría de Pesca will intensify the inspection and surveillance and will coordinate with other authorities in the execution of this article.

On 2 March 1992, the President of Mexico, working through the Secretaría de Pesca, established the Comité Técnico para la Preservación de la Totoaba y la Vaquita. Committee members include scientists and institutional representatives. The Committee's main objectives are to plan, coordinate, and evaluate research on the totoaba and vaquita, and to recommend actions that will result in the preservation of both species in the long

term. The Committee has identified a number of projects described below.

On 22 April 1992 the Government of Mexico, represented by the President Carlos Salinas de Gortari, and the Cousteau Society, represented by Captain Jacques Yves Cousteau, signed an agreement to collaborate on the "Program of Protection and Recovery of the Mexican Porpoise called Vaquita and the Totoaba Fish." The agreement states:

(1) That the sanctuary located in the upper Gulf of California be ratified and that fishing methods that injure vaquitas and totoabas be forbidden.

(2) That the Committee established by President Salinas be in charge of the design and application of a survey and evaluation program that ensures that the fishing methods employed preserve the integrity of the vaquita and totoaba.

(3) That cooperative actions are taken to establish scientific research programs on the biology of vaquita and totoaba, including population censuses, and ecological studies of the upper Gulf of California region, which will also include the problems of the Río Colorado effluent and adjacent coasts.

(4) That collaboration occur in conducting socio-economic research and alternatives to fishing methods that avoid the damage to the vaquita and totoaba in all their life stages, and provide employment alternatives to the coastal human populations.

(5) That the Cousteau Society participate in an education and awareness programs for fishermen, the fishing industry, and the general public about the agreed-to program.

(6) That support be provided for the research to coordinate and balance the actions that help to reach the conservation objectives for these species.

4.2. Present and future research.

Several studies presently are being conducted on the vaquita, the totoaba, and their habitat, as well as the socio-economic situation in the upper Gulf of California. The Mexican government has designated funds to various projects to implement the research program of the Committee. Of these, six projects are devoted to the study of totoaba, six to the vaquita, two to environmental studies, and one each to public education and socio-economic evaluation.

These projects are not independent of the proposed recovery plan, and it is hoped that the Committee-identified projects, other studies in progress, and the proposed recovery plan will share a similar framework and the same goal: to preserve and protect the two endangered species.

Studies identified and endorsed by the Committee are as follows:

1. Vaquita distribution and abundance.

   Conducted by the Fishery Research Regional Center (CRIP) at La Paz, Baja California Sur; Institute of Biology, Universidad Nacional Autónoma de México (UNAM); and Instituto Tecnologico de Estudios Superiores, Monterrey (ITESM), Campus Guaymas, Sonora.

2. Vaquita incidental mortality.

   Conducted by the CRIP, La Paz, Baja California Sur; and ITESM.

3. Vaquita biology and ecology.

   Conducted by the CRIP, La Paz, Baja California Sur.

4. Vaquita age and sexual maturity.

   Conducted by Conservation International A.C., Mexico.

5. Educational program for the coastal communities about the conservation and protection of the vaquita and totoaba.

   Coordinated by the Dirección General de Organización y Capacitación Pesqueras, from the Secretaría de Pesca (DGOCP); Center for the Study of Deserts and Oceans (CEDO), Puerto Peñasco, Sonora; and CRIP at Ensenada, Baja California Norte.

7. Environmental effects of freshwater reduction and agricultural chemicals.

   Conducted by the CRIP at Ensenada, Baja California Norte.

8. Environmental impact of fisheries and other human activities.

   Coordinated by ITESM; Centro de Investigaciones del Estado de Sonora (CIDESON); and Centro Ecológico de Sonora (CES).

9. Environmental, economic, and social status, including assessment of alternatives to fishing.

Coordinated by the DGOCP from the Secretaría de Pesca.

VAQUITA RECOVERY PLAN

This recovery plan describes actions designed to help the vaquita population attain viability. The ultimate goal is to ensure a population that is biologically successful, and of sufficient size to withstand normal environmental fluctuations and the impact of human activities. Successful implementation of the actions described here will require cooperative efforts among concerned governments, organizations, and individuals.

V. RECOMMENDED RECOVERY ACTIONS

5.1. Goals and objectives.

GOAL

To restore to and maintain the vaquita population at levels that will ensure its continued survival and viability.

OBJECTIVES

I. Identify, avoid, or reduce interactions with commercial fisheries.

II. Identify and characterize potential threats to essential habitats.

III. Determine and monitor the status and trends of the vaquita population.

IV. Coordinate local, state, federal, and international efforts to implement the recovery plan.

I. Identify, avoid, or reduce interactions with commercial fisheries.

High mortality incidental to gillnet fishing is probably the biggest threat to the vaquita, and minimizing or eliminating this impact is essential to the recovery of the species. Steps should be taken to quantify the incidental mortality and to limit or eliminate its occurrence with the goal of reducing incidental mortality to zero.

Two institutions, CRIP of La Paz and ITESM of Guaymas, Sonora, are working on this problem (project number 2, above). The ITESM has been monitoring the incidental mortality of

vaquitas in fisheries since 1985, and its researchers have a good knowledge of the people and fishing activities in the upper Gulf of California. Every effort should be made to continue, and possibly expand upon, this research.

1.1. Establish additional regulations and/or improve enforcement of restrictions on gillnets.

Fishing restrictions currently exist, particularly with respect to the capture of totoaba. By federal agreement, the use of gillnets with mesh larger than 10 inches is prohibited. However, enforcement is difficult because the area to patrol is vast, enforcement resources are limited, fishermen are able to offload their catch in remote areas, and the boats using gillnets are small and many are unregistered. It may be necessary to impose more stringent restrictions or to place greater emphasis on enforcing existing laws. For example, it may be necessary to completely prohibit the possession of any type or size of gillnet. Such broadening of the prohibition would greatly facilitate enforcement.

At this time, enforcement of regulations is conducted at sea by patrol boats from the Secretaría de Marina of Mexico. Land-based inspection, primarily in the main fishing camps along the coast, is the responsibility of the Secretaría de Pesca. It may be possible to institute aircraft surveillance of gillnetting activities, particularly if such fishing operations are banned entirely. Aerial surveillance may be the most rapid, efficient, and cost-effective means of monitoring fishing operations, and this possibility should be examined.

Porpoise interactions with gillnets may be greatly reduced by limiting use of the nets to certain seasons or locations. As discussed in Section 4.1 (Article One), the use of gillnets for totoaba is prohibited in the region shown in Figure 2 during the whole year. Expansion of the restricted area and the possibility of other time and area restrictions should be explored.

1.2. Evaluate effectiveness of current regulation and enforcement efforts.

Once adequate regulations are in place and enforcement is improved, the systems must be continually evaluated and refined. The Technical Committee for the Preservation of the Totoaba and the Vaquita will have a major role in organizing periodic meetings to review the status of the research on the vaquita and totoaba and their habitat. The Committee will analyze the results of the protection activities and evaluate the effectiveness of the coordinated actions. Following such analyses, the Committee will have a major role in defining the execution of steps of the plan presented herein, or proposing changes accordingly.

1.3. Identify and assess possible alternative fishing techniques and possible economic alternatives to gillnet fishing.

Although gillnet fishing is a relatively recent practice in the upper Gulf, it has quickly assumed an important role in the lives and economy of local communities. If gillnetting is to be eliminated, it may be necessary to provide and/or subsidize other means of livelihood. Therefore, a detailed review should be conducted of the demographics of the northern Gulf, including sources and levels of income. If possible, an ongoing evaluation of the economic health of the region should be initiated. Specific recommendations should be made regarding economic alternatives to gillnet fishing and the extent to which such alternatives could replace lost income opportunities. Recommendations should be specific and should take into account the regional economy and sociological structure, utilizable fish resources, and the expense of shifting to new practices. Recommendations should address the role of local, regional, and federal governments in encouraging alternatives and the role that domestic and international businesses might have in implementing alternatives. Emphasis should be placed on encouraging existing occupations rather than introducing new ones, and alternatives may include "eco-tourism" or whale-watching businesses, aquaculture, or guided fishing trips for tourists. The potential environmental impact of these activities also should be assessed.

1.4. Eliminate exportation of totoaba fillets.

There is information suggesting that substantial markets for illegally caught totoaba exist in both Mexico and the United States. Attempts should be made to eliminate the markets through a variety of approaches.

1.4.1. Develop a biochemical test of fish proteins to identify illegal and legal species.

One of the biggest problems in eliminating the illegal totoaba market is that, once filleted, totoaba cannot be distinguished from other, legally obtained species. Studies suggest that an approach to this problem is to develop a quick and accurate means of biochemically identifying totoaba. The test could be carried out at the Mexico-U.S. border where totoaba meat enters headed for U.S. fish markets.

The U.S. National Marine Fisheries Service has apparently developed this technology, and the Chemistry Institute of the UNAM is also interested in this problem.

1.5. Develop a program to educate fishermen about the rare status of the vaquita and the consequences of violating fishing restrictions.

Fishermen need to be apprised of the legal consequences of violating fishing restrictions. In addition, most fishermen are aware of vaquitas, but do not appreciate the ecological importance of the species or the increasing scientific and popular interest in the protecting the species.

Posters about the vaquita have been produced and distributed by researchers at the UNAM and CEDO; these efforts should be continued and expanded. Public hearings, lectures, and other educational venues might be developed. The importance of the environmental conservation, particularly conservation of the vaquita, should be addressed in the schools of the states (Sonora and Baja California) that border the upper Gulf of California. In addition, local residents should be encouraged to participate in conservation efforts (*e.g.*, by reporting sightings and strandings). The effort should be expanded to the United States, particularly to call attention to the reduced Río Colorado effluent entering the Gulf and its effects on the marine life.

This issue was also considered by the Committee in project 5 of section 4.2, and the plan to develop slide talks, technical manuals for ecologically related tourism, and posters for the vaquita and totoaba, has financial support.

1.6. Monitor incidental mortality rates in fisheries.

Effective mitigation of fishing-related deaths relies on accurate estimates of incidental mortality rates. To this end, current efforts to acquire data on fishing-related mortality should be continued and expanded through interviews with fishermen, observation of net retrievals, and recovery of porpoises killed in nets. Researchers at the ITESM have conducted surveys to monitor the incidental mortality since 1985. This task coincides with the Committee's project (number 2) to estimate vaquita mortality.

II. Identify and characterize potential threats to essential habitats

Degradation of habitat may also affect recovery of the vaquita population. Important habitat should be defined and potential adverse impacts to these areas mitigated.

2.1. Review available information to determine vaquita habitat use patterns and potentially important habitats in the northern Gulf.

Although data are scant, some conclusions on habitat utilization may be made based on sighting information. Reviews of existing information on habitat utilization should be conducted and, as possible, attempts should be made to characterize important habitats.

2.2. Identify high use habitat areas to determine, as possible, why these areas are important.

Determining why vaquitas use certain habitats will be critical to management efforts and habitat protection. Therefore, habitats should be surveyed to quantify important features. For example, a high frequency of occurrence of vaquitas off San Felipe may be related to upwelling and areas of well-mixed water. Therefore, areas that exhibit similar processes should be investigated to help predict distribution and abundance of vaquitas. Studies number 3 and 9 of the Committee's research program are for the characterization of environmental conditions that influence vaquita distribution. The combination of results obtained by these two projects and those conducted on the abundance and distribution of the vaquita contribute to a better understanding of habitat utilization by the species.

2.3. Assess impact of shrimp trawlers on habitat and the ecosystem.

Scores of shrimp boats scour the sea floor of the upper Gulf of California. In these fisheries, there is considerable waste of non-target species and disruption of benthic communities. These activities may indirectly affect the vaquita population through food web disruption. As possible, the impact to the habitat and food source of vaquitas should be quantified and steps taken to minimize the impact. As previously described, the Committee's research project number 8 also addresses the issue of the shrimp fishery in the upper Gulf of California ecosystem.

2.4. Assess the impact of the freshwater reduction in the upper Gulf by water use and dams in the United States.

The Río Colorado delta and upper Gulf have changed from an estuarine to a negative estuary condition which may have affected food webs. Since the possibility of increased salinity levels exist, continuous, long-term monitoring of the region's physical parameters should be conducted. This corresponds to study number 7 of the Committee program.

2.5. Assess potential adverse impacts from industrial, agricultural, and municipal effluents.

Although industrial effluent is probably minimal in the upper Gulf, construction of a desalinization plant on the Río Colorado is under consideration. If built, this might lead to elevated levels of brine to the northern Gulf ecosystem. In addition, it is likely that untreated municipal waste is being discharged into the upper Gulf, and the seasonal influx of tourists from the United States and Mexico may overwhelm local treatment facilities. Such potential impacts from terrestrial discharges should be investigated and assessed. This problem is part of the objectives of the studies 7 and 8 mentioned in section 4.2.

2.6. Assess and monitor levels of anthropogenic contaminants in porpoise tissue.

Various human activities may result in the introduction of contaminants (*e.g.*, organochlorine and heavy metals) into the environment. These in turn subsequently may be incorporated into porpoise tissues. Although available studies indicated that organochlorine and heavy metal levels were low in recently collected *P. sinus* tissue, the levels and potential effects (*e.g.* possible reduction of reproductive capacity, as identified for other taxa) should be systematically monitored.

Procedures should be developed for standardized monitoring of contaminant levels. To better accomplish this goal, efforts to collect vaquita specimens should be coordinated among the many institutions collecting specimens in the upper Gulf.

2.7. Produce and distribute educational materials regarding threats to the vaquita population and its habitat to schools and U.S. and Mexican tourists.

The Committee's project number 5 also addresses this task.

III. Determine and monitor the status and trends of the vaquita population.

Determining the success of the recovery of the species will depend on accurate estimates and ongoing monitoring of the population size. Likewise, assessments of the effectiveness of recovery efforts and potential direction of specific tasks will depend on trends in the population size, distribution, and mortality. Therefore, research on population monitoring and salvage and necropsy programs are vitally needed to support management, and programs should be developed to address these needs.

3.1. Improve current population estimates.

At present, systematically obtained population estimates do not exist, and attempts to quantify population size through a limited number of surveys have been thwarted by the low number of porpoise sightings. Reliable population estimates are needed and might be obtained through analysis of existing data and the establishment of strategies to improve estimates.

3.1.1. Review and assess previous population surveys to determine how the distribution and status of the vaquita population can best be monitored.

3.1.2. Establish systematic and standardized population monitoring program based on results of task 3.1.1.

3.2. Improve and maintain the salvage and necropsy program.

Ongoing efforts to collect vaquita carcasses should be continued and expanded. This will require continuing efforts by field workers to maintain contact with fishermen to obtain porpoises as they are retrieved in nets and or discovered on beaches. It will be necessary to establish and maintain adequate facilities to hold specimens and to develop detailed plans to make resources (*e.g.*, personnel, vehicles, and a network of researchers) available to recover specimens.

3.2.1. Design and maintain a program for periodic surveys of beaches to obtain beach-cast specimens.

3.2.2. Conduct systematic and periodic surveys of beaches by foot, vehicle, or plane. Maps of beach coverage and assignments for various locations should be developed.

3.2.3. Develop a protocol for collecting and handling various tissue types for subsequent analyses.

3.2.3.1. Develop a protocol for collecting and analyzing stomach contents for assessment of prey items.

Assessment of prey and diet will facilitate conclusions about habitat and will aid in determining potential threats to prey availability. Detailed study plans might be identified in which stomach contents are routinely collected and analyzed. This will require collecting and cataloging fish otolith collections from the Gulf because many species are endemic and otolith collections from other location may not be useful.

3.2.3.2. Establish a program to analyze contaminant levels in tissue.

Often unique techniques for collecting and handling tissue samples require special procedures to assure accurate and complete analysis. Procedures for analyzing contaminants in tissue should be developed and implemented. However, based on current data, it appears that contaminant loads in *P. sinus* are relatively low. Therefore, if tasks are placed in priority order, continued examination of contaminant levels may be of secondary importance.

3.2.3.3. Establish program to collect and analyze tissue for life history data, particularly age at sexual maturity, calving interval, and longevity of females.

3.2.3.4. Establish program for genetic analysis of potential "bottleneck effects."

Severely depleted populations may experience limited genetic diversity through restriction of available genetic material, and therefore may experience less resistance to environmental changes. Protocols should be developed for collecting, storing, and analyzing material for genetic studies.

3.3. Establish and maintain a database on all strandings and gillnet mortalities (including location, date, condition, and carcass deposition).

Records of carcass recovery locations will aid in defining the range and distribution of the species and mortality trends. Facilities should be established to house a database, and resources and personnel should be made available to update and maintain the database.

IV. Coordinate local, state, federal, and international efforts to implement the recovery plan.

4.1. Establish and maintain a Recovery Team.

Provisions should be made to convene meetings at least annually to provide overall advice on recovery activity priorities and work.

4.2. Designate and support a recovery Coordinator to organize and direct day-to-day recovery activities and implementation of this plan.

4.3. Periodically review and update the Recovery Plan.

VI. IMPLEMENTATION SCHEDULE

Priorities in column 3 of the following Implementation Schedule are assigned as follows:

> Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
>
> Priority 2: An action that must be taken to prevent significant decline in species population and habitat quality or some other significant negative impact short of extinction.
>
> Priority 3: All other actions necessary to provide for full recovery of the species.

I M P L E M E N T A T I O N S C H E D U L E

PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE ENTITIES
Establish additional regulations	1.1.	1	continuing	S.M. SEPESCA ST-GOV
Evaluate effectiveness of enforcement	1.2	1	continuing	COMMITTEE SEPESCA
Identify fishing and economic alternatives	1.3	1	2 years	DGOCP CEDO ST-GOV
Eliminate totoaba exportation and develop biochemical test	1.4.1	1	1 year	*NMFS UNAM
Develop education program	1.5	2	continuing	CEDO UNAM ST-GOV DGCOP
Monitor incidental mortality	1.6	1	continuing	ITESM UNAM CRIP-G CRIP-L
Review information on vaquita habitat use	2.2	1	1 year	ITESM UNAM
Assess impact of shrimp trawling	2.3	1	2 years	ITESM CIDESON CES
Assess impact of freshwater reduction	2.4	2	2 years	CRIP-E *CICESE

PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE ENTITIES
Assess impact of agricultural and municipal effluent	2.5	2	2 years	CRIP-E *CICESE
Assess and monitor contaminants in vaquita	2.6	2	continuing	*UNAM *ITESM *CICESE *NMFS
Produce and distribute educational material	2.7	2	continuing	DGOCP CEDO ST-GOV
Review information on vaquita surveys and improve methods	3.1.1	1	1 year	*MMC *SWFC *ITESM
Establish program for population monitoring	3.1.2	1	continuing	ITESM UNAM CRIP-L *SWFC
Design program for periodic survey of beach-cast specimens	3.2.1	2	continuing	*CEDO *ITESM *UNAM *CRIP-E *CRIP-L
Conduct periodic surveys and mapping	3.2.2	1	continuing	*CEDO *ITESM *UNAM *CRIP-E *CRIP-L
Establish protocol for vaquita tissue analysis	3.2.3	1	continuing	*ITESM *UNAM
Develop protocol for stomach contents analysis	3.2.3.1	2	continuing	*ITESM *UNAM

PLAN TASK	TASK NUMBER	PRIORITY	TASK DURATION	RESPONSIBLE ENTITIES
Establish program to analyze contaminants	3.2.3.2	1	continuing	*UNAM *CICESE
Establish program to collect and analyze tissue for life history	3.2.3.3	1	continuing	CIMEX ITESM *SWFC
Establish program for genetic analysis	3.2.3.4	1	2 years	UNAM *SWFC *NMFS
Database on strandings and entanglements of vaquita	3.3	2	continuing	ITESM UNAM
Establish and maintain a Recovery Team	4.1	1	continuing	COMMITTEE *MMC
Designate Coordinator to organize recovery activities	4.2	1	continuing	COMMITTEE
Review Recovery Plan advancements	4.3	2	continuing	COMMITTEE *MMC

* These organizations and agencies have yet to commit to participation in recovery activities.

INSTITUTIONS AND AGENCIES

S.M.	Secretaría de Marina.
SEPESCA.	Secretaría de Pesca.
ST-GOV.	State Governments of Sonora and Baja California.
COMMITTEE	Comité Técnico para la Preservación de la Totoaba y la Vaquita.
DGOCP.	Dirección General de Organización y Capacitación Pesquera.
CEDO.	Centro de Estudios del Desierto y del Oceano (Puerto Peñasco, Sonora).
UNAM.	Universidad Nacional Autónoma de México (México Distrito Federal).
ITESM.	Instituto Tecnológico de Estudios Superiores Monterrey (Campus Guaymas, Sonora).
CRIP-G.	Centro Regional de Investigación Pesquera (Guaymas, Sonora).
CRIP-L.	Centro Regional de Investigación Pesquera (La Paz, Baja California Sur).
CRIP-E.	Centro Regional de Investigación Pesquera (Ensenada, Baja California).
CIDESON.	Centro de Investigación y Desarrollo del Estado de Sonora (Hermosillo, Sonora).
CES.	Centro Ecológico de Sonora (Hermosillo, Sonora).
CICESE.	Centro de Investigación Científica y Estudios Superiores de Ensenada (Ensenada, Baja California).
NMFS.	National Marine Fisheries Service.
MMC.	Marine Mammal Commission.
SWFC.	Southwest Fisheries Science Center (La Jolla, California).
CIMEX.	Conservation International de México, A. C. (México, Distrito Federal).

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VIII. FIGURES

Figure Captions

Figure 1. Map of the Gulf of California showing locations where vaquita sightings have occurred or specimens have been recovered. Locations of vaquita records are indicated by **o**.

Figure 2. Map of the Gulf of California illustrating the area in which some types of gillnets are restricted. Restricted area is indicated by .__.__.

Figure 1

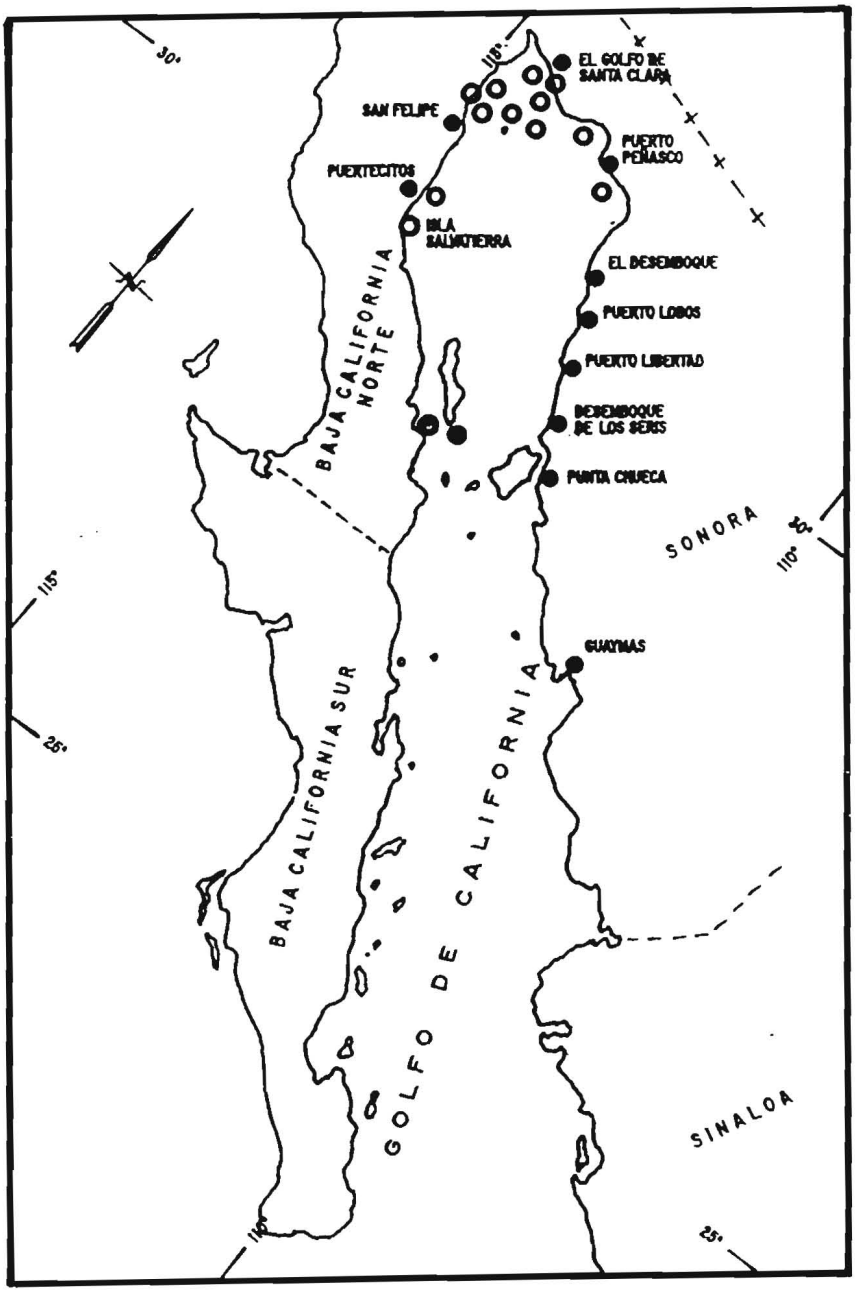
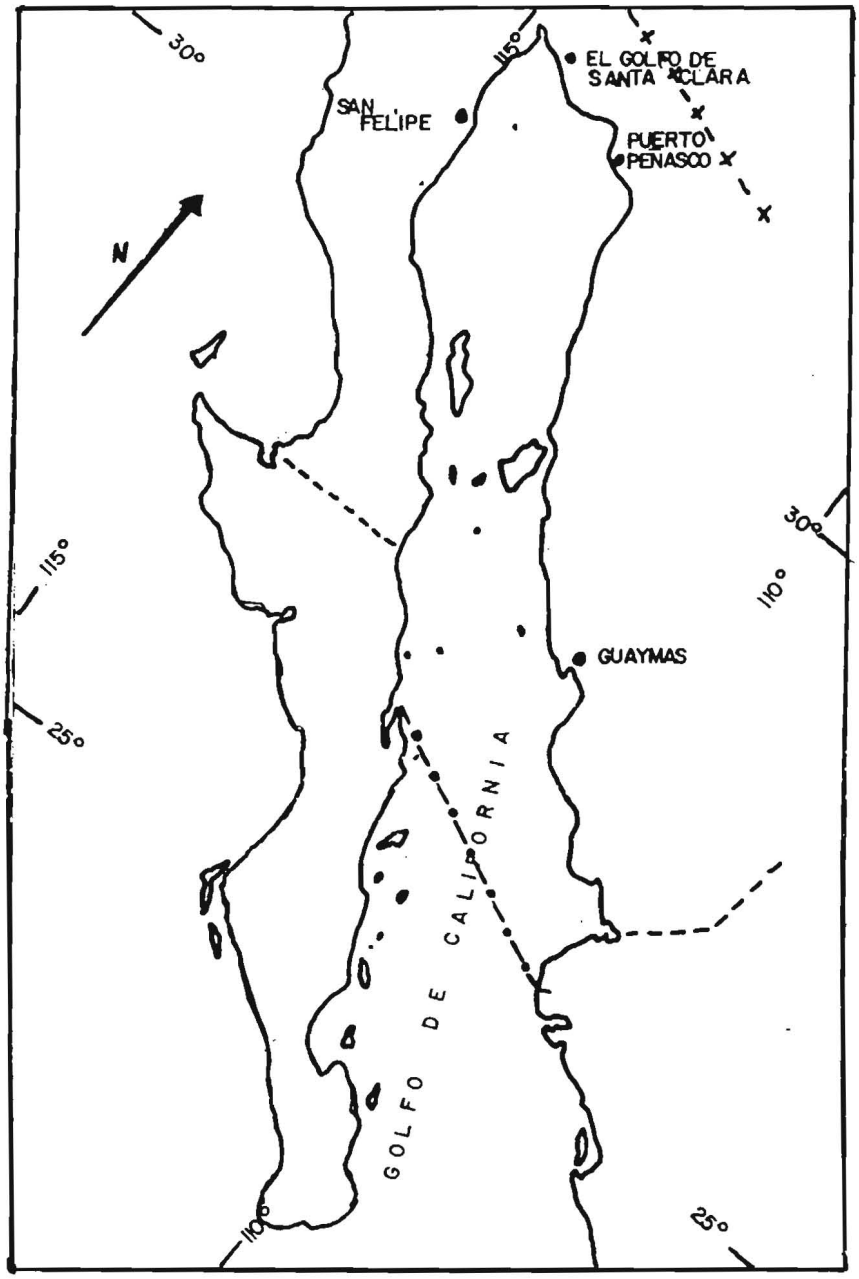

30°
115°
25°
110°
EL GOLFO DE SANTA CLARA
SAN FELIPE
PUERTO PEÑASCO
PUERTECITOS
ISLA SALSIPUEDES
EL DESEMBOQUE
PUERTO LOBOS
PUERTO LIBERTAD
DESEMBOQUE DE LOS SERIS
PUNTA CHUECA
BAJA CALIFORNIA NORTE
SONORA
GUAYMAS
BAJA CALIFORNIA SUR
GOLFO DE CALIFORNIA
SINALOA

Figure 2



---- RESTRICTED AREA FOR THE USE OF GILL NETS