TESTING ATTACHMENT TECHNIQUES FOR SATELLITE TRANSMITTERS ON BOTTLENOSE DOLPHINS NEAR SARASOTA, FLORIDA

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Andrew J. Read[1], Andrew J. Westgate[1], Randall S. Wells[2], Danielle M. Waples[2], Bernadette M. Allen[2], Michael D. Scott[3], and Aleta A. Hohn[4]

[1] Duke University Marine Lab, 135 Duke Marine Lab Road, Beaufort, NC 28516

[2] Chicago Zoological Society, Sarasota Dolphin Research Program, c/o Mote Marine Laboratory, 1600 Thompson Parkway, Sarasota, FL 34236

[3] InterAmerican Tropical Tuna Commission, c/o Scripps Institute of Oceanography, La Jolla, CA 92038

[4] National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort Laboratory, 101 Pivers Island Road, Beaufort, NC 28516

Introduction

The collection of information on the structure of stocks of bottlenose dolphins (*Tursiops truncatus*) in the southeastern U.S. has become recognized by scientists and managers as a research topic of high priority, particularly with reference to the depleted stock(s) along the mid-Atlantic coast (Wang *et al.* 1994; Hohn 1997). Data on ranging patterns are crucial for stock identification. Such information can be obtained through a variety of techniques, including photographic identification, tagging, and radio-tracking (Scott *et al.* 1990). The nature of the questions determine the relative effectiveness of each technique. Recent efforts off the coast of North Carolina used short-range, short-term, well-tested VHF transmitters to monitor within-season movements of bottlenose dolphins in coastal and estuarine waters (Read *et al.* 1996). To address critical questions regarding long-distance, seasonal movements, a different form of radio-tracking would be more appropriate. Newly-developed satellite-linked transmitters can provide data over periods of months, and over unlimited distances, relayed to remote tracking stations (Mate *et al.* 1995; Read and Westgate in press).

Satellite-linked radio systems are still undergoing refinement. Questions remain regarding the impacts of long-term attachments of the transmitters on the animals themselves. As a result of this concern, a NMFS/ONR/MMS/MMC-sponsored workshop on marine mammal tagging and tracking recommended that animals in resident populations should be used to test attachment longevity (NMFS 1992). Known residents can be tracked and re-located visually on a periodic basis to evaluate animal and transmitter conditions, and intervene if problems occur. In preparation for the application of satellite-linked transmitters to mid-Atlantic bottlenose dolphins, we were contracted by the National Marine Fisheries Service to test transmitters used previously with much success by Read and Westgate (in press) on harbor porpoises (*Phocoena phocoena*) on members of the long-term resident bottlenose dolphin community near Sarasota, Florida. Differences in the habitat used by the two species, and previous experience with bottlenose dolphins attempting to remove gear attached to their own dorsal fins dictated the need for testing before applying these transmitters under less-controlled circumstances along the Atlantic seaboard (Scott *et al.* 1990). Specifically, we were contracted:

- To attach satellite-linked radio transmitters and VHF transmitters to bottlenose dolphins during June 1997,
- To monitor the condition of the dolphins and the attachment for two weeks post-attachment,
- To provide data on the condition and movements of the tagged dolphins,
- From these results, to provide recommendations on improvements to the satellite-linked transmitter configuration and attachment.

Methods

We attached satellite-linked radio transmitters, or platform transmitting terminals (PTTs), to two adult male dolphins (FB-10 and FB-46), captured in Anna Maria Sound, just north of Sarasota, FL on 09 June 1997. FB-10 and FB-46 were 16 and 19 years old and measured 251 and 267 cm in length, respectively. Both males were robust and physically healthy, based on intensive veterinary examinations at capture, and subsequent blood sample analyses. The sighting histories of these animals over the past ten years or more indicate that they are a strongly-bonded male pair, who travel together and are almost always seen in each other's company.

We used a side-mount configuration, consisting of a flat-board ST-10 PTT (Telonics, Mesa AZ, USA) mounted in a low-profile rectangular lexan box. Prior to tag attachment, the dorsal fin of each dolphin was cleaned with a topical antiseptic and the tagging site injected with an analgesic. The PTTs were attached to the side of the dorsal fin using three 8-mm diameter delrin pins, which passed through holes cut in the fin with a sterilized cork borer mounted on a cordless electric drill. A sterilized hypodermic needle was used to probe the proposed site of each pin, to ensure that it would not impact any major blood vessels. The 3-mm backing plate on the transmitter housing provided attachment points for the delrin pins. The pins passed through the backing plate and dorsal fin and were secured on the opposite side of the fin with a plastic washer and fastened with a bi-metallic combination of washers and nuts. Both backing plate and plastic washers were lined with open cell foam to reduce the possibility of abrasion. Each PTT had a 17-cm whip antenna, measured 1.1 x 5 x 2 cm and weighed approximately 150 g in air.

To minimize the size of the PTT packages, we used only one sensor, a surface time counter, which provided a cumulative record of the time the tag was above the water's surface. The value of the surface time counter was transmitted twice during each signal, allowing us to detect possible transmission errors. Each tag also incorporated a salt-water switch, which prevented transmissions when the animal was submerged. To further conserve battery life, we used a duty cycle of six hours tag operation each day. The PTTs were powered by two 2/3 A lithium cells which, under these operating conditions, should provide several months of battery life.

We also deployed standard Model 2 VHF radio transmitters (ATS, Ipsanti, MN, USA) on both dolphins. These tags transmitted in the 148 MHz range at 110 pulses per minute, without a salt water switch or duty cycle. The VHF transmitters have a life expectancy of more than 50 days. The tags were attached to livestock ear tags (Jumbo Roto-tags, Dalton Supplies, Nettlebed, ENG) applied to the trailing edge of the dorsal fin. In one case (FB-46), we were able to use an existing hole in the trailing edge of the dorsal fin to attach the roto-tag. The VHF tags had a 33 cm-long whip antennae, measured 1.1 x 2.5 x 5.5 cm and weighed 15 g in air. The VHF transmitters had an effective range of approximately 5 km at sea level. Similar roto-tag VHFs have been used on bottlenose dolphins in Florida and North Carolina (Read *et al.* 1996).

We attempted to relocate the two tagged dolphins daily using standard radio-tracking techniques during the initial period following attachment. The animals were followed for varying periods while photographs, video recordings, and standard behavioral observations were taken. After usable signals from the VHF radios ceased (by 19 June), the dolphins were relocated visually, and recorded photographically whenever possible.

Results

Data Uplinks

We obtained 23 uplinks from FB-10 between 12 June and 10 July. Ten of these uplinks provided usable location estimates, although the quality of the estimates was generally poor (Service ARGOS location classes A and B). The estimated locations of FB-10 generated by Service ARGOS are plotted in Figure 1a. In general, the location estimates (particularly the B class locations) exhibit longitudinal, rather than latitudinal, error. We received only six uplinks from FB-46 (all Z-classes), due to the change in transmitter configuration that occurred shortly after the release of this dolphin (see below).

Dolphin locations during and after tag attachment were consistent with previous locations, suggesting that the tags did not alter the basic ranging patterns of the dolphins (Figures 1a, 1b, 2). Some of the location estimates for FB10 from the satellite-linked tag indicated movements slightly to the north and west of the region normally surveyed, but these locations are within the known range of resident Sarasota dolphins.

We received a considerable amount of usable surface time data from FB-10. The tag mounted to the dorsal fin of FB-10 was above the water's surface for 3.05% of the period between 12 June and 06 July.

Tests conducted with PTTs and mock dorsal fins suggest that the poor quality of location estimates we received was caused by the location of the transmitter (and antenna) on the dorsal fin. In our attachment, we concentrated on placing attachment pins away from major blood vessels. As a result, the tags were situated fairly low on the dorsal fin, and the transmitting antennae did not extend beyond the anterior margin of the fin. Placement of the PTTs slightly higher on the dorsal fin should alleviate this problem, as suggested from the results of concurrent tracking of a rehabilitated stranded bottlenose dolphin with a similar PTT mounted higher on the fin (Wells *et al.* in prep).

Visual Observations

At the time of this writing, the two dolphins have been monitored over a period of 106 days post-attachment, from 09 June 1997 through 23 September 1997. One or both dolphins were observed on 38 occasions during this period (Table 1). The tags (PTTs) remained attached to FB46 until 17 July (37 days), and to FB10 until 22 July (43 days). The losses of the PTTs were preceded by the early failure of one or two attachment pins on each animal. Within 30 days of attachment, the PTTs, washers, and attachment plates were covered with a film of olive-green algae, making real-time evaluation of fin and tag condition difficult.

During initial tracking, we relocated the two dolphins together on 10, 11 and 12 June. On 11 and 12 June, the two males were accompanied by a young adult female, FB-101. During these sightings, photographs indicated that the tags were intact and all delrin pins were in place. On 13 and 14 June, radio signals indicated that the two tagged dolphins were in the Gulf of Mexico; strong westerly winds prevented us from relocating them on these days. On 15 June, the two dolphins (and FB-101) were resighted entering Big Pass from the Gulf of Mexico. At this time, it was evident that two of the three pins securing the PTT to FB-46 had sheared (forward and top/middle); the tag was attached by only the top/posterior pin and was upside-down, with the antenna pointing downwards. The transmitter's backing plate was lodged between the roto tag for the VHF radio and the dorsal fin, helping to stabilize its inverted position. The PTT on FB-10 was still in place, but the nut and washer which held the top/middle delrin pin had sheared. In each case where pins were lost, eroded areas containing a core of reddish tissue surrounded by white tissue where the padded washers had been in contact with the fin remained, suggesting pressure necrosis (Figures 3, 4).

The tag on FB46 was lost between 16 July and 17 July. This apparently occurred when the remaining pin sheared on the left (transmitter) side of the fin. Photographs from 17 July show the end of the delrin pin protruding through an area of necrosis on the raised convex lateral surface of the left side of the fin,

and the top of the washer, nut, and pin remaining on the left side penetrating the fin tissue (Figure 4). The last pin was gone by 22 July, leaving a red, granulating wound surrounded by white tissue. By 15 August, all three pin sites demonstrated successful healing. While still evident as indentations in the fin, all three sites were fully re-pigmented, with no indication of complications (Figure 4).

The tag on FB10 fell off the fin during observations on 22 July. The two remaining pins, washers, and nuts had been intact on 21 July. The remaining pins were jettisoned when the tag fell off (Figure 3). The left (transmitter) side of the fin did not exhibit the level of apparent necrosis seen on FB46. Small holes remained after loss of the transmitter, and a piece of delrin pin might have remained in the anterior-most hole initially that appeared fully healed by mid-August. The pin/washer sites on the right side of the fin exhibited erosions similar to those on the right side of FB46's fin, and these also appeared well-healed by mid-August.

Recommendations

This test of the PTT attachment system was successful, because we learned which components of the system need to be changed so that we can obtain long-term positional data on coastal bottlenose dolphins via satellite telemetry. This test, on two mature dolphins in the middle of the breeding season when agonistic conspecific interactions are most common, might be considered to be worst-case. Nevertheless, there is a clear need to improve the strength and durability of the PTT attachment system, while minimizing the impacts of the system on the fin. For future deployments of PTTs on bottlenose dolphins, we recommend:

1. Positioning the PTT higher on the dorsal fin and stiffening the antenna, so that the transmitting antenna is clear of the fin. This should improve the quality of location estimates received from Service Argos.

2. Increasing the number of delrin pins attaching the PTT to the dorsal fin to four or five, thus strengthening the attachment. Thus, if one or two pins break, the integrity of the attachment will less likely be compromised.

3. Investigating materials for attachment pins other than delrin that might be more resistant to shear forces that large, shallow-water dolphins can generate.

4. Using a backing plate or light-weight wrap-around saddle design instead of independent washers on the opposite side of the fin from the transmitter in order to distribute the support pressures, and relieve direct contact pressure on the fin.

5. Looking into the possibility of using different backing materials (other than open cell foam) that would relieve some of the pressure necrosis.

6. Investigating the use of anti-fouling agents that would reduce the build-up of flora and fauna on the tags and their attachments.

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List of Tables and Figures

Table 1. Sightings of satellite-tagged dolphins.

Figure 1. Location data for dolphin FB10.
1a. Locations from tag transmissions.
1b. Sighting locations during 1 January 1996 - 8 June 1997, prior to tag attachment (filled circles), and during 9 June 1997 - 23 September 1997, following tag attachment (open circles).

Figure 2. Sighting locations for dolphin FB46, 1 January 1996 - 8 June 1997, prior to tag attachment (filled circles), and during 9 June 1997 - 23 September 1997, following tag attachment (open circles).

Figure 3. Dorsal fin of dolphin FB10 with tag attached and following loss of tag. (Note: color photographs from which each figure was obtained are available)
3a. FB10 on 11 June 1997: right side of fin showing intact pins, washers, and nuts. Note FB46 in background.
3b. FB10 on 16 June 1997: left side of fin showing intact transmitter and attachments. Note VHF radio on roto tag attached to trailing edge of fin.
3c. FB10 on 18 June 1997: right side of fin showing missing attachment.
3d. FB10 on 18 June 1997: left side of fin.
3e. FB10 on 17 July 1997: right side of fin showing wound from attachment.

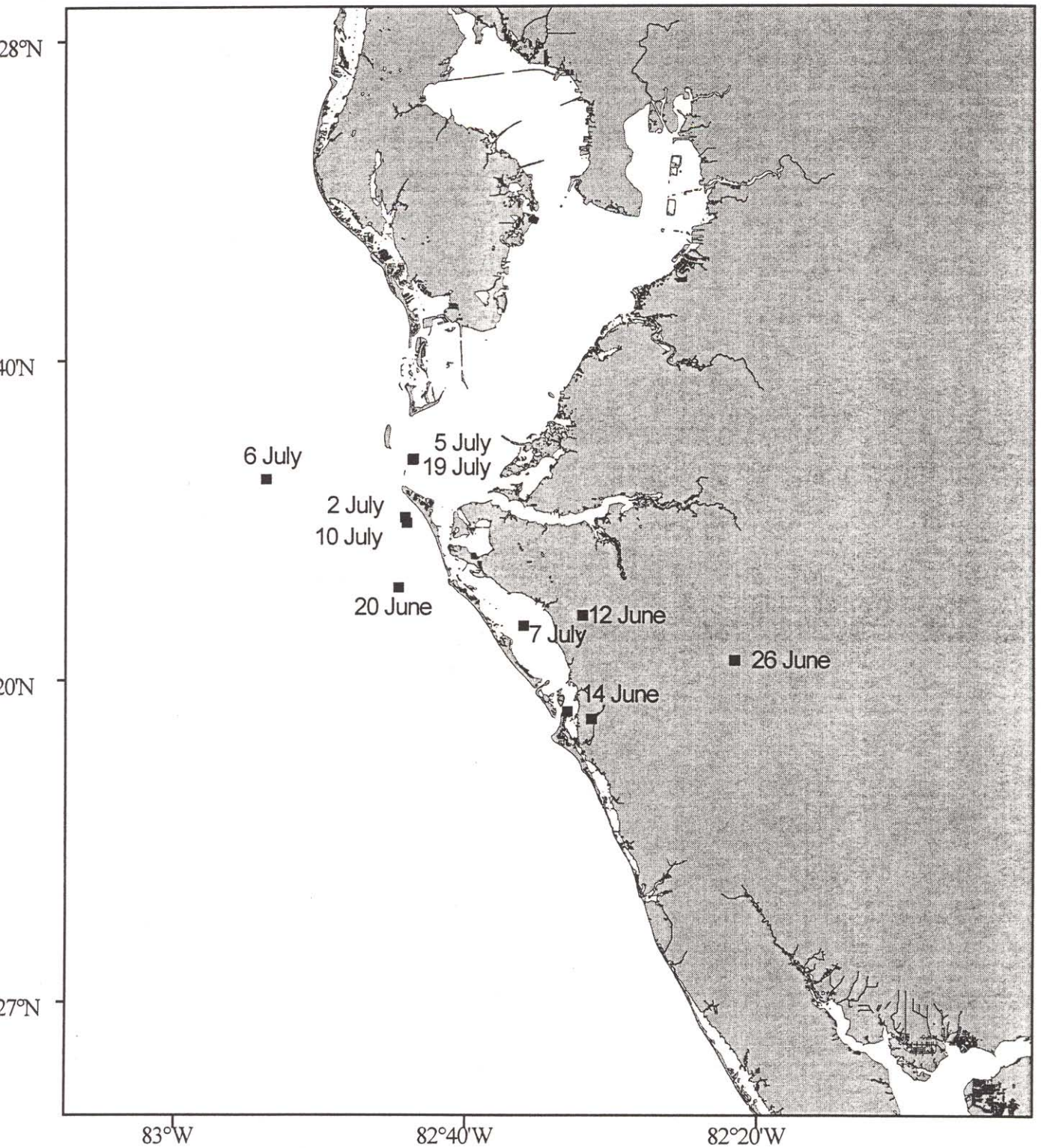
3f. FB10 on 17 July 1997: left side of fin, showing algal growth on transmitter.
3g. FB10 on 22 July 1997: left side of fin following loss of transmitter. Note lack of damage to fin tissue, and possible piece of delrin pin protruding from anterior hole.
3h. FB10 on 1 August 1997: left side of fin, showing healing.
3i. FB10 on 19 August 1997: right side of fin showing healing.

Figure 4. Dorsal fin of dolphin FB46 with tag attached and following loss of tag. (Note: color photographs from which each figure was obtained are available)
4a. FB46 on 11 June 1997: right side of fin showing intact pins, washers, and nuts.
4b. FB46 on 11 June 1997: left side of fin showing intact transmitter and attachments.
4c. FB46 on 16 June 1997: right side of fin showing last remaining attachment.
4d. FB46 on 16 June 1997: left side of fin showing inverted transmitter. Note FB10 ahead of FB46.
4e. FB46 on 8 July 1997: right side of fin showing wounds from attachments.
4f. FB46 on 8 July 1997: left side of fin showing inverted transmitter. Note how the (normal) bottom of the transmitter is leaning away from the fin, applying pressure to the top of the washer on the opposite side of the fin.
4g. FB46 on 17 July 1997: right side of fin showing wounds from attachments, and top of remaining washer cutting into fin from leverage of inverted transmitter on opposite side. Note FB10 in background.
4h. FB46 on 17 July 1997: left side of fin showing wounds from transmitter and remaining pin protruding through wound.
4i. FB46 on 22 July 1997: right side of fin showing initial healing of wounds following loss of transmitter and attachments.
4j. FB46 on 15 August 1997: right side of fin showing healing of wounds.

Table 1. Sightings of satellite-tagged dolphins.

Date	Time Begin	Time End	Location	FB10	FB46	Comments
Jun 09, 97	1653	2031	Perico Harbor channel, Anna Maria Sound	Y	Y	Capture for tagging
Jun 10, 97	1354	1504	Passage Key Inlet	Y	Y	
Jun 11, 97	1053	1135	N of Siesta Key, Big Sarasota Pass	Y	Y	
Jun 11, 97	1225	1340	SE of Stephens Point, Sarasota Bay	Y	Y	
Jun 11, 97	1505	1517	N of Stephens Point, Sarasota Bay	Y	Y	
Jun 12, 97	1005	1020	E of Sister Key, Sarasota Bay	Y	Y	
Jun 12, 97	1114	1127	SW of Sister Key, Sarasota Bay	Y	Y	
Jun 12, 97	1428		W of N Longboat Key, Gulf of Mexico	Y	Y	
Jun 15, 97	1802	1933	N of Siesta Key, Big Sarasota Pass	Y	Y	FB10: pin missing; FB46: inverted, 2 pins missing
Jun 16, 97	1343	1725	New Pass	Y	Y	
Jun 16, 97	1725	1736	N of Siesta Key, Big Sarasota Pass	Y	Y	
Jun 17, 97	1303	1457	New Pass	Y	Y	
Jun 18, 97	0833	0900	NW Sarasota Bay	Y	Y	
Jun 18, 97	1430	1449	Sarasota Bay	Y	Y	
Jun 20, 97	1250	1440	E of Longboat Pass	Y		
Jun 23, 97	0908	0926	E of City Island	Y	Y	
Jun 30, 97	1340	1410	Anna Maria Sound		Y	FB46: pack covered by algae
Jun 30, 97	1331	1345	NW Sarasota Bay	Y		
Jul 04, 97	0933	0952	Sarasota Bay	Y	Y	FB10: pack covered by algae
Jul 08, 97	1047	1127	NW Sarasota Bay	Y	Y	
Jul 11, 97	1400	1413	NW Sarasota Bay	?	?	Couldn't determine which dolphin present
Jul 14, 97	1113	1138	E of Longboat Pass	Y	Y	
Jul 15, 97	1441	1444	Anna Maria Sound	?	?	Couldn't determine which dolphin present
Jul 16, 97	0920	1105	SE of Sister Key		Y	
Jul 16, 97	0929	1150	NE of Anna Maria Island	Y		
Jul 16, 97	1146	1326	S of Longboat Pass		Y	
Jul 17, 97	1416	1441	NW of Anna Maria Island	Y	Y	FB46: Pack missing since yesterday (37 days)
Jul 18, 97	1530	1556	Anna Maria Sound	Y		
Jul 21, 97	0947	1004	NE of Jewfish Key	Y		
Jul 21, 97	1005	1010	Sister Key Flats	Y		
Jul 22, 97	0957	1118	NE of Longboat Pass	Y	Y	FB10: Pack jettisoned (43 days); FB46: last pin gon
Jul 25, 97	1414	1425	Cortez, Anna Maria Sound		Y	
Jul 28, 97	1036	1116	W of Anna Maria Island, Gulf of Mexico	Y		
Aug 01, 97	1124	1131	NW Sarasota Bay	Y	Y	
Aug 15, 97	1401	1434	NW Sarasota Bay	Y	Y	
Aug 19, 97	1350	1426	NW Sarasota Bay	Y	Y	
Sep 18, 97	1107	1130	SE of Passage Key	Y	Y	
Sep 23, 97	0952	1007	NW Sarasota Bay	Y	Y	

Figure 1a. Location data for dolphin FB10: locations from tag transmissions.



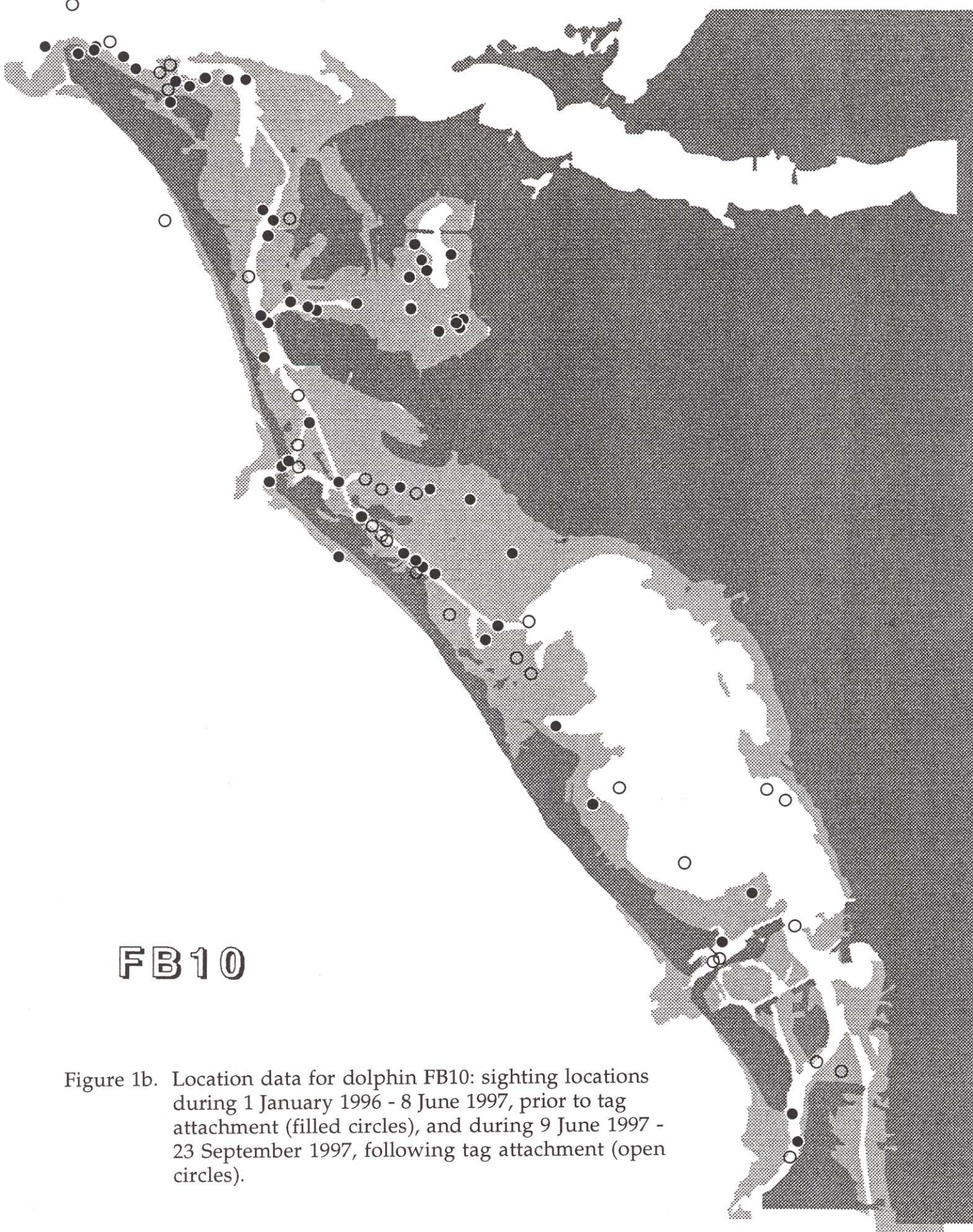


Figure 1b. Location data for dolphin FB10: sighting locations during 1 January 1996 - 8 June 1997, prior to tag attachment (filled circles), and during 9 June 1997 - 23 September 1997, following tag attachment (open circles).

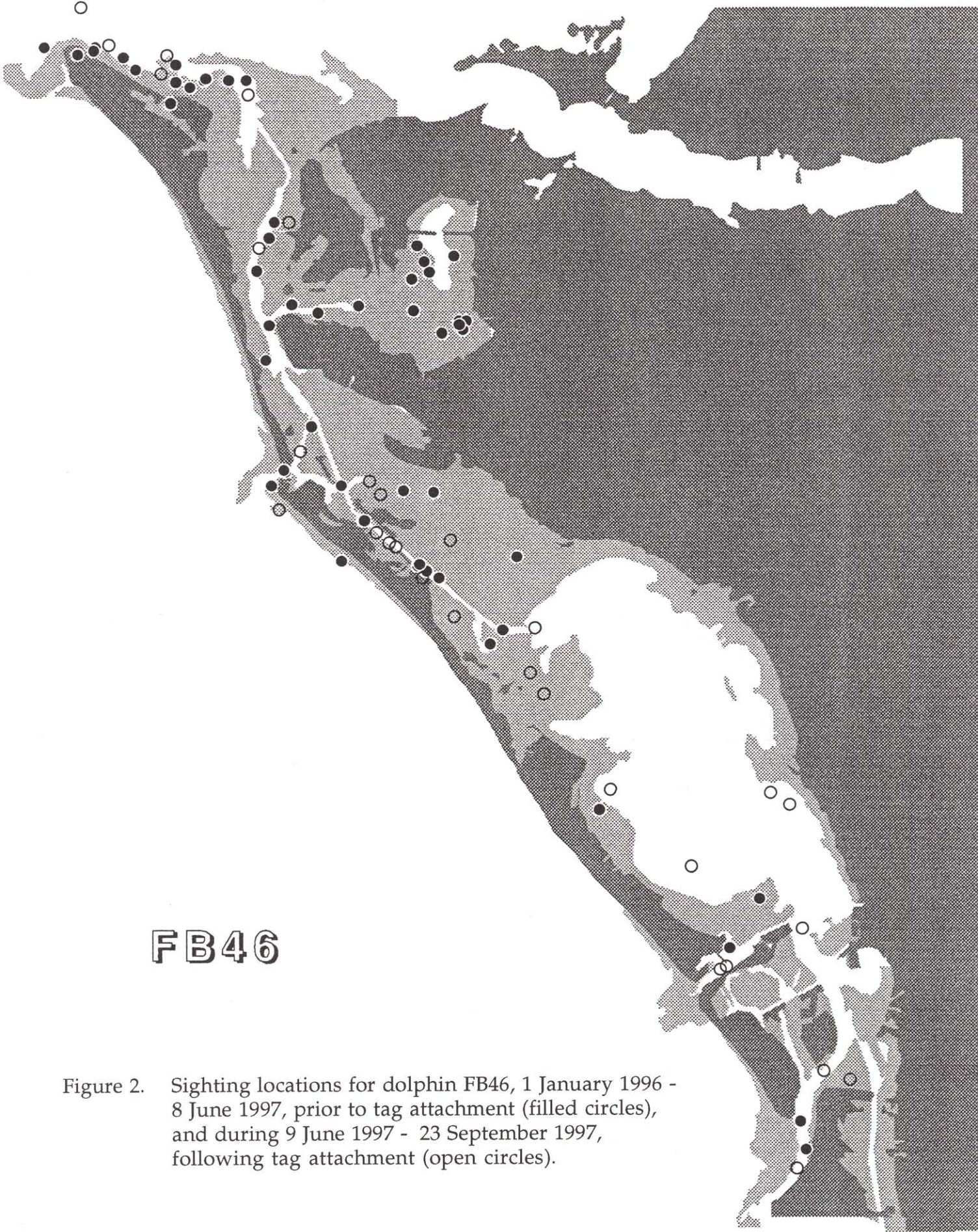


Figure 2. Sighting locations for dolphin FB46, 1 January 1996 - 8 June 1997, prior to tag attachment (filled circles), and during 9 June 1997 - 23 September 1997, following tag attachment (open circles).

Figure 3a

Figure 3b

Figure 3c

Figure 3d

Figure 3e

Figure 3f

Figure 3g

Figure 3h

Figure 3i

Figure 4a

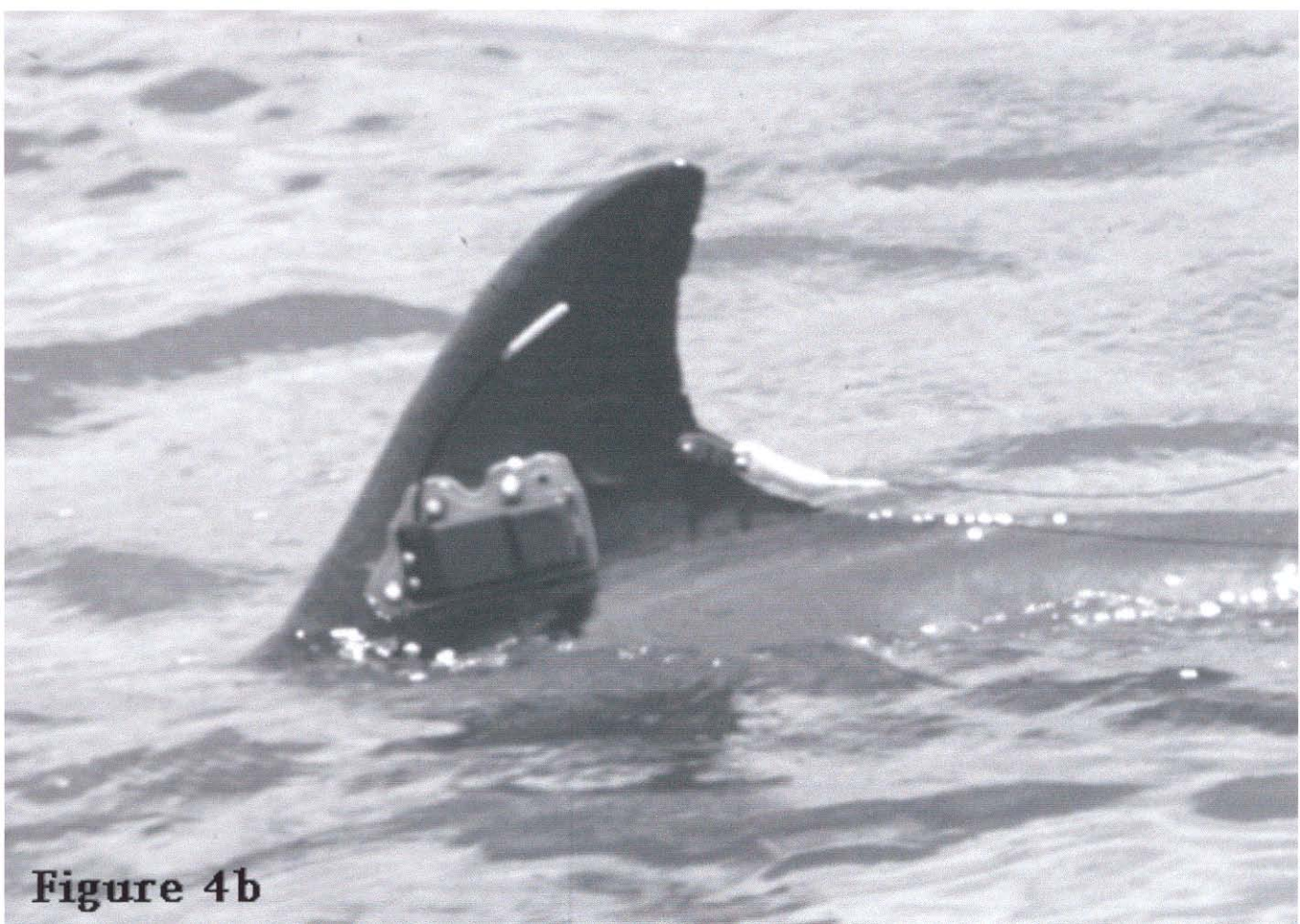


Figure 4b

Figure 4c

Figure 4d

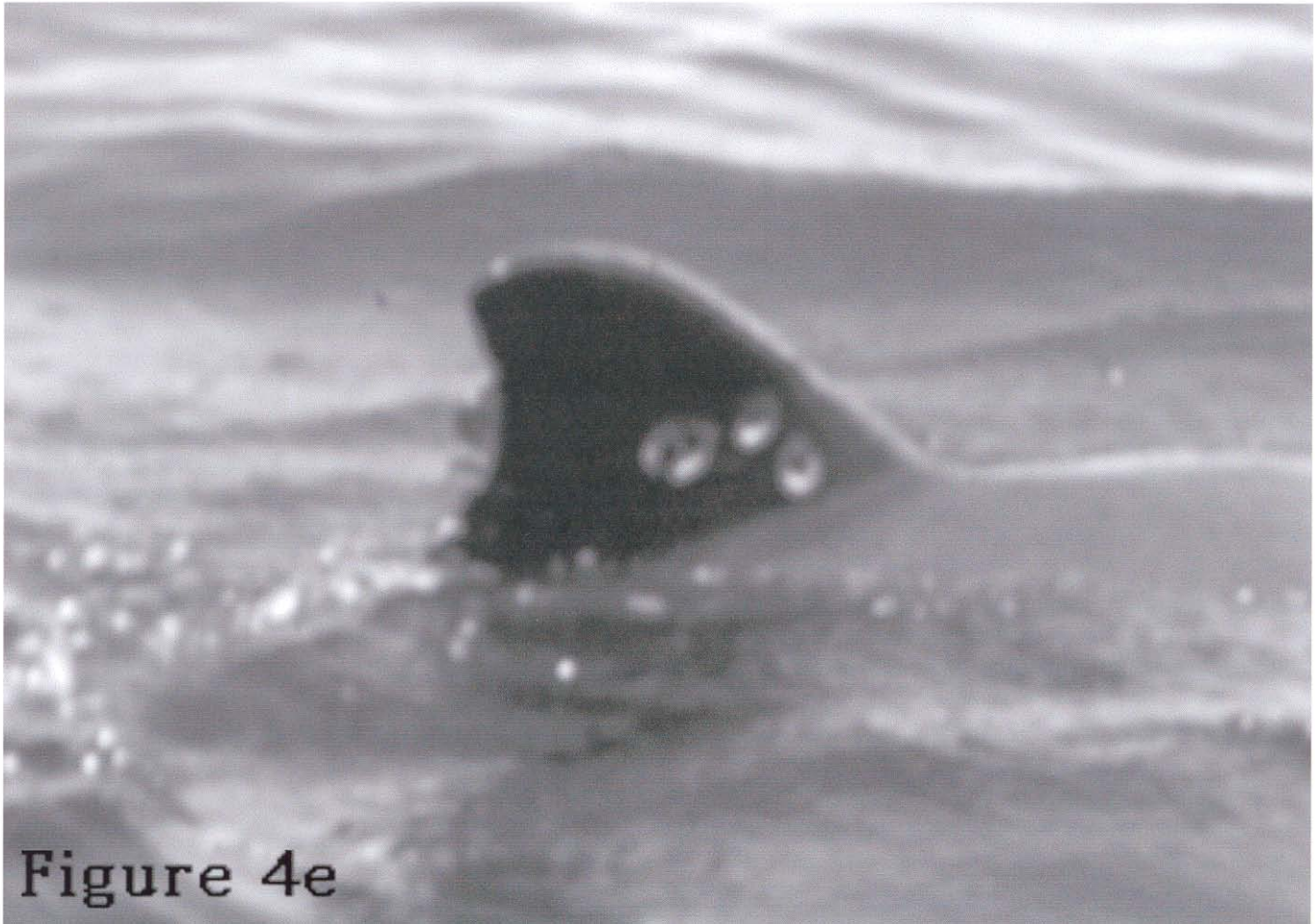


Figure 4e

Figure 4f

Figure 4g

Figure 4h

Figure 4i

Figure 4j