



DATE: February 13, 2011

TO: Eileen Maher,  
Environmental Services  
Port of San Diego  
3165 Pacific Highway  
San Diego, CA 92101-1128

FROM: Rebecca Lewison Ph.D.<sup>2</sup>  
Tomoharu Eguchi, Ph.D.<sup>1</sup>  
Jeffrey Seminoff, Ph.D.<sup>1</sup>  
Sheila Madrak<sup>2</sup>  
Bradley MacDonald<sup>2</sup>

<sup>1</sup>Marine Turtle Ecology and Assessment Program  
NOAA - National Marine Fisheries Service  
Southwest Fisheries Science Center  
3333 Torrey Pines Court  
La Jolla, CA 92037

<sup>2</sup>Department of Biology  
San Diego State University  
5500 Campanile Drive  
San Diego, CA 92182

**Progress report: "Identifying critical habitat for endangered species in San Diego Bay",  
SDSU and NOAA**

The goal of this project is to characterize the movements of East Pacific green turtles in San Diego Bay using a combination of active and passive acoustic telemetry. This is a Port-supported collaborative research effort between NOAA and SDSU. Using NOAA and Port-sponsored equipment, researchers at SDSU are leading the efforts to track turtles and monitor the Bay for turtle activity. Scientists at NOAA are in charge of all turtle capture; telemetry equipment deployment in a combined effort between researchers from NOAA and SDSU.

Turtle presence and temperature data will be used to calculate home range size, map movement patterns, and assess thermal conditions across use areas. Variability in home range among individuals will be examined based on size, sex, season, and association with high-traffic areas where density of human activities are highest. Temperature and location data will also be collected to determine variability in habitat usage based on temperature, time of day, and season. Knowledge of green sea turtle habitat usage in San Diego Bay will identify overlap between high activity areas of green turtles in the bay and human activities, such as shipping channels,

commercial docks, marinas, and Naval testing and training grounds. Emergent behavioral patterns will inform local conservation strategies

**The activities described herein focus specifically on activities from November 1, 2010 to January 31, 2011 conducted by the SDSU and NOAA research team.**

This report covers 4 main areas of research activity

1. **Turtle capture**
2. **Passive tracking**
3. **Active tracking**
4. **Summary of tracking activities (11/1/2010-1/31/2011)**
5. **Upcoming objectives**
6. **Executive summary**

The data included in this report should be cited as “Lewison, Eguchi, MacDonald, Madrak and Seminoff, , unpublished data.”

## 1. Turtle capture

A total of 10 turtles were captured and tagged between November 10, 2010 and January 25, 2011 (table 1). Three turtles (ID# 1990, 5806, and 88129) were captured multiple times during this period. One of these turtles (ID# 5806) was missing its tag upon second capture; a new transmitter was attached. Another turtle (ID# 88129) appeared to be underweight but was responsive to stimuli when captured on December 16, 2010; upon being captured a second time on January 6, 2011, the same turtle was judged to be emaciated, lethargic, and unresponsive to stimuli. The turtle was moved by NOAA biologists to Sea World rehabilitation facilities for recovery and monitoring by Sea World veterinarians. X-rays of the individual revealed a previously broken plastron as well as numerous shotgun pellets embedded in the tissue of the turtle’s neck. Veterinarians at Sea World believe the turtle will recover and can be released back into San Diego Bay sometime in the late spring or summer of 2011. As of January 31, 2011, 9 turtles from the ongoing capture season continue retain their acoustic tags in addition to one turtle (ID#13690) that has retained its tag from the 2009-2010 capture season.

Year	Month	Day	ID	Sex	Tag Added	Freq. (KHz)	P.I. (ms)	Pattern	Weight (kg)	CCL (cm)	SCL (cm)	CCW (cm)	SCW (cm)
2010	12	02	98157	Juv	Yes	37	990	3-3-7-7	27	64.5	59.6	58.2	47.0
2010	12	16	1990	Female	Yes	38	1110	3-7-7-6	138	105.3	99.6	90.9	68.0
2010	12	16	5806	Male	Yes	39	1010	3-4-5-4	138	100.7	95.5	89.4	71.0
2010	12	16	2116	Male	Yes	38	1010	3-4-4-8	136	107.2	102.0	93.9	74.3
2010	12	16	33145	Juv	Yes	40	910	4-6-6	58	79.2	74.5	73.0	57.0
2011	01	06	13962	Male	Yes	38	1030	3-4-7-8	96	92.4	88.3	86.6	65.8
2011	01	06	23647	Female	Yes	39	990	3-3-8-4	140	109.8	103.1	101.7	75.9
2011	01	06	98310	Male	Yes	39	1050	3-5-6-5	138	102.7	98.5	93.6	72.8
2011	01	06	88129	Male	Yes	39	1210	5-6-6-8	115	102.0	97.7	88.2	71.0
2011	01	06	1990	Female	No	38	1110	3-7-7-6					
2011	01	06	5806	Male	Yes	37	1170	4-6-6-7					
2011	01	25	88129	Male	No	39	1210	5-6-6-8					

Table 1. Turtles tagged during capture events between November 10, 2010, and January 25, 2011. Columns indicate, in order, year of capture, month of capture, day of capture, turtle ID, sex, sonic tag added (yes or no), frequency of sonic tag, pulse interval of sonic tag, pattern of sonic tag, weight, curved carapace length, straight carapace length, curved carapace width, and straight carapace width.

## 2. Passive tracking: Tracking using SUR stations

Turtles are tracked passively using Sonotronics SUR-1 submersible ultrasonic receivers. The submersible ultrasonic receivers (SURs; Figure 1) are programmed to scan for a range of frequencies. Presence of acoustic tags is recorded into the SUR memory when a tag is within detectable range. Since the start of the project, we have deployed SUR sites in South Bay based on areas of interest, including potential foraging areas (i.e. seagrass beds) and high-traffic areas (boating channels, marinas, & docks). HOBO U22 Water Temp Pro v2 temperature data loggers are deployed at each of the SUR sites. SURs are checked for proper functioning and battery life approximately every 8-10 weeks and data are downloaded at that time. These data will help to determine when and where turtles occur over time, particularly with regard to diel patterns of presence/absence at sites.



Figure 1. Submersible ultrasonic receiver (SUR; Sonotronics, Tucson, AZ).

### *SUR Station Locations*

Between November 1, 2010, and January 31, 2011, there were 14 SUR stations (SUR and HOBO data logger) monitoring for turtle presence throughout south San Diego Bay (Figure 3).

During routine tracking activities on December 14, 2010, it was noted that orange buoy markers at stations NF2 and NF3 were missing. On December 17, an SDSU diver assisted in searching at the GPS coordinates for stations NF2 and NF3 – the entire SUR station at NF2 (station materials + SUR + temperature datalogger), less the orange marker buoy, was found at its GPS coordinates, however no station was found at NF3. It is believed that buoy theft was

responsible for the disappearance of both station buoy markers; a dive effort in February, 2011, will be undertaken in a second effort to locate the SUR station components at site NF3.

In November, 2010, a U.S. Coast Guard employee contacted Dr. Eguchi regarding SURs deployed at channel markers R36 and R38, relaying the information that SURs at those locations were removed by USCG divers during routine cleaning of the channel marker anchor lines. After speaking with Dr. Eguchi, the employee confirmed that the USCG would re-attach SURs to those anchor lines post-cleaning. During SUR retrieval and deployment activities on January 13, 2011, SURs were not present at sites R36 and R38. The current location of these SURs are still unknown.

SURs in the effluent outfall of the South Bay Power Plant were retrieved on December 16, 2010. DAN array of SUR stations called “North Fence”, NF1-NF5, was selected based on areas of habitual use by turtles, as determined through active tracking to date. Additional SUR stations were deployed at channel markers G13, G21, and R18.

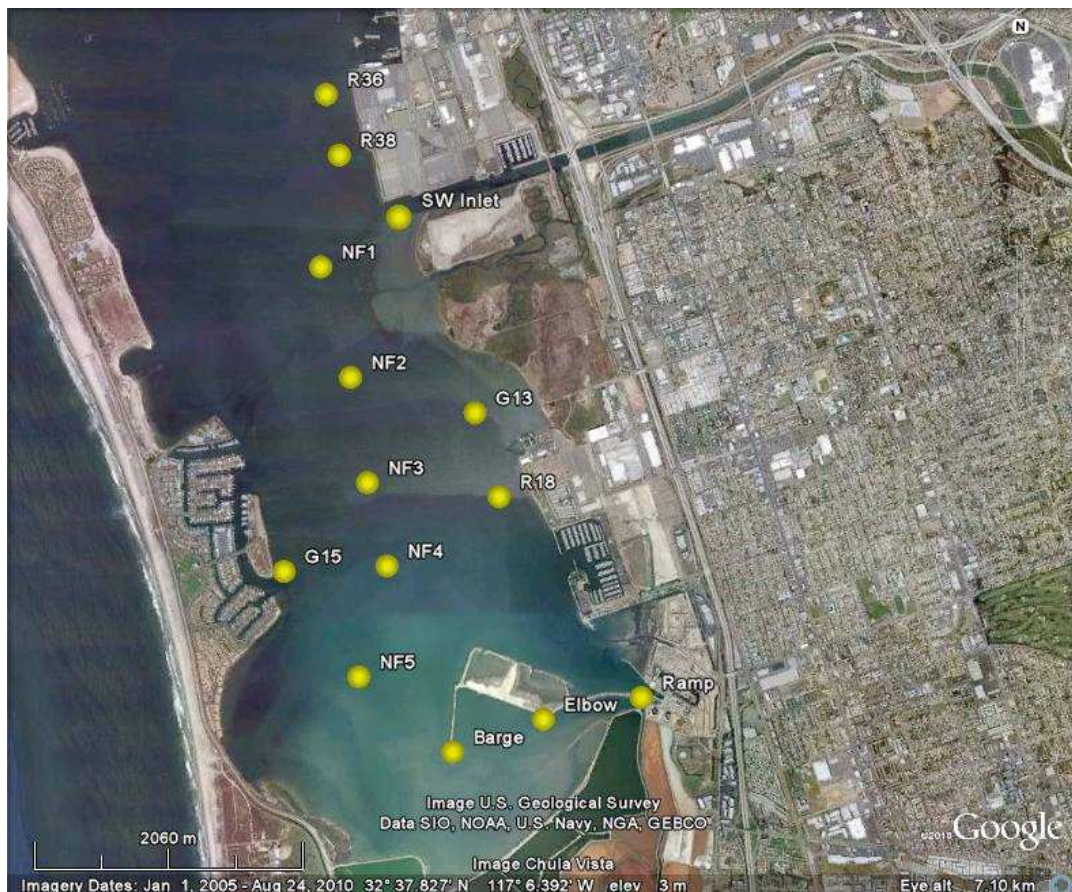


Figure 2. SUR locations in San Diego Bay November 1, 2010 to January 31, 2011. SUR stations are marked by yellow circles.

#### *SUR Station Data*

Downloaded data from each SUR were processed using SURsoftDPC (Sonotronics, Tucson, AZ), which extracted date and time of detections of all tags. Temperature data from HOBO U22 Water Temp Pro v2 temperature data loggers were downloaded and plotted using HOBOWare Software v 3.0.0. HOBO data loggers were set to record water temperature once every 2 minutes and at this setting were able to record data for 60 days.

Detection data for stations Ramp, Elbow, Barge, NF5, NF4, NF2, NF1, and SWI are displayed in Figure 3, a-h. These graphics are displayed in the order that the SUR sites occur from south to north. The numbers in the far left of each row indicate turtle ID, and each filled circle indicates a detection. Vertical lines indicate midnight of each day. The timeline across which detections occurred is noted by the date on the upper right of the graphic (end of monitoring period). Detection data are not available for sites NF3, R36, and R38 because those stations are still missing. Data from sites G13, G21, and R18 will be retrieved on 2/21/2011.

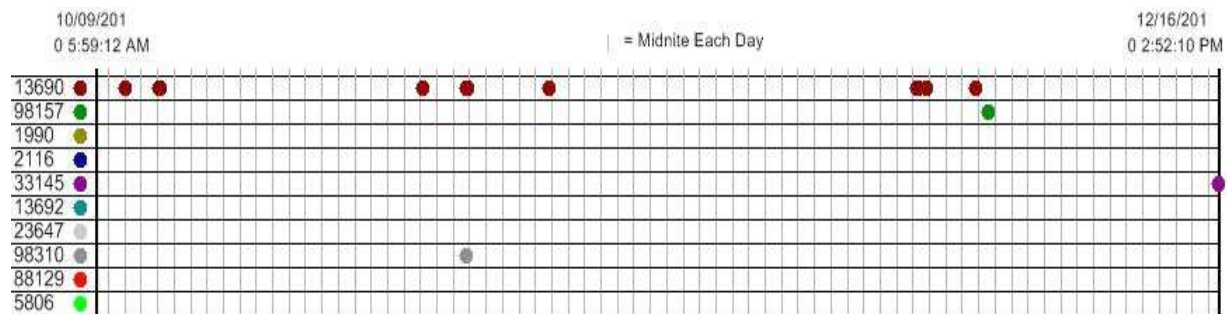


Figure 3.a. Detections at site Ramp from October 8, 2010, to December 16, 2010.

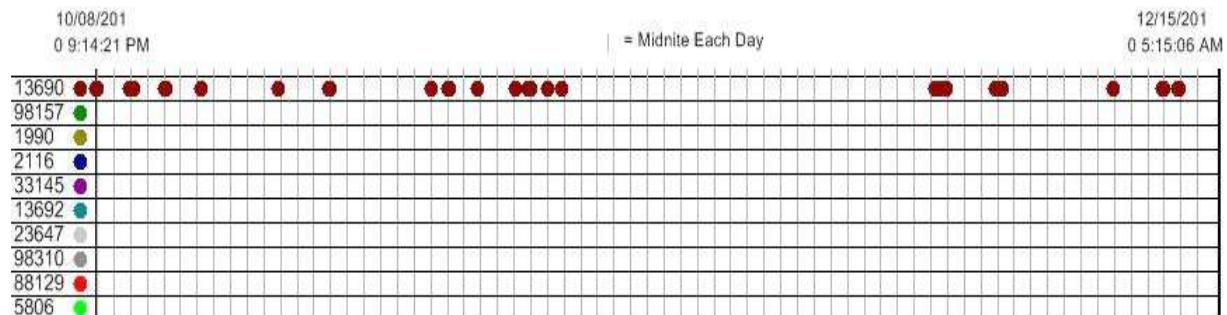


Figure 3.b. Detections at site Elbow from October 8, 2010, to December 16, 2010.

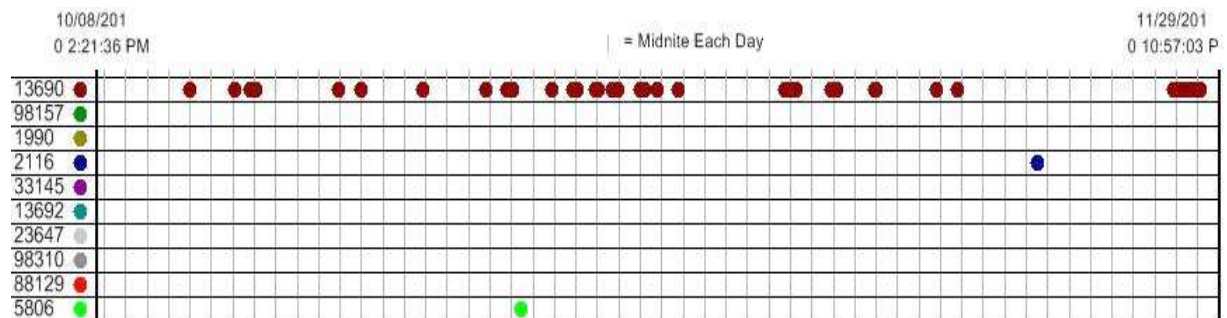


Figure 3.c. Detections at site Barge from October 8, 2010, to December 16, 2010.

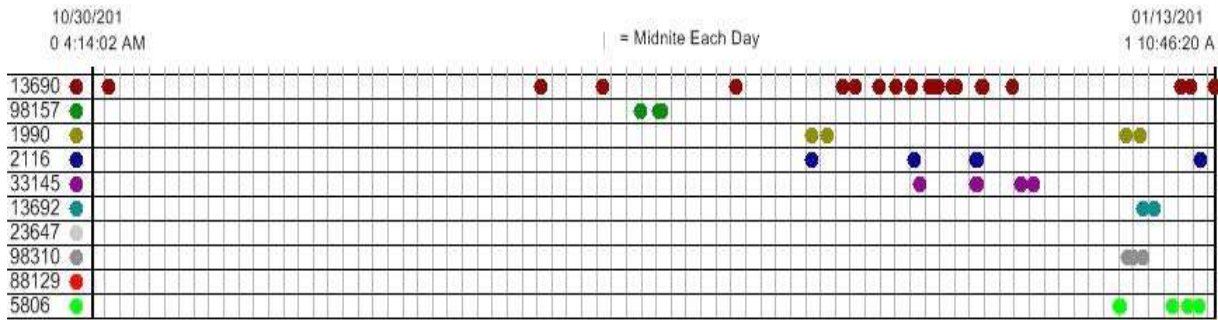


Figure 3.d. Detections at site NF5 from October 30, 2010, to January 13, 2011.

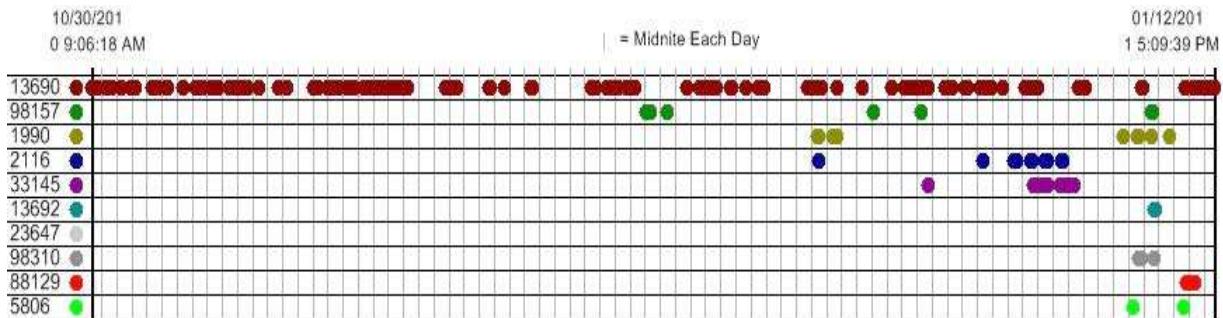


Figure 3.e. Detections at site NF4 from October 30, 2010, to January 13, 2011.

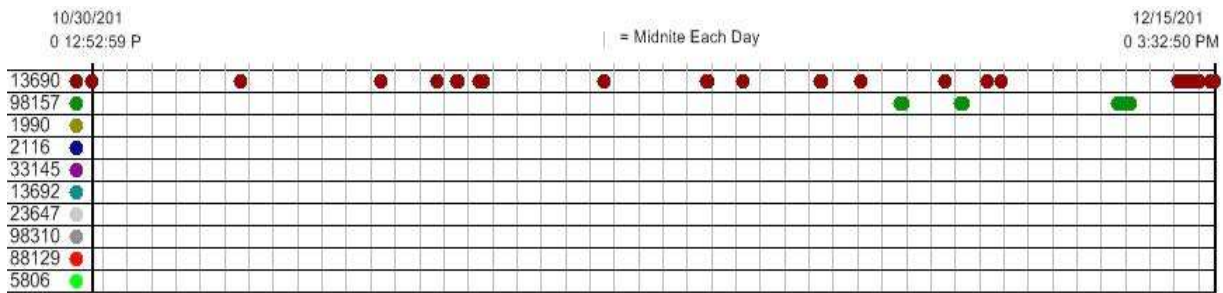


Figure 3.f. Detections at site NF2 from October 30, 2010, to December 17, 2011.

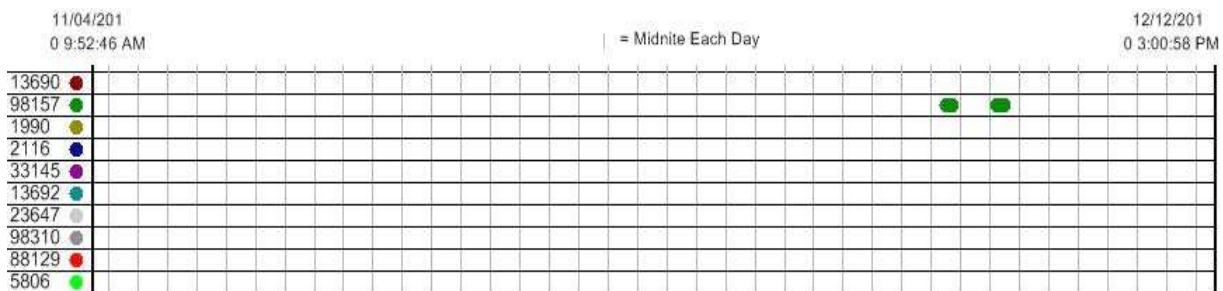


Figure 3.g. Detections at site NF1 from October 30, 2010, to January 13, 2011.

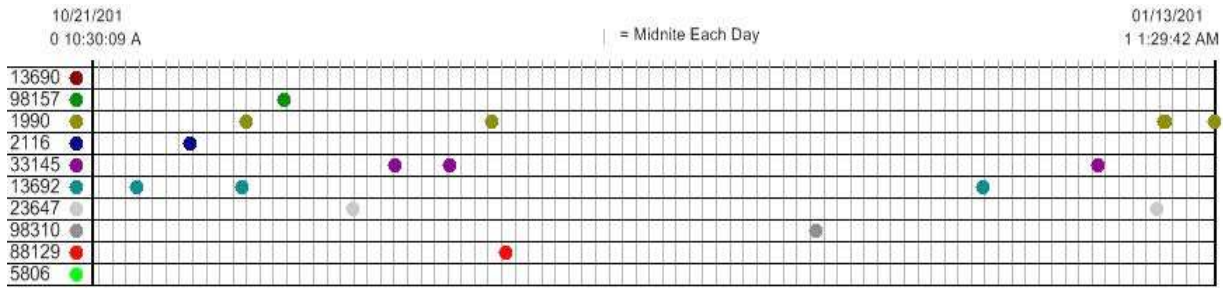
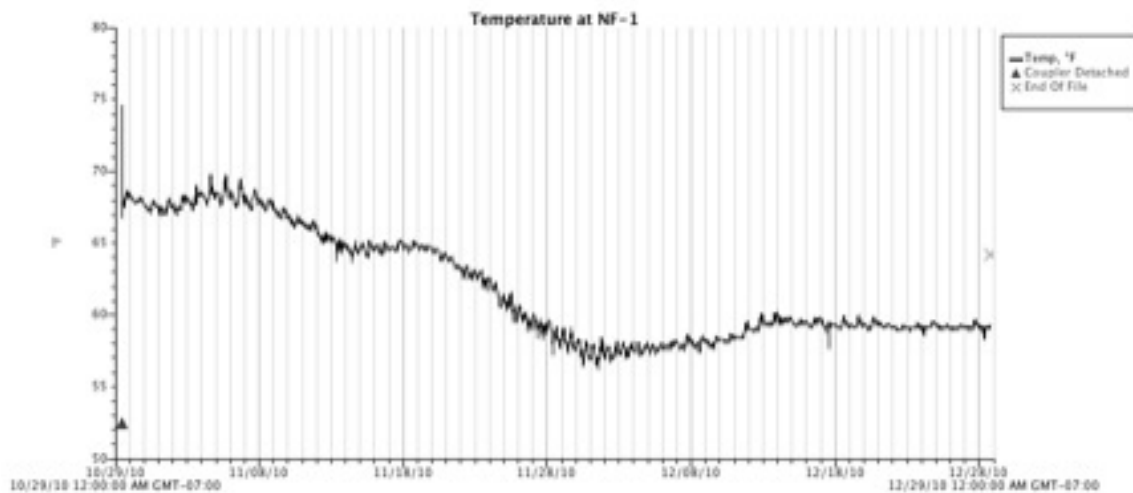


Figure 3.h. Detections at site SWI from November 19, 2010, to January 13, 2011. \*\*Note that detections in the first half of the SWI graphic are “false positive” detections, as the date of the detections occurs before any of the listed turtles had been captured and tagged.

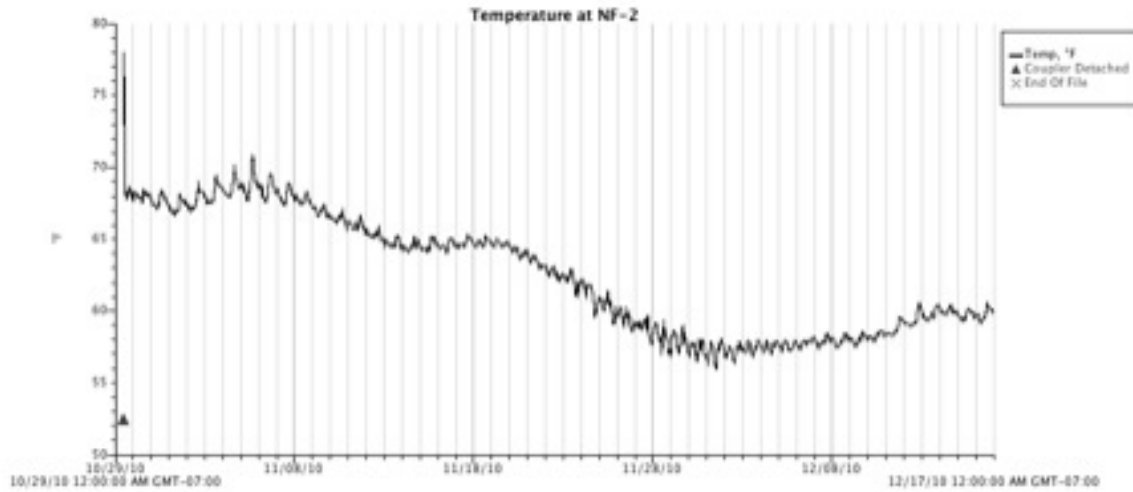
Detections of tagged turtles by SURs continue to show that turtles most heavily utilized the southern portion of south San Diego Bay during the monitoring period. Detections were most numerous at sites NF4 and NF5, which are situated along eelgrass beds in the south bay. Visitation to high traffic sites along boat channels (NF1 & SWI) was lower in both detections and frequency of visitation compared to other locations. Visitation patterns of more recently tagged turtles to areas near the South Bay Power Plant (Ramp, Elbow, Barge) will likely only be revealed in the next round of data retrieval from those SURs, as the last data retrieval (12/16/10) occurred prior to the capture and tagging of nine of the turtles captured this season.

#### *Temperatures in North Fence Array*

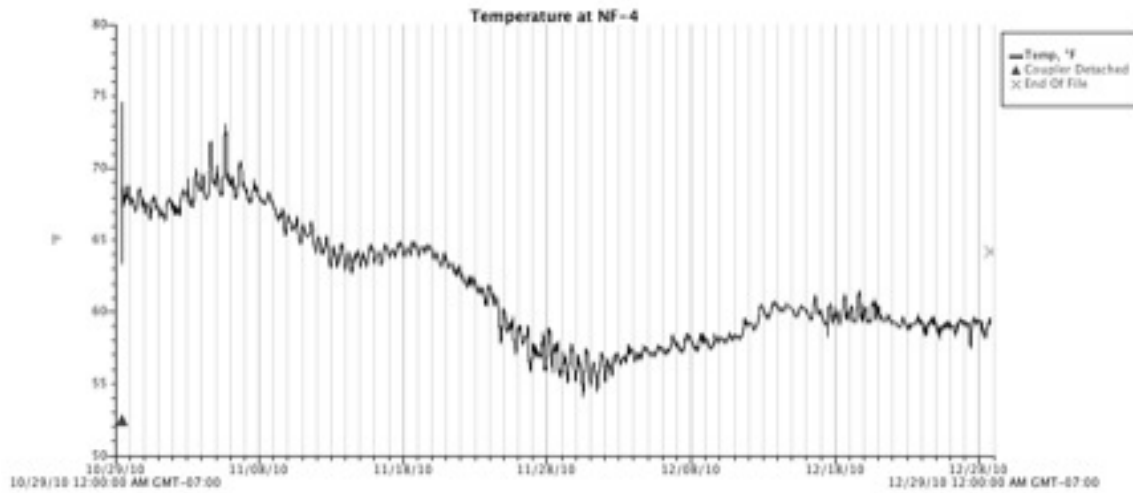
The array of SUR stations called “North Fence”, NF1-NF5, was selected based on areas of habitual use by turtles, as determined through active tracking to date. Temperatures in this region are presumably unaffected by warm water effluent from the South Bay Power Plant outfall array. As such, temperatures recorded between October 29 – December 28, 2010 showed only a gradual decrease in this period, as recorded across all HOBO data loggers. Temperatures in this array are likely represented of natural seasonal change in the thermal environment in the “South Bay” region of San Diego Bay.



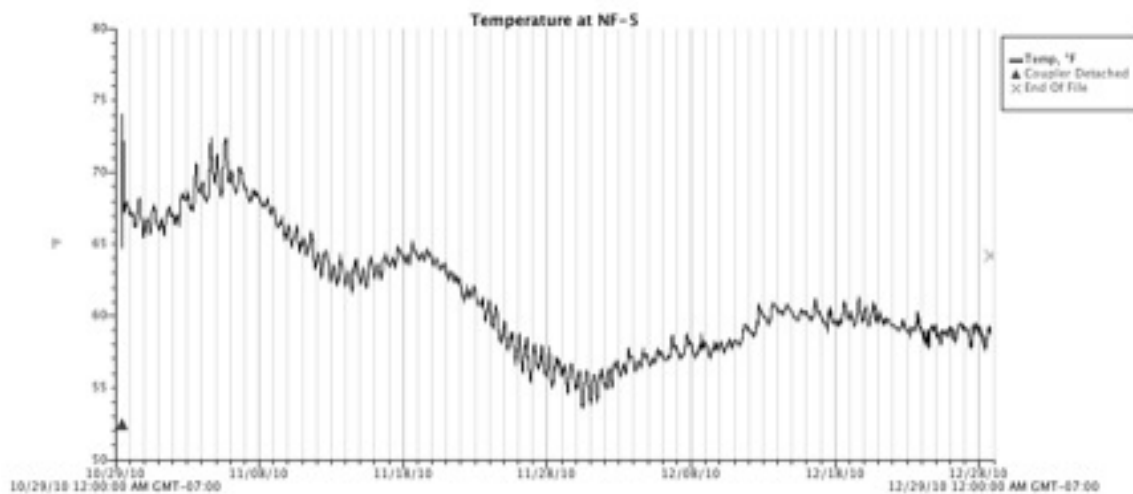
4.a. NF1 temperatures from October 28 to December 28, 2010



4.b. NF2 temperatures from October 29, 2010 to December 17, 2010



4.c. NF4 temperatures from October 29, 2010 to December 28, 2010



4.d. NF5 temperatures from October 29, 2010 to December 28, 2010

Figure 4.a-d. Temperature as recorded by HOBO data loggers along the “North Fence” SUR station array. Across the array (NF1-NF5), temperatures showed a decline from approximately 65-70 F in October to approximately 60 F in December; a demonstrative but minimal seasonal decline.

*Temperature at the Sweetwater Marine Terminal Channel (Sweetwater Inlet-SWI)*

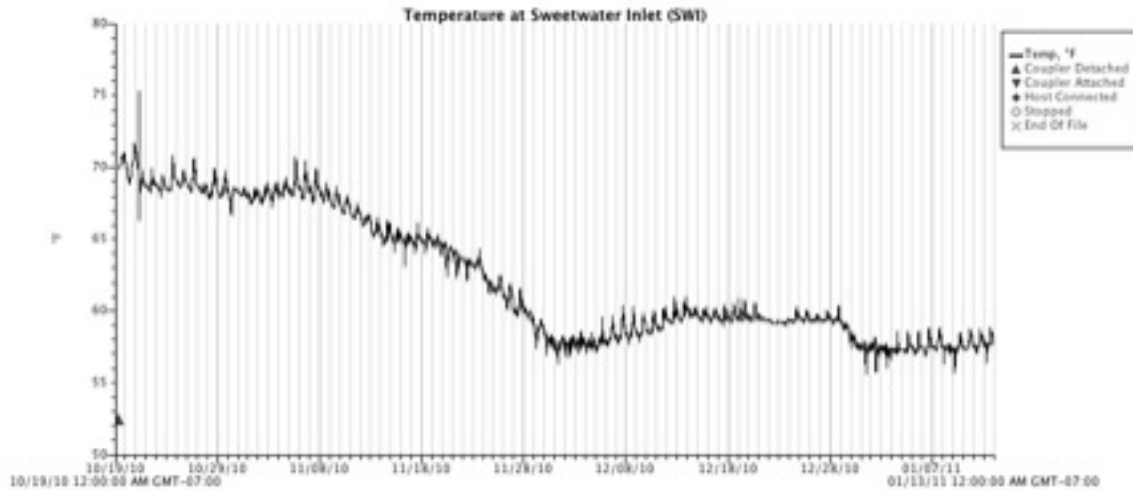
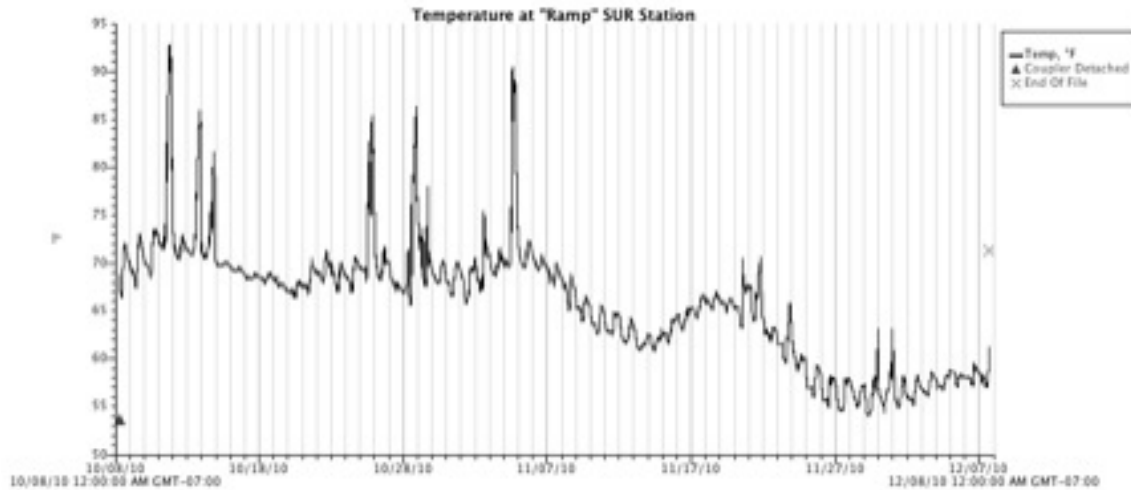


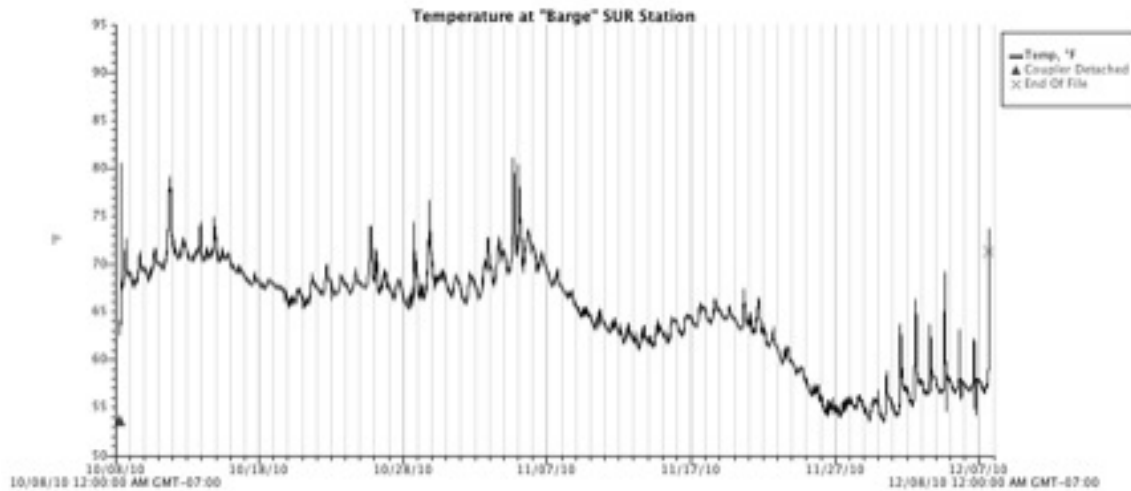
Figure 5. Temperatures as recorded by HOBO data loggers at the Sweetwater Inlet (SWI). Temperature showed a similar seasonal decline to that of the North Fence array, with a slightly greater magnitude of change. October temperatures were between 72-75 F and dropped to between 55-60 F in December.

*Temperature in the South Bay Power Plant Outfall Area*

HOBO temperature data loggers that were deployed from October 8 – December 8, 2010 in the South Bay Power Plant outfall area – “Ramp” and “Barge” – demonstrated marked fluctuations in temperature, presumably associated with release of warm water effluent from SBPP (Figure 6.a-b). Temperature spikes occurred on October 11, 13, 14, 25, 28, 2010 and November 4-5, 2010. These spikes were most dramatic at the “Ramp” location – as expected, due to proximity to effluent release point. These spikes were also evident at “Barge” location, however the fluctuations were less dramatic as temperature dissipates with increasing distance from the effluent release point.



6.a. Ramp temperatures from October 8, 2010 to December 8, 2010.



6.b. Barge temperatures from October 8, 2010 to December 8, 2010.

Figure 6 a-b. Temperature data from HOBO U22 Water Temp Pro v2 temperature data loggers deployed at the “Ramp” and “Barge.” Temperature spikes on October 11, 13, 14, 25, 28, 2010 and November 4-5, 2010 presumably correlate with release of warm water effluent from SBPP.

### 3. Active tracking: Bay-wide monitoring and individual follows

Tagged turtles are actively tracked in the water using Sonotronics DH-4 directional and omnidirectional hydrophones and a Sonotronics USR-96 ultrasonic receiver.

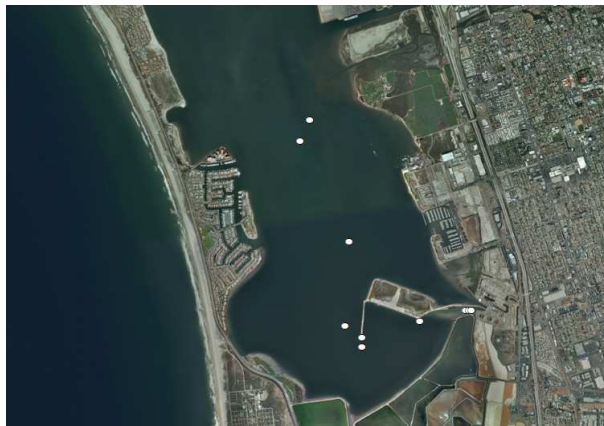
#### *Bay-wide monitoring*

To systematically monitor the entire Bay for turtle activity, we established a "grid" of intersecting transect lines spaced at 500m x 500m intervals, creating a comprehensive series of listening stations across the entirety of San Diego Bay. Each location on the grid is visited weekly to determine presence/absence of tagged turtles. Regular visitation to all locations

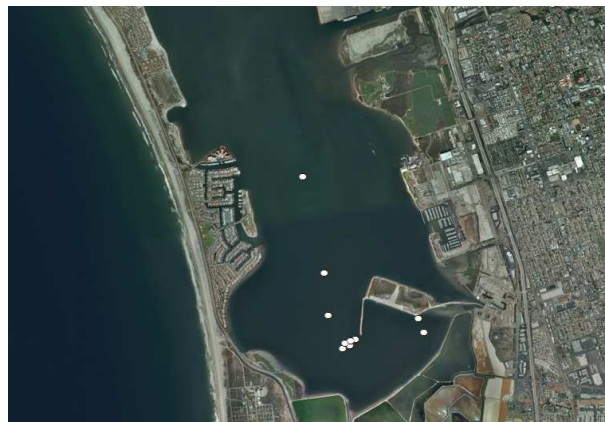
accounts for spatiotemporal sampling biases common to traditional telemetry studies. When a turtle's transmitter is detected, the research vessel tracks and locates the exact position of the detected individual. A turtle is considered to be in close proximity when the transmitter can be heard uniformly through a 360-degree rotation of the directional hydrophone at the receiver's lowest gain setting. A GPS coordinate is recorded using a handheld Garmin GPS unit (accuracy 3-5 m); water temperature at the location is recorded at a depth of 1m. Once a turtle's location has been determined, the research vessel continues to the next listening station.

Bay-wide surveys are completed in 2 field days: 1 day for South Bay and 1 day for central/north Bay. After a temporary stoppage of surveys during October and November due to lack of tagged turtles, surveys were resumed following regular turtle capture in December, 2010. Turtle locations from December 1, 2010 to January 31, 2011 were recorded based on these surveys (Figure 7a-j).

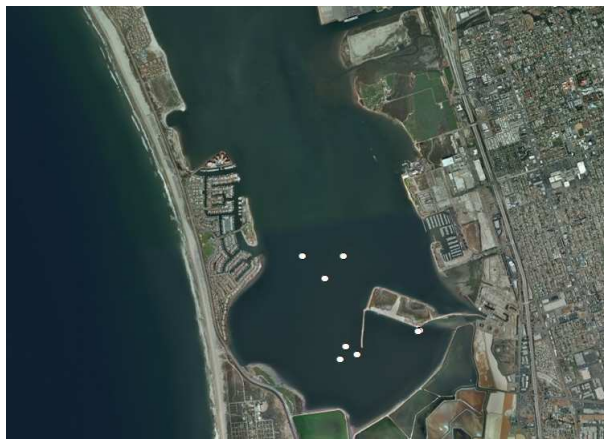
Figure 7a-j: GPS locations of turtles from Bay-wide surveys between December 1, 2010 and January 31, 2011. Turtle ID is displayed below each graphic. Filled white circles indicate locations where the turtle was found.



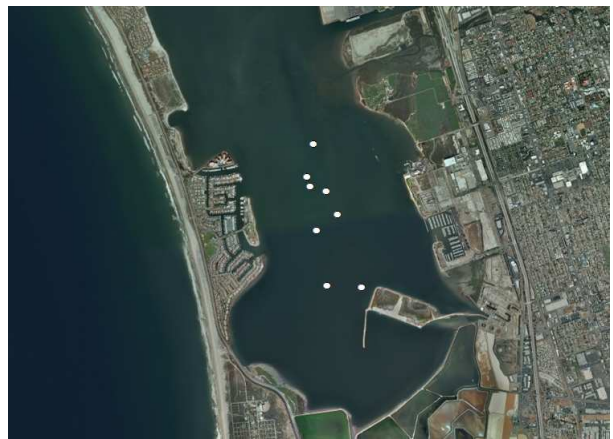
a.) Turtle ID #1990



b.) Turtle ID #2116



c.) Turtle ID #5806



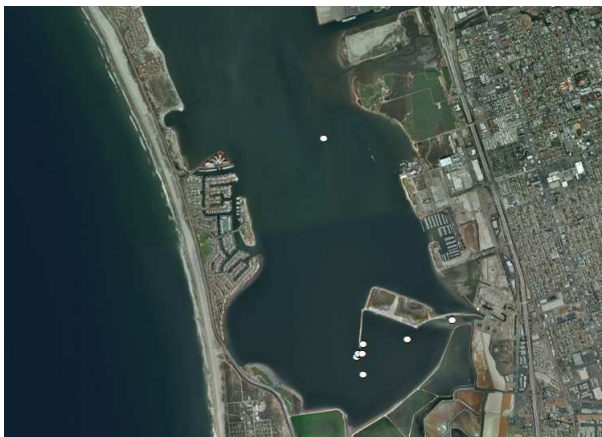
d.) Turtle ID #13690



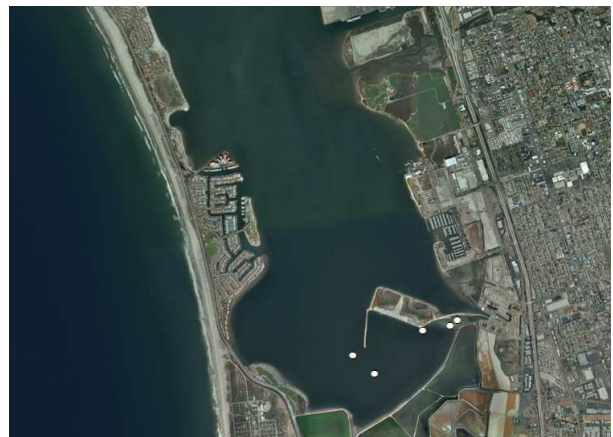
e.) Turtle ID #13692



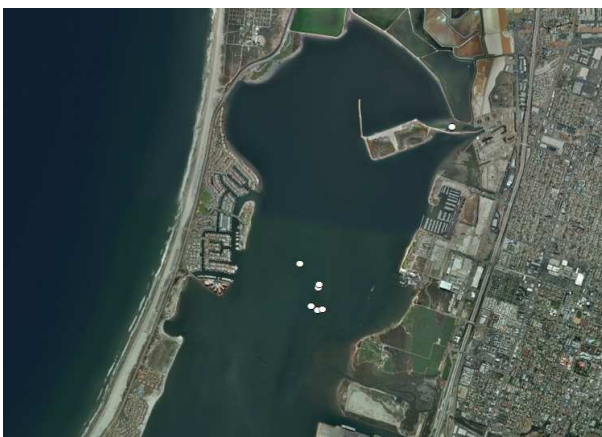
f.) 23647



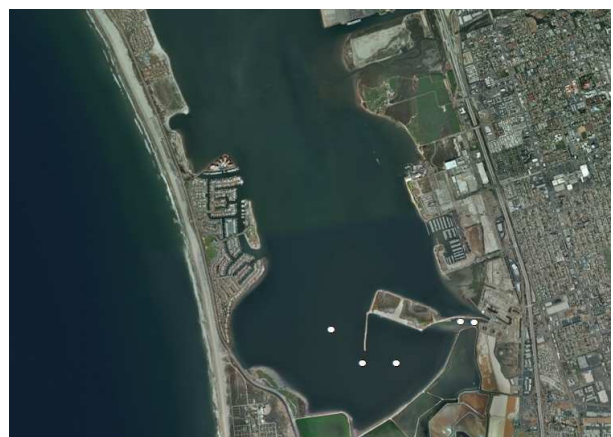
g.) Turtle ID #33145



h.) Turtle ID #88129



i.) Turtle ID #98157



j.) Turtle ID #98310

### *Individual follows*

Beginning December 1, 2010, two field days every other week are spent tracking an individual turtle for a period of 2-6 hours. These “short follows” provide information about turtle movement patterns and are held at varying times during the day (i.e. dusk, dawn, mid-day, etc). Multiple short follows taken together provide high-resolution data for comparisons in daily turtle

movement behavior. Data from turtle follows conducted during this period will be processed and analyzed during spring 2010.

#### **4. Summary of tracking work conducted to date (November 1, 2010-January 31, 2011)**

##### **November**

- Total Field Days: 2
- Capture Days: 11/10/2010
- Passive tracking: SUR station maintenance on 11/19/2010

##### **December**

- Total Field Days: 9
- Capture Days: 12/2/2010 (1 turtle); 12/16/2010 (4 turtles)
- Active tracking: 4 days
- Extended Follows: 2 days
- Passive tracking: SUR station maintenance on 12/16/2010; searched for missing SUR stations on 12/17/2010

##### **January**

- Total Field Days: 14
- Capture Days: 1/5/2011 (6 turtles); 1/25/2011 (1 turtle)
- Active tracking: 8 days
- Extended follows: 3 days
- Passive tracking: SUR station maintenance on January 13, 2011

#### **5. Upcoming Objectives: February-April, 2011**

##### **Turtle Capture**

- Capture season continues until May, 2011 (approx. 2 days/mo.)
- Tagged turtles will be actively tracked as soon after capture as possible

##### **Active Tracking**

- Short follows 2xper week, every 2 weeks
  - 2-6 hour individual follows
  - Equal emphasis of follows at all periods (i.e. dusk, dawn, mid-day, etc.)
- Bay-wide monitoring
  - Bi-monthly surveys
  - Entire coordinate grid of San Diego Bay covered each survey with 1 day spent at each of 2 regional sections of San Diego Bay (south and central/north)

##### **Passive Tracking**

- Currently 14 SUR stations (with HOBO logger) deployed
  - Regular SUR station maintenance every 6-8 weeks

#### Data Analysis

- Preliminary results confirm high site fidelity of all turtles to south San Diego Bay. Preliminary results will be shared at the International Sea Turtle Symposium in San Diego in April, 2011.
- Further data management and analysis will take place throughout spring 2011. Student MacDonald will begin focusing on data analysis and writing MS thesis in May, 2011.

### **6. Executive Summary**

- We have developed a robust protocol, based on a thorough equipment testing and performance.
- The passive tracking array has yielded turtle distribution data and temperature data. Based on these data, individual turtles continue to heavily utilize south San Diego Bay, and presence in high traffic areas near Sweetwater Marine Terminal appears to be infrequent and sporadic. Presence was highest in the dense eelgrass beds of south San Diego Bay, but this may change depending on local water temperatures throughout the winter. Further analysis will reveal how turtle presence correlates with temperature and also how turtles respond to the decommissioning of the South Bay Power Plant, which was officially closed on December 31, 2010.
- We have established an effective Bay-wide monitoring regime that is providing critical information on turtle habitat use throughout the Bay. This has been and will continue to be conducted every week to assess turtle activity throughout the Bay and seasonal changes in those patterns. Our Bay-wide surveys have indicated that overall turtles are regularly present in South Bay, south of Sweetwater Inlet. Thus far, we have not detected turtles north of Sweetwater Inlet.
- Our individual turtle follows are generating high-resolution data on individual turtle behavior. These data will be overlaid with habitat data (sea grass maps) and temperature data. We will continue to conduct focal animal follows to obtain high-resolution data on habitat use.
- Continued turtle tagging is essential for this project to continue. The SDSU/NOAA team is working closely to ensure continued capture of turtles throughout the field.