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VOLUME 11-2  
ADDENDUM TO  
SYNOPTIC STUDIES OF THE PLUME OF SONGS  
UNITS 2 AND 3

Submitted to: Marine Review Committee  
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## INTRODUCTION

This addendum to ECO-M's Volume II-2, "Synoptic Studies of the Plume of SONGS Units 2 and 3", reports our results and conclusions from the two latest dye studies.

2.6 An Overall Description of Surface Water Movement at SONGS  
on April 7, 1987

2.7 Dilution Estimates from the Dye Study of May 22, 1987

## 2.6 An Overall Description of Surface Water Movement at SONGS on April 7, 1987

The area of study is hydrodynamically complex; its currents and circulation patterns are governed by the interaction of the discharge from the cooling system, local currents, and the north and south kelp beds.

This study is aimed towards a better understanding of the interaction of the above parameters. A fluorescent dye was used to trace water masses in the vicinity of the cooling system, both inside and outside the kelp beds. All the dye releases described here were point or line releases of rhodamine dye.

Figure 1 displays the starting locations of various dye patches (22) with a circle. The trajectory for each dye patch has been indicated at half hour intervals by a small dark circle. Arrows indicate that patches have continued to move in the same direction at about the same speed.

In addition to the dye patches, we released two line injections of dye. We will refer to the dye stripe released upcoast of the north SOK kelp bed as Stripe 1 and the second stripe released on the inshore boundary of the south SOK kelp bed as Stripe 2. Figure 2 shows the starting locations of Stripe 1 and Stripe 2.

The patches were observed from 12:52 P.M. to 5:30 P.M. Aerial photographs were taken every 20 minutes throughout the study. Fixes were made with a Motorola Mini-Ranger III system at release points and also at the end of the study for the patches still visible. We also anchored three buoys (markers) with known positions to aid us in determining the location of patches with time. Table 1 lists the dye patch release times.

Prior to the study, we deployed three current meters in three locations at 3 m below the water surface. Inter-Ocean S4 instruments were used for the current measurements. The current meter locations are also shown in Figure 2. Measurements of the currents are displayed in Figure 3. On this day, all pumps were operating and the power levels for Units 1, 2 and 3 were 92%, 98% and 100% respectively.

Following are several important conditions and observations pertaining to the study.

1. Measurements from current meters indicate that the current pattern is steady throughout the study (see Figure 3).
2. The discharge water from Units 2 and 3, together with the ambient current, formed a plume front (see Figure 1).
3. Patch 4 moved offshore to the plume edge and remained along the plume front as it travelled downcoast.
4. Patches 5, 6, 7, 8, 11, and 12, located offshore and south of the SOK kelp bed, moved approximately parallel to the shore. They demonstrate no offshore velocity.
5. Patch 9 moved slowly along the inshore side of the south kelp bed, then offshore more quickly through a less dense channel of the kelp bed, indicating the effect of the kelp in deflecting the flow.
6. Patches 13, 14, 15 and 17 displayed an offshore velocity in the vicinity of the diffuser system. This indicates that SONGS' cooling system directs the flow towards the south kelp bed. Notice the offshore and longshore components of the current near the diffuser line decreased as the patches moved further from the diffuser line.

7. Patch 16 never moved appreciably from its release point, indicating a stagnation area caused by the interaction of the discharged water, entrained water, make-up flow, and the local currents. (Patch 16 dispersed somewhat by the end of the day).

8. Dye patches A, B, C, and D demonstrate clearly that the surface upcoast water moved inshore and downcoast towards the diffuser line of Unit 3. The movement of these patches towards the Unit 3 diffuser line, but not towards the Unit 2 diffuser line, indicates that Unit 2 entrained water from levels lower than the surface.

9. At the end of the study, patches 1 through 8 had moved approximately 4000 meters from their release points.

The two dye stripes released during the study show the following:

1. The north SOK stripe moved inshore and downcoast towards the diffuser line of Unit 3 and was deflected by the north SOK kelp bed.
2. The south SOK stripe first moved quickly as it entered the kelp bed at about 18 cm/sec and then slowed down substantially inside the kelp bed to a speed of about 7 cm/sec.

From the aerial photo collection, we have chosen a representative series (see Figures 2-6-1 through 2-6-10). These photos demonstrate the above points. With each photo, we have included a description of various events.

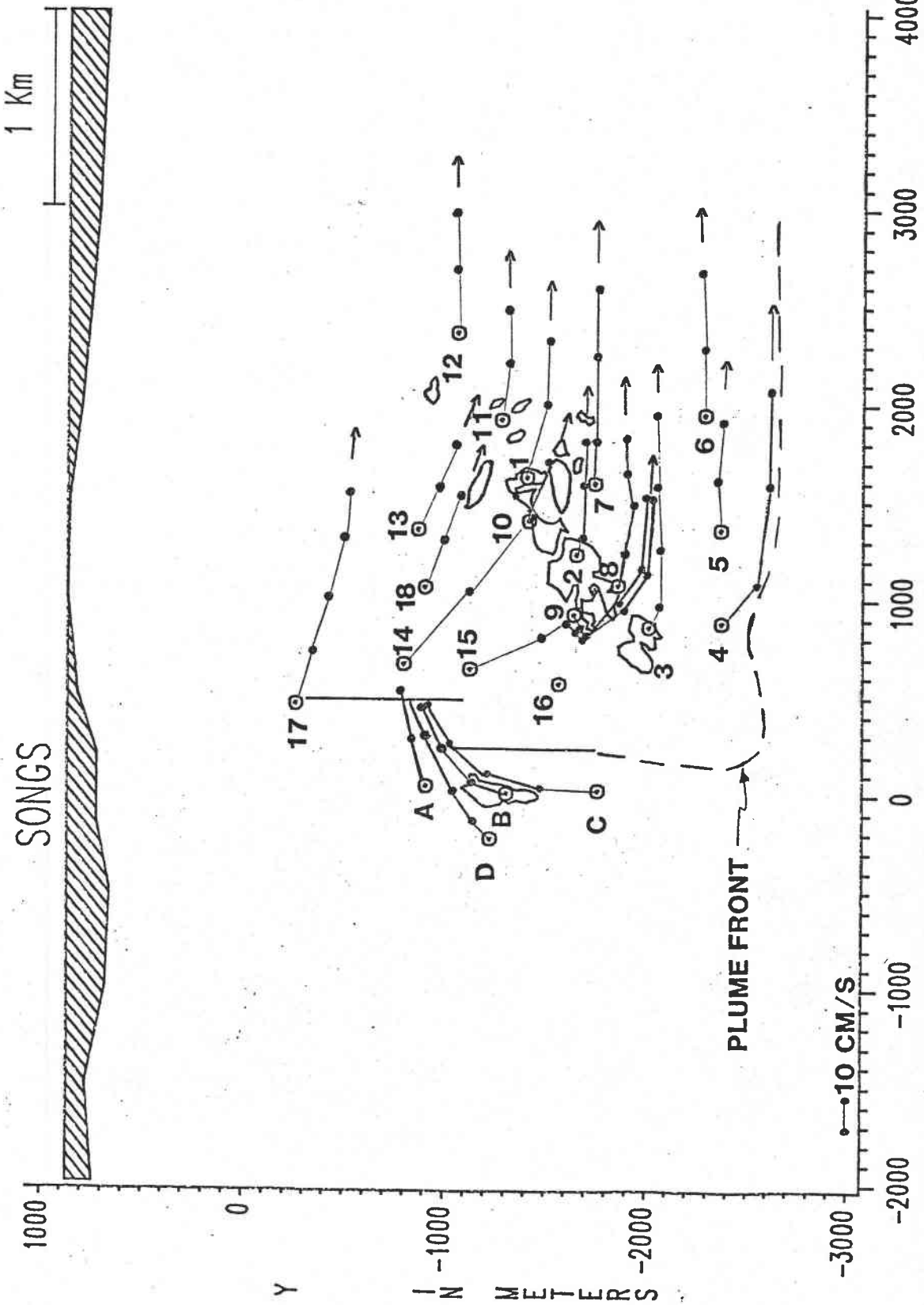
TABLE 1

## Release Time of Various Dye Patches

<u>Patch</u>	<u>Release Time</u>	<u>Patch</u>	<u>Release Time</u>
1	12:30	13	13:20
2	12:33	14	13:24
3	12:37	15	13:26
4	12:42	16	13:30
5	12:45	17	14:05
6	12:48	18	14:40
7	12:54	A	13:43
8	12:58	B	13:45
9	13:02	C	13:51
10	13:05	D	13:54
11	13:09	Stripe 1	14:14
12	13:12	Stripe 2	14:31

# DYE STUDY

07APR87



Note

Patch 16 never moved appreciably from its release point.

X IN METERS

Figure 1 Starting locations and trajectories for 22 dye patches. Dark circles represent half hour intervals.

# DYE STUDY

07APR87

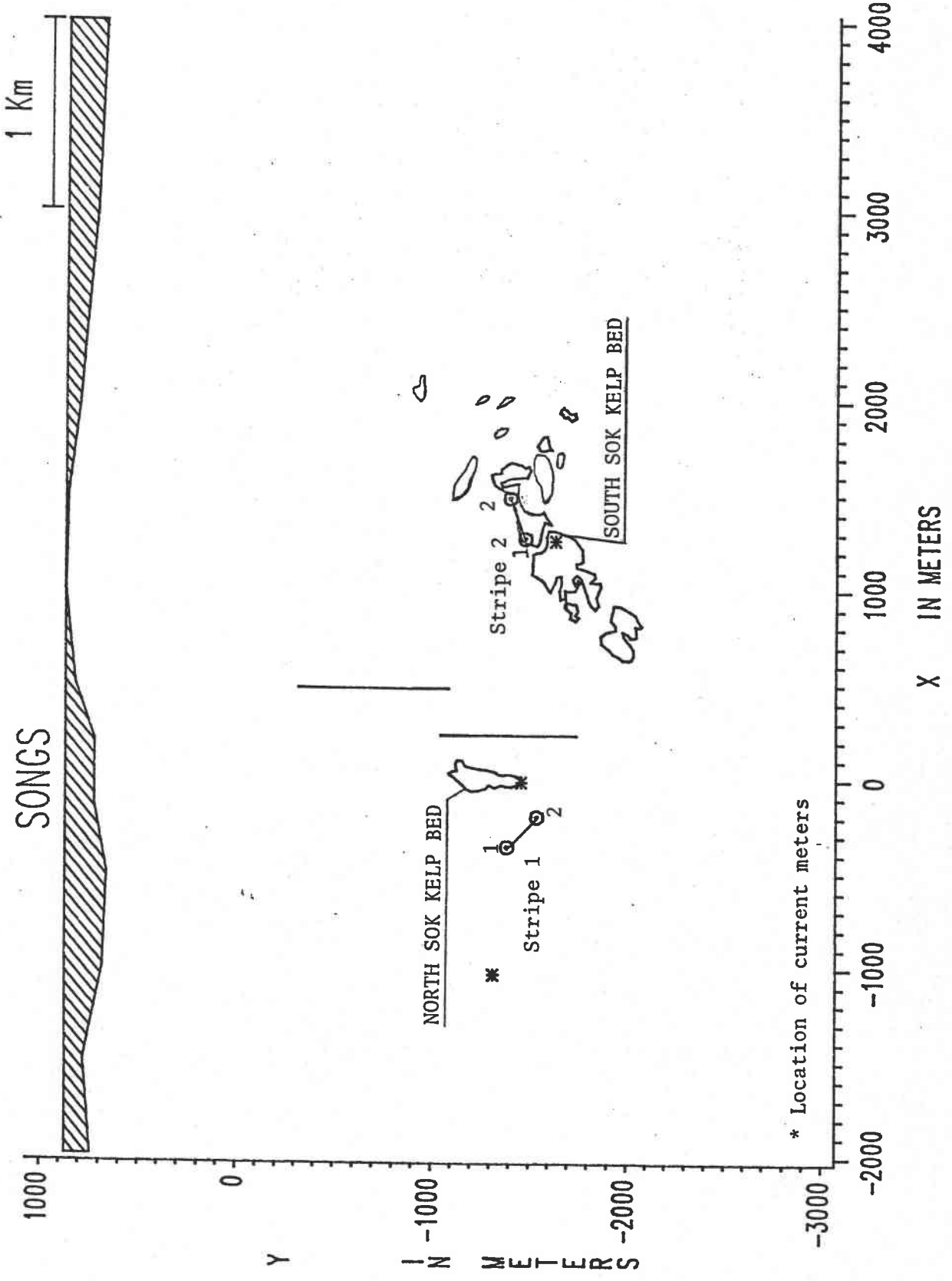
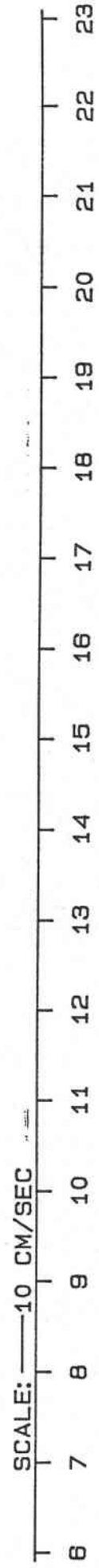
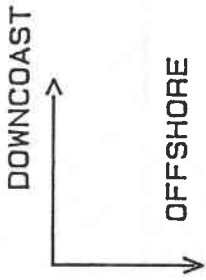


Figure 2 Starting locations of Stripe 1 and Stripe 2, and current meter locations.



# HOURLY CURRENT (CM/SEC)

AT 3 METERS BELOW SURFACE



HOUR

Figure 3 Vector representations of current on 07apr87. Ambient current (out of kelp bed) shows a steady onshore/downcoast flow. Note that the flow in the south kelp bed is greatly reduced. 07APR87



Figure 2-6-1: Starting locations of dye patches 1 through 6. Time: 12:52.



Figure 2-6-2: Dye patches 1 through 12. Notice dye patch 4 moving offshore and downcoast. Time: 13:18.



Figure 2-6-3: Dye patches 1 through 16. Notice the plume front, the movement of dye patch 4 along this front, and the slight movement of dye patch 9 from its release position. Time: 13:43.



Figure 2-6-4: Dye patches A, B, C, D, 17 and Stripe 1. Notice dye patches 14 and 15 have already reached the south SOK kelp bed and dye patch 16 has not moved from its release location. Time: 14:28.



Figure 2-6-5: Starting location of Stripe 2 at the inshore part of the south SOK kelp bed. Notice dye patch A is on the Unit 3 diffuser line, dye patch 15 has joined the tail of dye patch 9, both deflecting into the less dense part of the kelp bed; dye patch 16 is still in the same location and dye patch 17 has moved downcoast. Time: 14:38

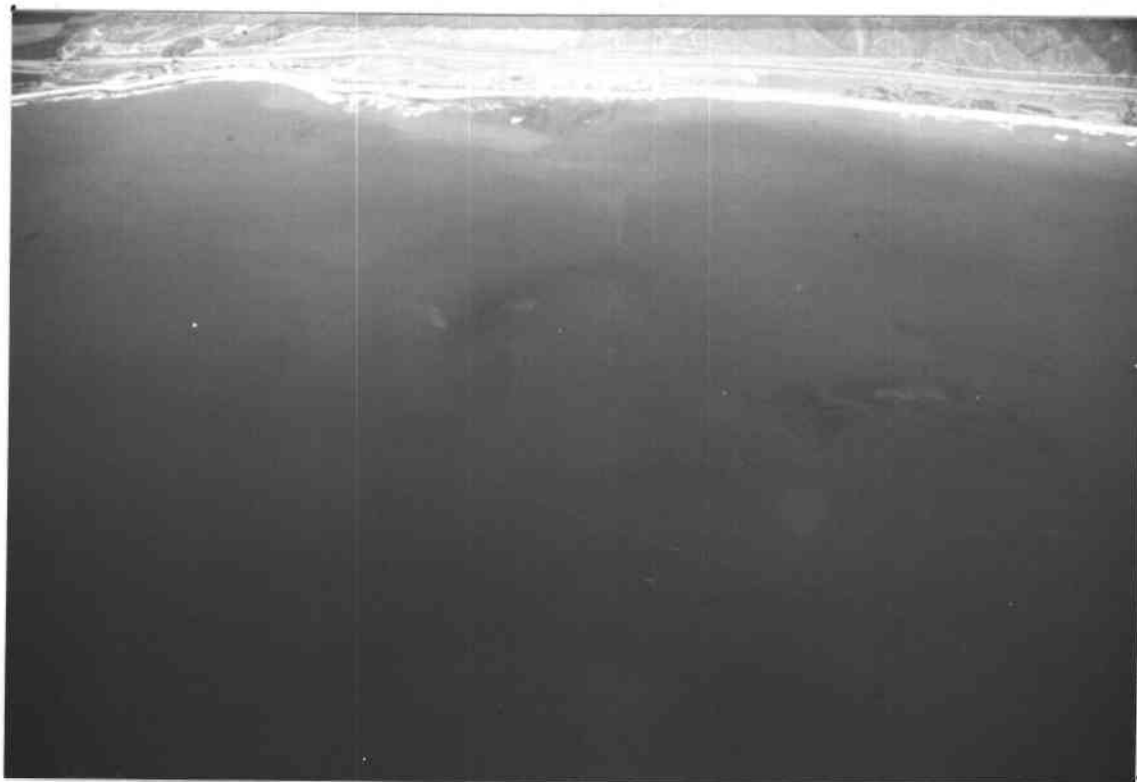


Figure 2-6-6: Starting location of dye patch 18. Notice that the dye patches north of SONGS have moved towards Unit 3 diffuser line, and Stripe 2 has quickly moved into the south SOK kelp bed. Time: 14:52.

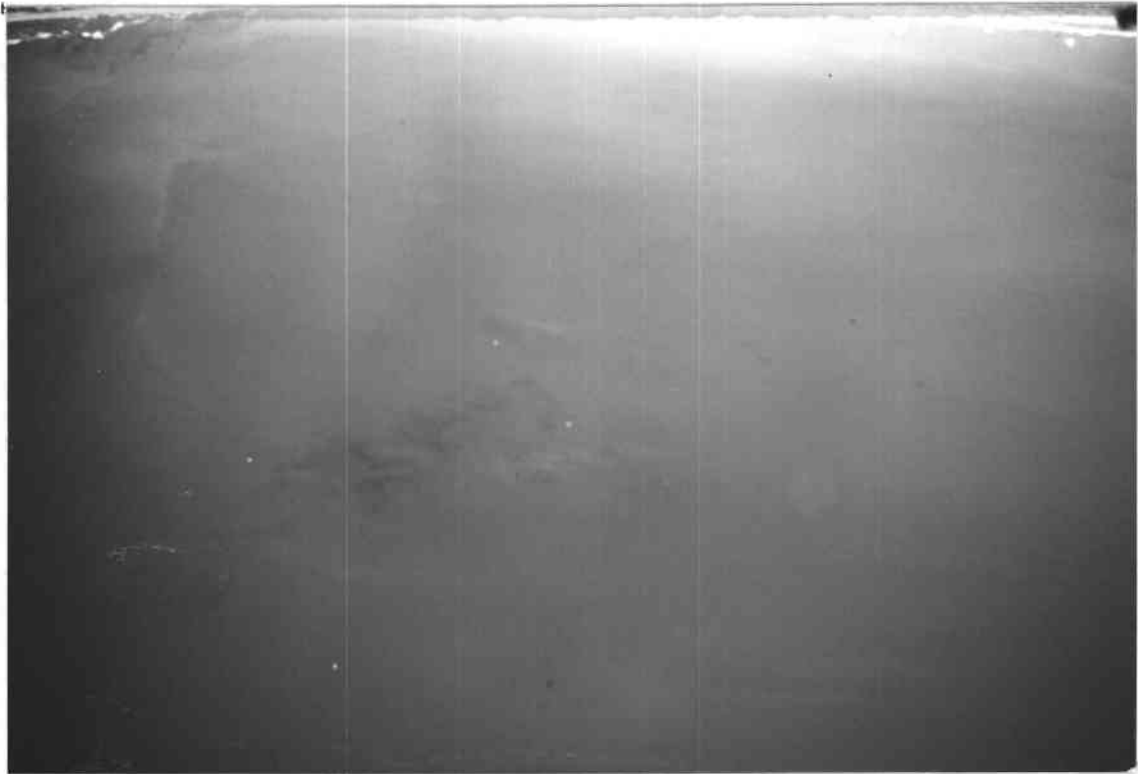


Figure 2-6-7: Stripe 2 is still in the south SOK kelp bed, moving offshore and downcoast. Notice dye patch 17 continuing downcoast and parallel to the shoreline. Time: 15:41.





Figure 2-6-8: Dye patch D is on the Unit 3 diffuser line, dye patch 16 is still in the release vicinity, and Stripe 2 is slowly advancing out of the SOK kelp bed. Time: 15:44.

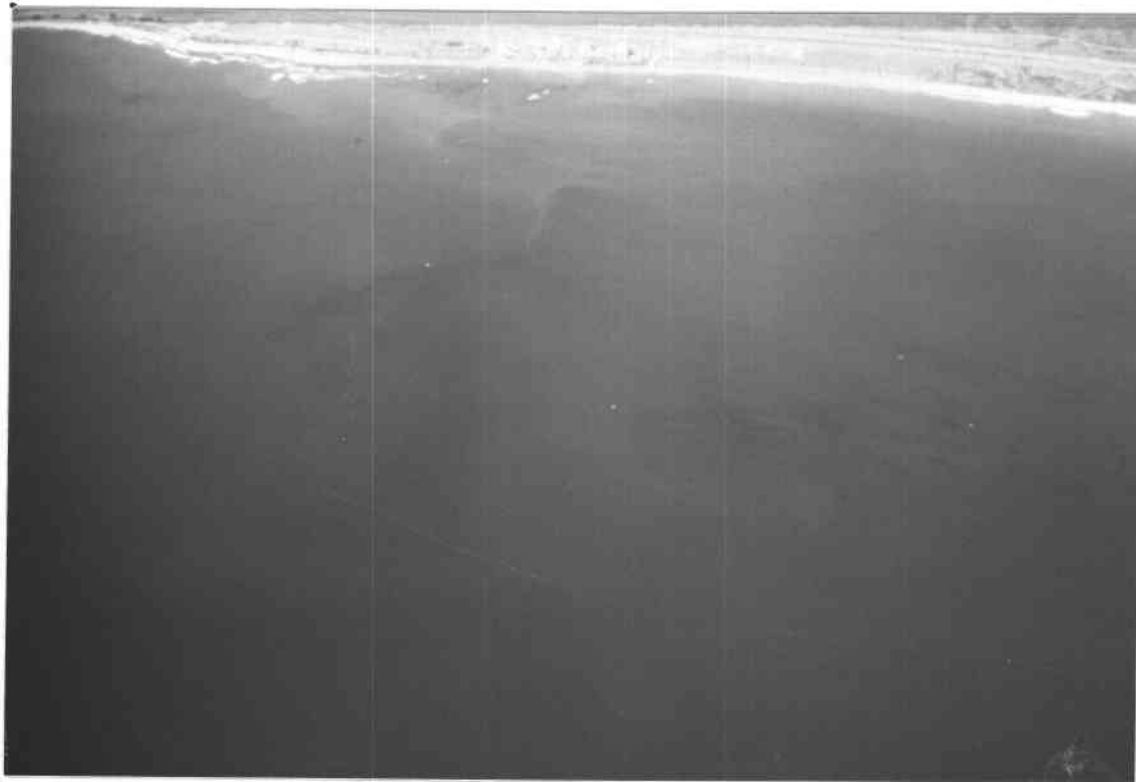


Figure 2-6-9: Stripe 1 is moving downcoast and inshore towards the Unit 3 diffuser line. Patch 16 is dispersing, and Stripe 2 is slowly moving to the offshore boundary of the south SOK kelp bed. Time: 15:55.



Figure 2-6-10: Stripe 1 is moving towards the Unit 3 diffuser line.  
Dye patch 16 is still visible. Time: 16:17.