ATTACHMENT 29

Status of Sea Turtles in San Diego Bay

1989 - 1990 Final Report

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by

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Table of Contents

Introduction 1

Study Site 1

Methods 2

Results 3
- Numbers and sizes 3
- Origins 3
- Carapace and plastron color and shape 4
- Diet 4
- Overall health 4
- Tumors, scars, and parasites 4

Discussion 5
- Population size and movements 5
- Protection 6
- Future research prospects 7

Recommendations 7

Acknowledgments 8

Literature Cited 8

Tables and Figures

Table 1.	Sea turtles tagged in south San Diego Bay, 1990.	10
Table 2.	Carapace and plastron colors and shapes.	11
Table 3.	Scars, marks, ectoparasites, and skin conditions of captured turtles.	12
Figure 1.	San Diego Bay, showing location of the San Diego Gas and Electric Power Company power plant.	13
Figure 2.	Diagram of south San Diego Bay with SDG&E power plant effluent channel.	14
Figure 3.	Sea turtle, *Chelonia* sp., sightings and water temperatures in the effluent channel adjacent to the SDG&E power plant in San Diego Bay, from May 1989 through June 1990.	15
Figure 4.	Juvenile black turtle (X105-106) caught in San Diego Bay, May 1990.	16
Figure 5.	Adult female black turtle (X107-108) caught in San Diego Bay, May 1990.	17
Figure 6.	Fibropapilloma tumors on the eye of an adult male black turtle.	18

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Introduction

Since its construction in 1960, the San Diego Gas & Electric (SDG&E) Power Plant on San Diego Bay has harbored a small population of sea turtles. This is the only area on the west coast of the United States where sea turtles are known to aggregate (Stinson 1984). They appear to be attracted to the warm water effluent discharged by the power plant. During the late 1970s, Stinson (1984) identified them as *Chelonia mydas*, the green sea turtle. She studied the turtles and their movements in relation to tidal flow, water temperatures, and a number of other parameters and stated that they were only present during November through April, migrating out of the bay at the onset of the warm summer months. Their origins and migratory habits remained a mystery.

Since Stinson's study there have been other sightings of turtles (Balazs, unpublished observations, Fredrik Jacobsen, SDG&E, pers. comm.) but no further studies. The present study was undertaken in order to assess the current status – number, species, maturity, sex and physical condition – of sea turtles in San Diego Bay. We also hope to identify origins and migratory habits. This information is crucial to the development of effective management plans.

Study Site

Our study site was the warm water effluent channel of the SDG&E power plant in Chula Vista, California, located at the southernmost point of San Diego Bay (Figure 1). The channel is bordered on the south by low grassy flatlands, and on the north by a dike extending about 1 km out from the power plant (Figure 2). The dike is designated a Least Tern Nesting Sanctuary, and is restricted from public access.

There is a bridge across the channel about 50 m from its origin and a large stationary barge is adjacent to the bridge. There are three outflow areas, two inside the bridge and one just outside. At this point the channel is at its narrowest, about 50 m across at high tide.

Channel width and depth fluctuate with the tide. At high tide, it is about 5 m deep and 150 m across. At low tide, it drops to about 2.5 m deep and 30 - 50 m across, and extensive mud flats are exposed on both sides.

San Diego Bay is heavily travelled and very industrialized. A major Naval base, shipyards, recreational marinas, restaurants, and houses cover virtually all of its 40 km shoreline. The only access to the bay from the ocean is at its northern point, about 15 km from the effluent channel.

Methods

We began observations in May, 1989. Once a week for one hour, two to four observers recorded turtle sightings from shore and from a bridge over the warm water effluent channel adjacent to the power plant (Figure 2). Surface water temperatures of both the inlet and effluent channels to and from the power plant were also recorded.

We began attempts to capture turtles in February, 1990, using a 45.7 m (150 ft) by 7.6 m (25 ft) tangle net with a 40.6 cm (16") mesh. We set the net across the channel from the stationary barge to the north shore using a boston whaler. After several unsuccessful daytime attempts, we began setting at sunset. The net was left in place from 17:00 to 21:30, and monitored continuously. On May 12 - 13 and May 26 - 27 two nets were used: the one previously described, set near the barge, and one 91.4 m (300 ft) long by 3.6 m (12 ft) deep, set approximately 100 m further out. These were in place from 17:30 to 10:00 the next morning, and were monitored hourly.

When a turtle was caught it was lifted into the boat, untangled from the net, and strapped to a neoprene-covered board for restraint. We weighed and measured the turtle and noted its general physical condition, including the presence of scars, lesions, or ectoparasites. Carapace color and shape and plastron color were noted, and each turtle was photographed. All turtles were double tagged with National Marine Fisheries Service (NMFS) inconel tags, one on the trailing edge of each front flipper one to two inches from the carapace, using standard techniques (Pritchard et al. 1983). Adults were also tagged through the rear flipper with a green Allflex™ plastic tag used by the Black Turtle Recovery Project in Michoacan, Mexico.

Blood samples were taken from some individuals by inserting a needle attached to a vacutainer into the venous sinus in the back of the neck, using the technique described in Bentley and Dunbar-Cooper (1980) and Owens and Ruiz (1980). These samples were sent to the University of Georgia, Department of Genetics where researchers will attempt to develop protocols for mitochondrial DNA analysis from blood to determine the origins of the turtles. Samples from the juveniles were also centrifuged, and the serum will be sent to Dr. Dave Owens at Texas A&M University for sexing.

Results

Between May 1989 and June 1990, bay water temperatures ranged from a low in February 1990 of 56.2°F to a high in June 1990 of 82.0°F, with corresponding effluent channel temperatures of 62.6°F and 98.1°F. The temperature differential between the inlet and effluent channel ranged from 4.7 - 16.1°F, so that the water in the effluent channel was usually at least 5°F warmer than that of the rest of the bay, and at least 20°F warmer than that of the ocean off San Diego (Kent Miles, San Diego Gas & Electric Co., pers. comm.).

Turtles were observed throughout the year in the effluent channel except on three occasions, in July and August 1989, and June 1990. As expected, effluent temperatures during these occasions were among the highest of the study (Figure 3). However, we know that the turtles did not entirely leave the bay, because power plant employees reported seeing turtles in the outlet channel in July 1989.

Numbers and sizes

We captured and tagged seven turtles: three juveniles, two adult males and two adult females. Straight carapace length ranged from 54.4 cm to 95.5 cm, and weights ranged from 24 kg to 112 kg. Complete morphological characteristics are outlined in Table 1. None of the turtles had tags, nor could we detect signs (i.e. scars or notches) of previous tags. We know through visual identification that there are at least two more turtles present in the channel. One of these, a very large adult female with a characteristic deformity of the carapace, looks identical to one that was tagged ten years ago (Stinson 1984). The other is a dark colored male with a large barnacle on his head.

Origins

Based on size, carapace and plastron color and carapace shape, we are distinguishing the black turtle, *Chelonia agassizi*, (also known as the eastern Pacific green), from the green turtle, *Chelonia mydas*. Black turtles nest in Mexico (Alvarado and Figueroa 1988), whereas green turtles nest elsewhere in the Pacific, notably in Hawaii[1] (Balazs 1976). We identified at least six of the seven captured turtles as blacks; the other may be a green. Attempts at positive identification by mitochondrial DNA analysis are in progress. Of the turtles that eluded capture, the large female can be identified by her rounded carapace and large size as a green.

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[1]The black turtle, or eastern Pacific green, is considered by some to be a subspecies of *Chelonia mydas* (Pritchard 1986). In this report we will refer to it as *Chelonia agassizi* in order to distinguish the two forms.

Carapace and plastron color and shape

Carapace colors ranged from solid black to dark brown with greenish or creamy streaks or specks (Table 2). Six of the turtles had carapace characteristics of *Chelonia agassizi*: dark in color, slightly elongated, with slight (in the juveniles) to very pronounced indentations in the rear edge of the carapace (Figures 4 and 5). All of these had gray plastrons, except for one juvenile whose plastron was creamy with gray blotches. One adult male had a dark gray, mottled carapace with no indentations, and may have been *Chelonia mydas*.

Diet

Stinson (1984) suggested that the San Diego Bay turtles were feeding on the eelgrass, *Zostera marina*, growing in several beds near the SDG&E channel (Figure 2). Our data appear to support this; a fecal sample collected from one of the captured adult females consisted of remnants of eelgrass.

Overall health

Except for the presence of small tumors (described below), the turtles generally appeared to be in good condition. Weights were as expected for their size, and they were active. Other than a small lesion on the axilla of one turtle, there were no skin lesions, and their shells were hard, smooth and intact.

Tumors, scars, and parasites

Three turtles -- one male, one female, and one juvenile -- had white flakes/growths (1 x 2 mm) on the eye and small (3 x 5 mm) pinkish growths on the eyelids (Figure 6). Photographs sent to George Balazs (NMFS, Honolulu Laboratory) enabled him to identify these as early growth stages of fibropapilloma tumors[2]. One female and one juvenile had concentrations of parasites on the soft tissue around the throat, neck, and axilla. Some of the parasites were collected and sent to Balazs, who identified them as *Ozobranchus*, probably *O. branchiatus*, a species of marine leech often found in association with fibropapilloma tumors (Choy et al. 1989). The juvenile also had a lesion (~1 cm diameter) on the left axilla, probably the result of parasitic attachment. Its eyes were inflamed, but did not contain tumors. Another female had a small white scar on the right shoulder that appeared to be a mating scar. The left front flipper of one male had a wide notch with a bright pink edge, as if it had been bitten. The carapace of one adult female had a notch out of the right rear edge. One male had eight barnacles attached to his carapace and plastron. We collected two of these; the carapace underneath was smooth and hard. These observations are outlined in Table 3.

[2]For more information on fibropapilloma tumors, see Balazs (1986).

Discussion

Population size and movements

Stinson (1984) estimated the San Diego Bay turtle population at about 30 individuals, although it is unclear what this estimate was based on, and she only captured and tagged six turtles. We have seen at most nine at any one time. This is the minimum number of turtles in the bay and should not be interpreted as a population estimate. Continued study is required until all the individuals have been captured and tagged. Furthermore, the population may fluctuate from year to year, so population estimates should not be based on one year's data.

We do not know whether these turtles have wandered into the bay and stayed, or leave periodically (to nest, for example) and then return. Unlike Stinson (1984), we saw turtles in the channel throughout the year, and did not observe emigration from the bay in April. The presence of a possible mating scar on one female suggests that they may leave to mate and nest, although sea turtles have been observed mating off the coast of San Diego (Hubbs 1977). Although the turtles we caught did not show evidence of previous tags, it is possible that some were present during Stinson's study ten years ago. At least one, the previously mentioned female with a deformed carapace, is identical to one Stinson described and photographed. At least two of the turtles currently present are juveniles, so there is some recruitment into the population.

Juveniles could be recruited into (or, conversely, emigrate out of) the bay with incursions of warm equatorial currents (known as "El Niño" events). The last major El Niño took place in 1983 (McGowan 1983); unfortunately, there are no records of the number of turtles in the bay at that time. Monitoring the turtle population in years prior to and following an El Niño could help test this hypothesis.

In general there appears to be no clear relationship between the number of turtles sighted and effluent channel temperatures. However, when the water temperature exceeded 90°F we did not see any turtles. It is possible that turtles move out of the effluent channel in summer to avoid extreme high temperatures. This is reasonable, because the channel temperature occasionally approached the lethal temperatures reported in the literature (91.4 -104°F: Bustard 1970; Faulkner and Binger 1927). Summer bay temperatures are comparable to those in the effluent channel in winter, and well within those temperatures at which green turtles are reported to occur (Mrosovsky 1980, Stinson 1984). Telemetry studies should be done to find out more about these short-range movements.

If turtles do leave the bay, the flipper tags will help us track their movements. In addition to the NMFS tags, we are also using the same tags that are being used on the beaches of Michoacan in the Black Turtle Recovery Project, where nesting females and their

eggs are protected (Alvarado and Figueroa, 1988). We are in contact with researchers from that project, who will notify us if any female we tag appears on the nesting beach. We are also in contact with Joe Cordaro, NMFS, Terminal Island, who compiles all reports of sea turtle strandings along the California coast, and George Balazs, NMFS Southwest Fisheries Center, Honolulu Laboratory. They will notify of any strandings or tag returns from turtles originally tagged in San Diego Bay.

Protection

The warm water effluent of the power plant is apparently enabling these turtles to exist in an area where sea turtles are not otherwise known to aggregate. Length/weight data indicate that the animals are getting plenty to eat; we assume they are feeding on eelgrass which grows in abundance near the channel. A fecal sample obtained from one of the captured females consisted entirely of eelgrass. In spite of the warm water and food availability, however, there are many potential hazards to sea turtles in the bay.

Gillnet Fishermen

Five permits have been issued for the use of gillnets to catch mullet in San Diego Bay (Phil Swartzell, California Fish and Game, pers. comm.). Only two are currently active; however, the fishermen often set their nets across the channel where the turtles occur, and in fact have admitted catching turtles as bycatch. Although these fishermen do not leave their nets unattended, the possibility of drowning a sea turtle here or elsewhere in the bay exists.

Recreational Use

Although the SDG&E channel is a restricted area, we have often observed speed boats, some towing water skiers, travelling up and down the channel. Boat propellers are a tremendous hazard to a turtle that happens to surface in the boat's path. Stinson (1984) noted that turtles did not increase their speed when followed by a boat, and we observed turtles surfacing within six feet of our boat, even when the motor was running.

Poachers

As public awareness about the turtles increases, the possibility of illegal turtle hunting might also increase. Hunting at night may be difficult to control or even detect.

Future research prospects

A study of the reproductive physiology of these turtles using laparoscopy or ultrasound would tell us whether they are reproductively active. Used in conjunction with

ultrasonic, radio and satellite tags to track movements, this could help provide valuable information on migration patterns and orientation of sea turtles in the Pacific. Ultrasonic tags in particular would be very useful for tracking turtles in the bay, and in determining whether they remain submerged for long periods of time in cold water.

Continued monitoring of the turtles will show whether they enter and leave the bay from year to year, and whether new turtles continue to arrive.

Recommendations

To help protect the sea turtles in San Diego Bay we recommend:

1. Alerting California Department of Fish and Game agents and the Harbor Police to the presence of the turtles, and pointing out the hazards presented by gillnet and recreational activities in south San Diego Bay, particularly in and around the effluent channel;

2. Posting signs near the effluent channel and Silver Strand warning boaters and fishermen to avoid the area inhabited by the turtles;

3. Continuing to monitor the population over at least the next three years to:
   a. determine whether any of the adults leave the bay;
   b. determine whether new turtles enter the bay;
   c. obtain growth rates for the juveniles;
   d. determine the extent of papilloma infection and monitor the progress of infected turtles;
   e. further study feeding habits and movements in order to better define a "critical habitat" for sea turtles in San Diego Bay.

4. Expanding the Chula Vista Nature Reserve (which now only includes the Least Tern Nesting Sanctuary) to include the SDG&E effluent channel and other critical habitat to be defined by the studies proposed in 3e.

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Donohoe, Regina Rudnicki, Elaine Corets, Dave Arney, and Becky Roberts. Margie Stinson provided helpful information at the beginning of the project. Dr. Dave Owens of Texas A&M University provided blood sampling equipment, and Brian Bowen of the University of Georgia is carrying out mtDNA analysis. Richard Byles, Jack Woody and Javier Alvarado were very supportive and helpful with their advice. Don Waller, Kent Miles, Fred Jacobsen and Chris Hawkins of San Diego Gas & Electric were consistently helpful and cooperative, and Mr. Miles provided water temperature charts and graphs of the channels. George Balazs, NMFS, provided tags and tagging equipment as well as constant advice and encouragement throughout the project.

The turtles were captured under National Marine Fisheries Service Permit #697 and California Department of Fish & Game permit No. 0411.

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Table 1. Sea turtles tagged in south San Diego Bay, 1990.

Tag Number						Carapace Length (cm)		Carapace Width (cm)	
NMFS	USFWS	Date Tagged	Time Tagged	Sex	Weight (kg)	Straight	Curved	Straight	Curved
X101, X102	none	3/31	18:50	Juv	29.0	56.7	59.6	46.8	57.2
X103, X104	A2779	5/12-13	21:28	Male	100.0	85.5	88.5	65.0	77.0
X105, X106	none	5/12-13	03:50	Juv	24.0	54.4	58.5	44.4	56.5
X107, X108	A2780	5/12-13	05:30	Fem	99.9	92.0	97.0	68.2	88.0
X109, X110	A2781	5/12-13	07:50	Fem	88.0	85.0	93.0	63.9	83.2
X111, X112	A2782	5/26-27	04:00	Male	112.0	95.5	99.0	69.0	90.0
X113, X114	none	5/26-27	09:47	Juv	40.5	67.0	71.4	54.5	68.5

Table 2. Carapace and plastron colors and carapace shapes.

Tag No.	Sex	Carapace	Plastron	Indentations
X101-102	J	Black, round	Gray, yellow patches	slight
X103-104	M	Dark gray, mottled, oblong	Gray	slight to none
X105-106	J	Dark brown with creamy streaks	Pale blue-gray	slight
X107-108	F	Dark brown with gray-green streaks	Gray with cream blotches	pronounced
X109-110	F	Brown with green-cream streaks	Gray with cream blotches	pronounced
X111-112	M	Black with gray-green mottling	Gray, mottled	pronounced
X113-114	J	Mottled olive and brown	Cream with gray blotches	pronounced

Table 3. Scars, marks, ectoparasites, and skin conditions of captured turtles.

Tag #	Sex	Comments
X101-102	J	No scars, marks, tumors, or parasites.
X103-104	M	No scars or marks. Small tumor on right eye, very small lesion/tumor on left. Seven barnacles on carapace, one on plastron.
X105-106	J	No scars or marks. White flakes/growths on eyelids, 1 x 2 mm. No parasites.
X107-108	F	Small (~1 x .25 inch) scar on right shoulder; possible mating scar. No tumors or lesions. No parasites.
X109-110	F	Notch in right indentation of carapace. Small lesions/tumors on both eyelids. Concentrations of parasites under both front flippers.
X111-112	M	Wide notch with pink edge on trailing edge of left front flipper. Left back flipper notched, giving the appearance of a toe. Possible barnacle scars on carapace. No tumors. No parasites.
X113-114	J	No scars. Eyes inflamed but no tumors. Parasitic barnacles (?) around throat, neck and armpits. Lesion (~1 cm) under left armpit may be result of parasitic attachment.

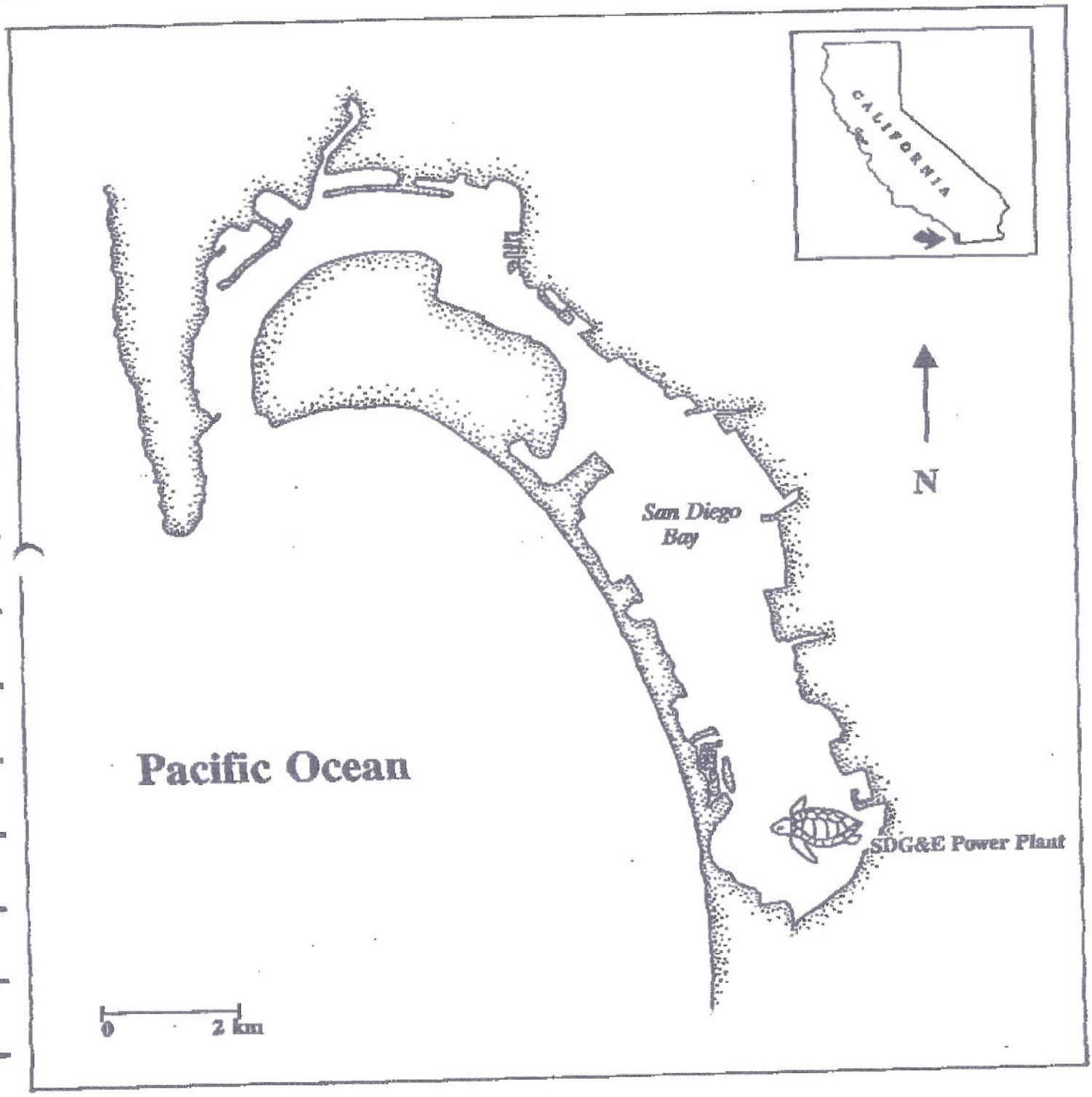

Figure 1. San Diego Bay, showing location of the San Diego Gas and Electric Power Company's power plant.

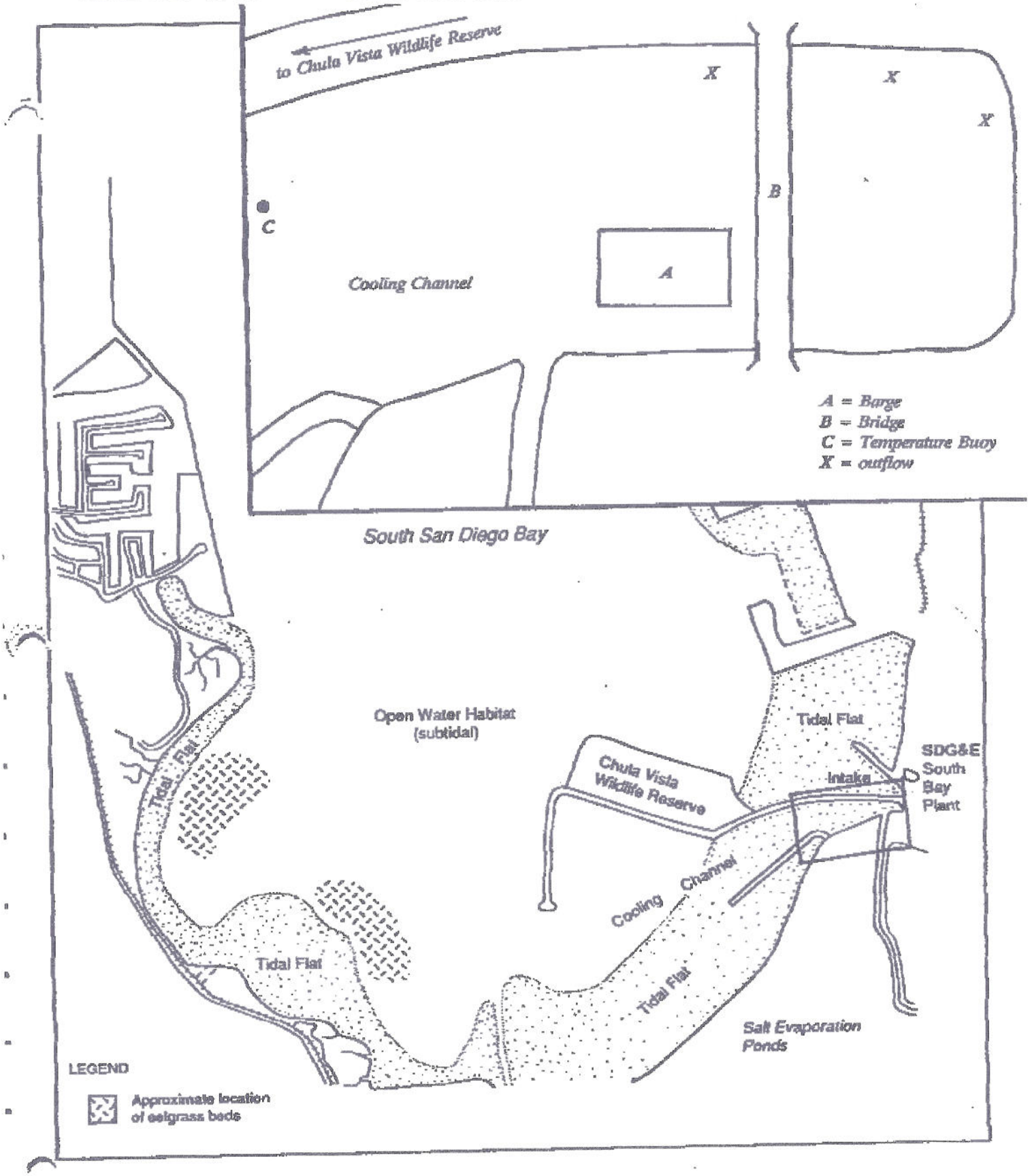

Figure 2. Diagram of south San Diego Bay with SDG&E power plant effluent channel. Inset shows main study area. (Main map courtesy of SDG&E.)

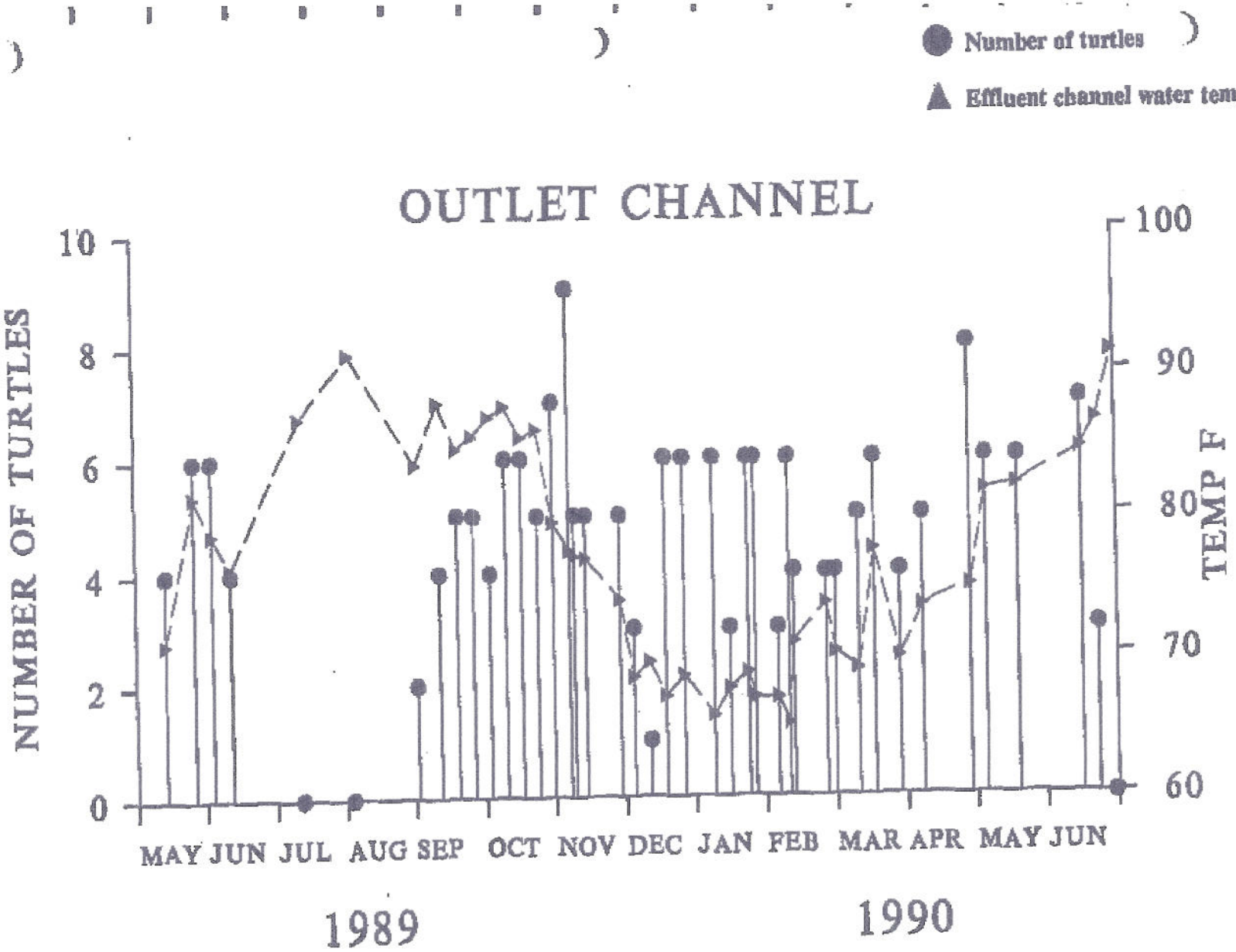

Figure 3. Sea turtle, *Chelonia* sp., sightings (●) and water temperatures (▲) in the effluent channel adjacent to the SDG&E power plant in San Diego Bay, from May 1989 through June 1990.

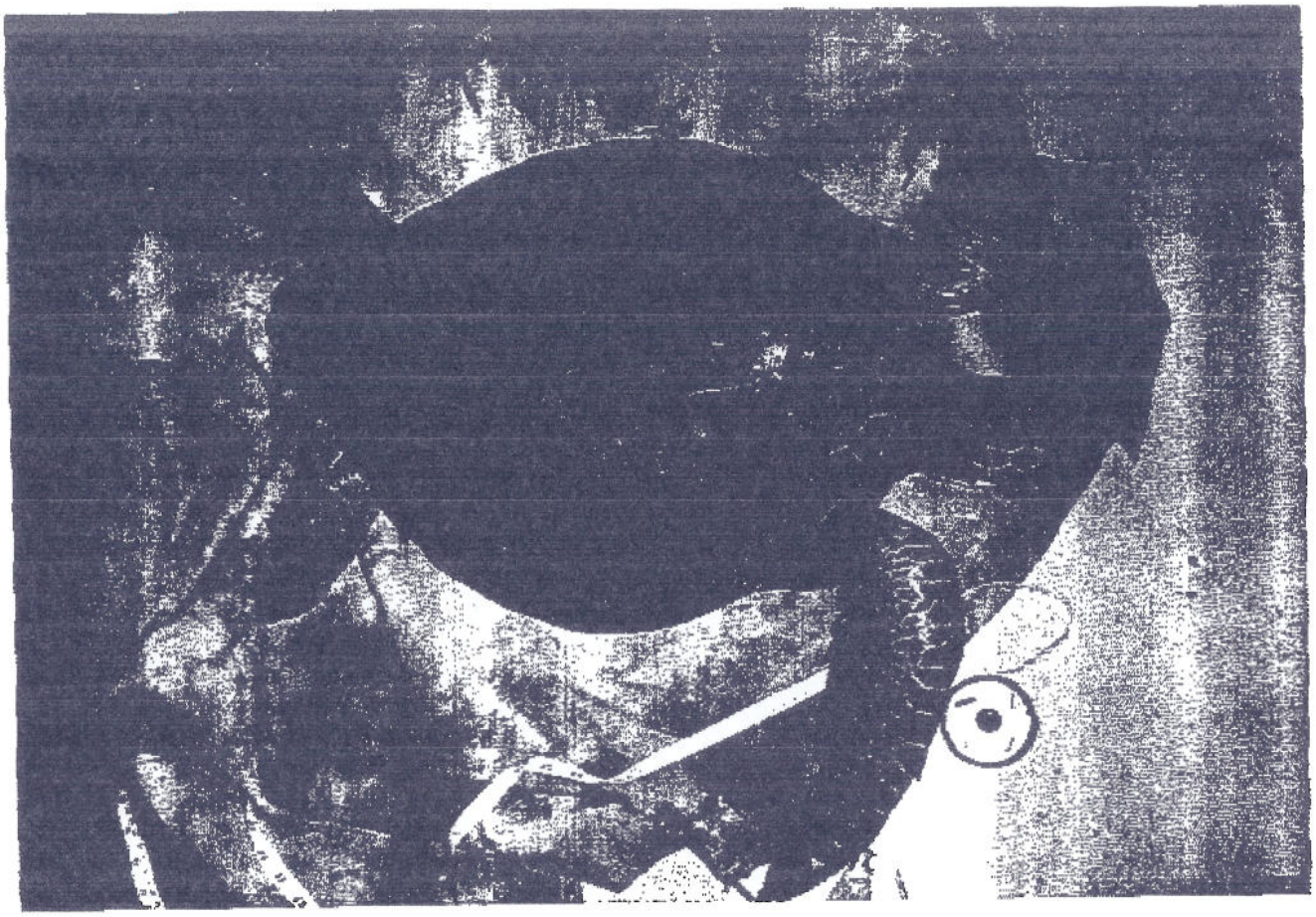

Figure 4. Juvenile black turtle (X105-106) caught in San Diego Bay, May 1990[1]. Note pointed carapace and slight indentations in its rear margins.

[1] The black turtle, or eastern Pacific green, is considered by some to be a subspecies of the green, *Chelonia mydas* (Pritchard 1983). In this report we will refer to it as *Chelonia agassizi* in order to distinguish the two forms.

Figure 5. Adult female black turtle (X107-108) caught in San Diego Bay, May 1990 (see footnote Figure 4). Note the strong indentations on the rear edges of the carapace.

Figure 6. Fibropapilloma tumors on the eye of an adult male black turtle.