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**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 July 1, 2010 to October 31, 2010 conducted by the SDSU and NOAA research team.

This report covers 4 main areas of research activity

1. **Turtles and tag retention**
2. **Passive tracking**
3. **Active tracking**
4. **Summary of tracking activities (7/1/10 – 10/31/10)**
5. **Upcoming objectives**
6. **Executive summary**

The data included in this report should be cited as “Eguchi, Seminoff, Madrak, MacDonald, and Lewison, unpublished data.”

1. Turtles and tag retention

A total of 18 turtles were tagged between November 5, 2009 and September 7, 2010. During the regular capture season (November 5, 2009 – April 15, 2010), 16 turtles were tagged; two turtles were tagged during additional capture events held on August 16 and September 7, 2010 (table 1). Tag retention appears to be approximately 4-6 months. **As of August 15, 2010, only one turtle (ID 13690) retained an acoustic tag.**

ID	Date Captured	Freq	PI	Mass	SCL	Sex	Pattern	Name	Last Det
1990	11/5/09	36	930	121	100.4	Female	5-5-5	Bonita	5-Jul
33145	11/17/09	38	950	50	70	Juv	6-7-8	Susan	
88129	12/3/09	36	870	146	98	Male	3-4-5	Simon	28-Feb
88329	12/16/09	37	1230	35	65.3	Juv	5-7-8-7	Trueno	17-Jun
13585	12/3/09	38	890	147	102.5	Female	3-7-7	Dolly P.	7-Jun
3004	12/3/09	36	1130	153	101	Female	4-4-6-5	A. Banderas	30-Mar
3005	12/3/09	36	1210	89	86.9	Male	5-6-5-8	Romain	26-Jul
8356	12/16/09	39	1250	130	97.2	Male	6-8-6-8	Rhonda	24-Dec
88416	1/5/10	37	890	81	87	Female	3-7-6	Isabela	11-Jul
13690	2/3/10	37	1050	62	80.9	Juv	3-5-5-8	Goose	24-Jul
88466	2/3/10	38	1070	18	54.9	Juv	3-6-3-6	JBJ	28-Jun
1989	2/18/10	40	1090	130	101.1	Male	3-6-7-7	Dr. Madrak	26-Jul
33149	2/3/10	40	1250	48	71.1	Juv	6-8-8-7	Barry M.	24-Jun
4546	2/3/10	39	1070	130	95.2	Female	3-6-3-7	Pina Colada	
11761	3/3/10	39	1190	133	100.8	Female	5-5-5-8	J. Rivers	8-Jul
8370	3/3/10	36	1150	132	101.8	Female	4-5-5-7		11-Apr
4546	4/15/10	40	1190	-	94.7	Female	5-5-6-6	Pina Colada	7-Jun
	9/7/10	39	970			Juv	3-3-5-4	Bill Pullman	
	9/7/10	35	870				3-4-4	Gary Busey	

Table 1. Turtles tagged during the 2009-2010 capture season. Columns from left to right: turtle identification number, date of capture (tag deployment), tag frequency, tag pulse interval, turtle mass, turtle straight carapace length, turtle sex, tag pulse pattern, turtle name, and date of last tag detection.

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 at 19 different locations in South Bay based on areas of interest, including potential foraging areas (i.e. seagrass beds) and high-traffic areas (boating channels & 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 once every 6-8 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

SURs have been deployed throughout the south portion of San Diego Bay (Figures 2, 3). As of October 29, 2010, 8 new SUR stations (SUR and HOBO data logger) were deployed (Figure 3). An 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.

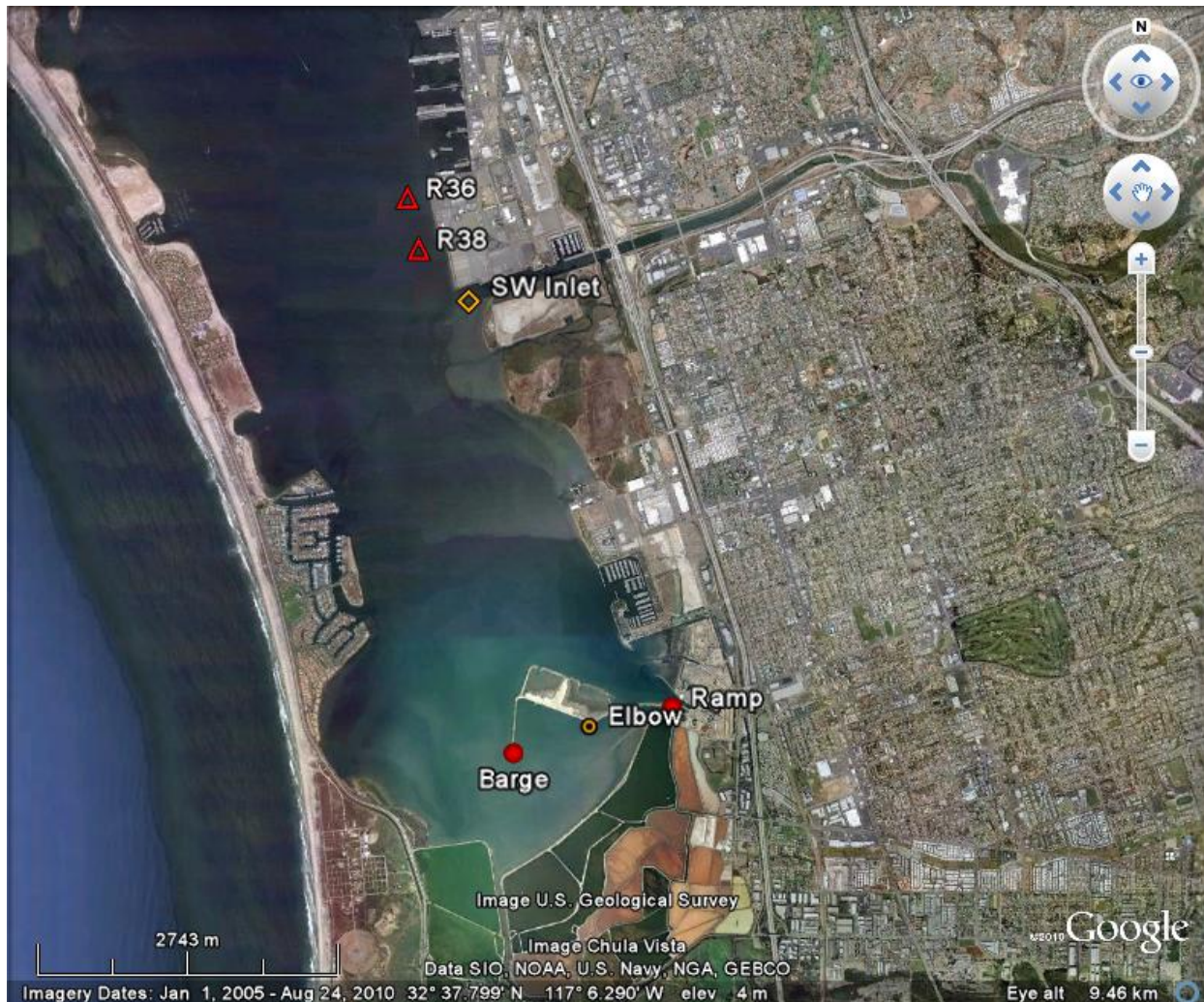


Figure 2. SUR locations in San Diego Bay July - October 2010. Red triangles correspond to channel markers, and are named appropriately. “SW Inlet,” marked by orange diamond, marks the SUR station at the Sweetwater Inlet. SUR stations within the South Bay Power Plant outfall area include: ramp, elbow, and barge.



Figure 3. SUR locations in San Diego Bay October 29, 2010 to present. Red triangles and green squares correspond to channel markers, and are named appropriately. The “North Fence” is a new array of 5 SUR stations: NF1-NF5. “SW Inlet,” marked by orange diamond, marks the SUR station at the Sweetwater Inlet. SUR stations within the power plant outfall include: ramp, elbow, and barge.

SUR Station Data and Preliminary Results

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.

Detections of tagged turtles by SURs indicated that some turtles have affinities to certain locations. A comparison of turtle visits between the South Bay Power Plant outfall area (SBPP) and the Sweetwater Marine Terminal reveals seasonal changes (Figure 4). Based on the low level

of commercial and recreational usage, the outfall area is considered a “low-traffic” area and was more frequently visited (overall) than the Marine Terminal, a “high-traffic” area. However, usage of both sites was more similar during the late spring/early summer months as these areas become more thermally alike (Figure 5).

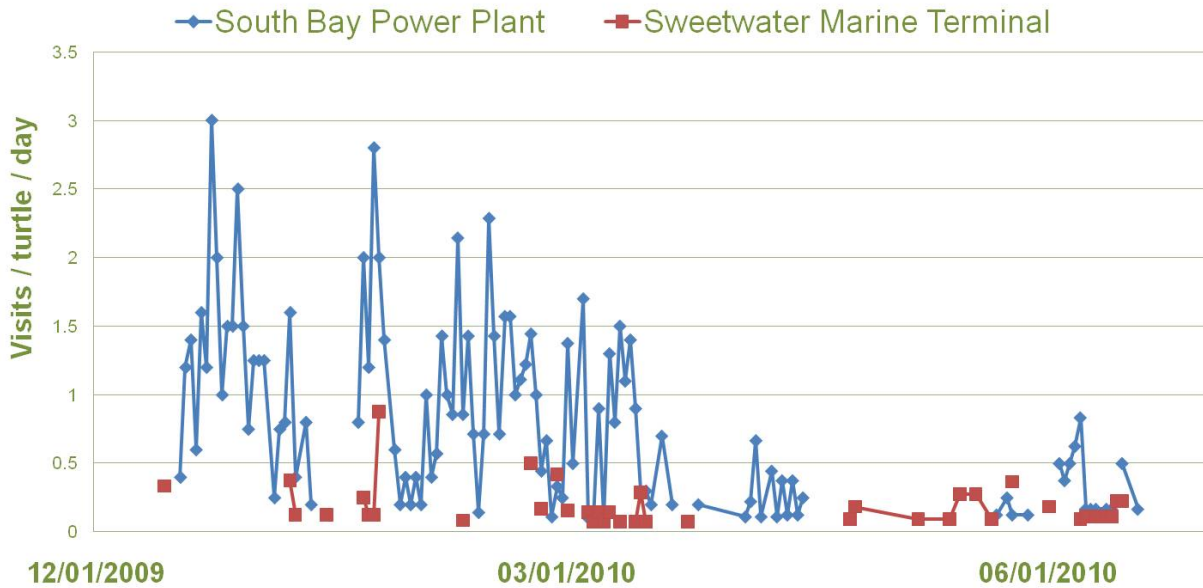
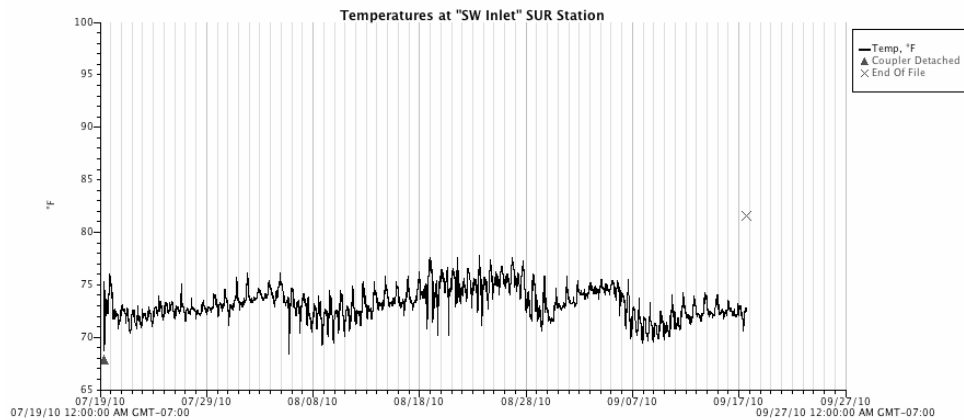
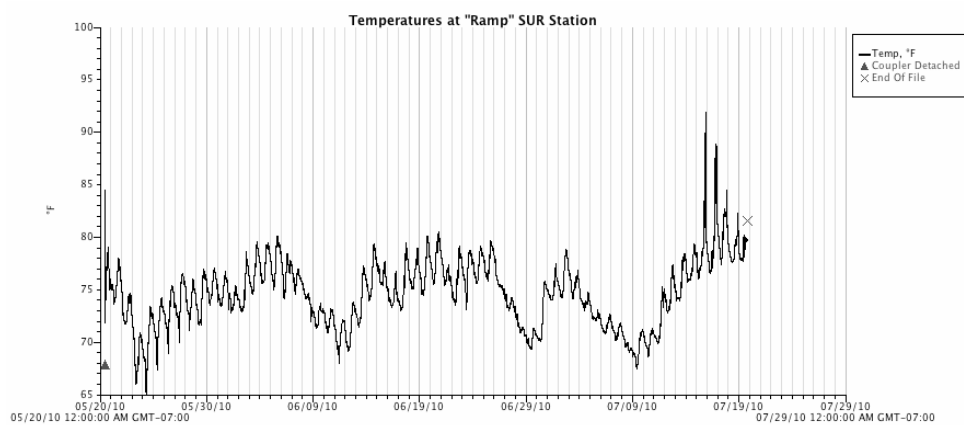


Figure 4. Turtle “visits” by site in San Diego Bay; comparison between South Bay Power Plant outfall area and Sweetwater Marine Terminal channel. A “visit” consists of at least 3 tag detections separated by not more than 15 minutes between detections.

a.



b.



c.

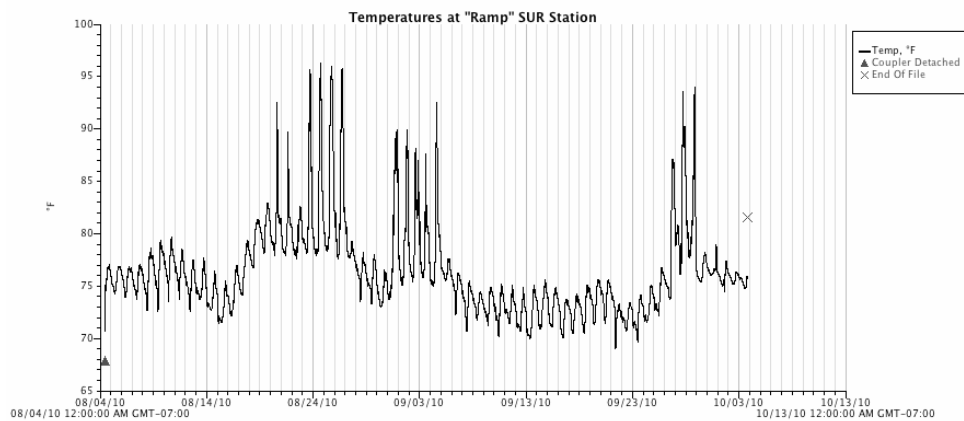
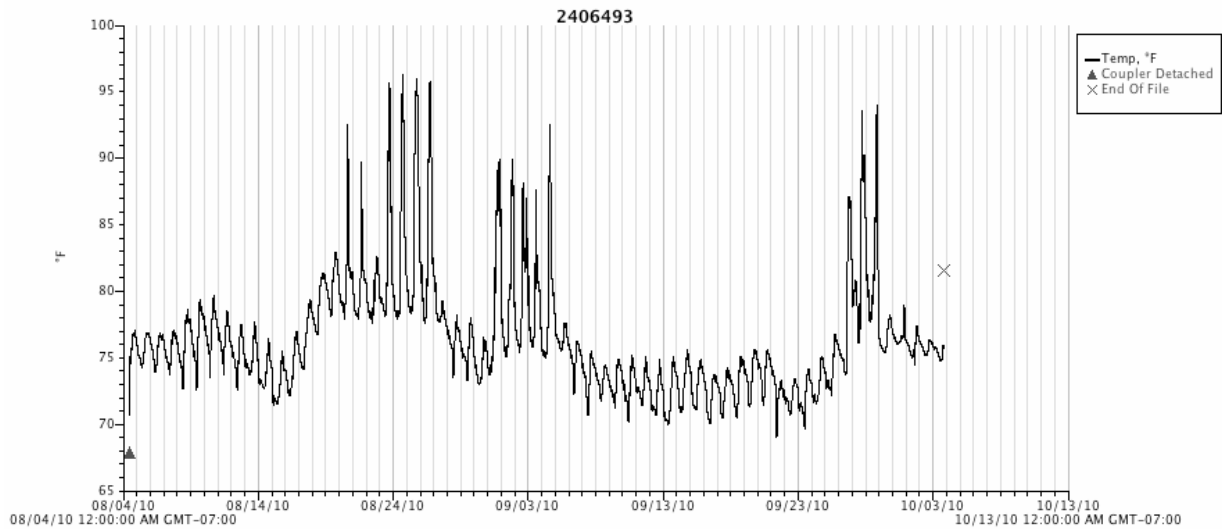


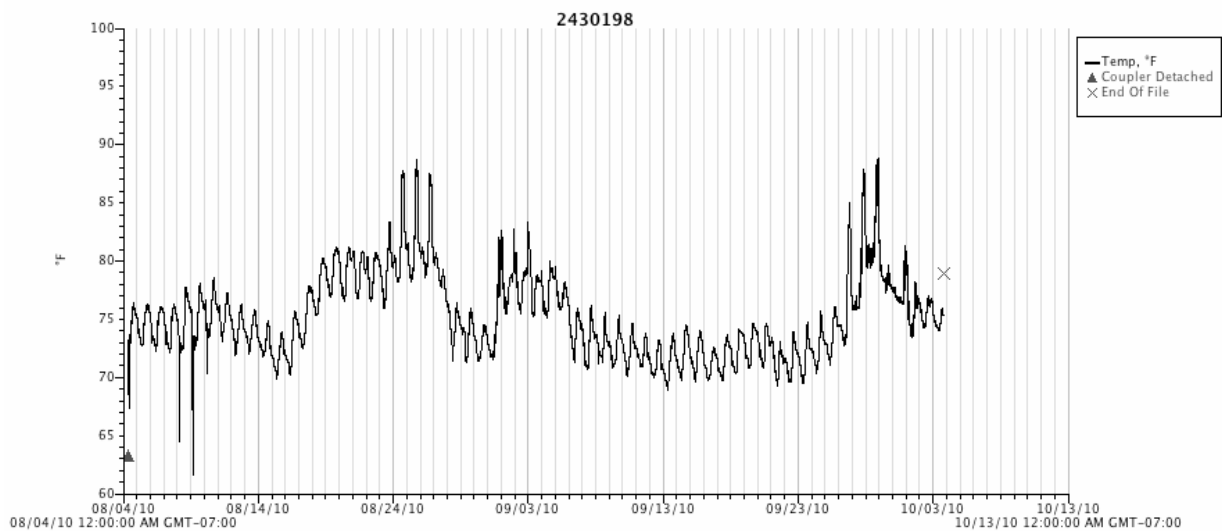
Figure 5 a-c. Temperature as recorded by HOBO data loggers at the “SW Inlet” (Figure 5a) and the “Ramp” (Figures 5b and 5c). On average, temperature at both locations appears to be approximately 75° F; excluding marked temperature spikes at the “Ramp” (presumably from warm-water release into the outfall area).

Temperature in the South Bay Power Plant Outfall Area

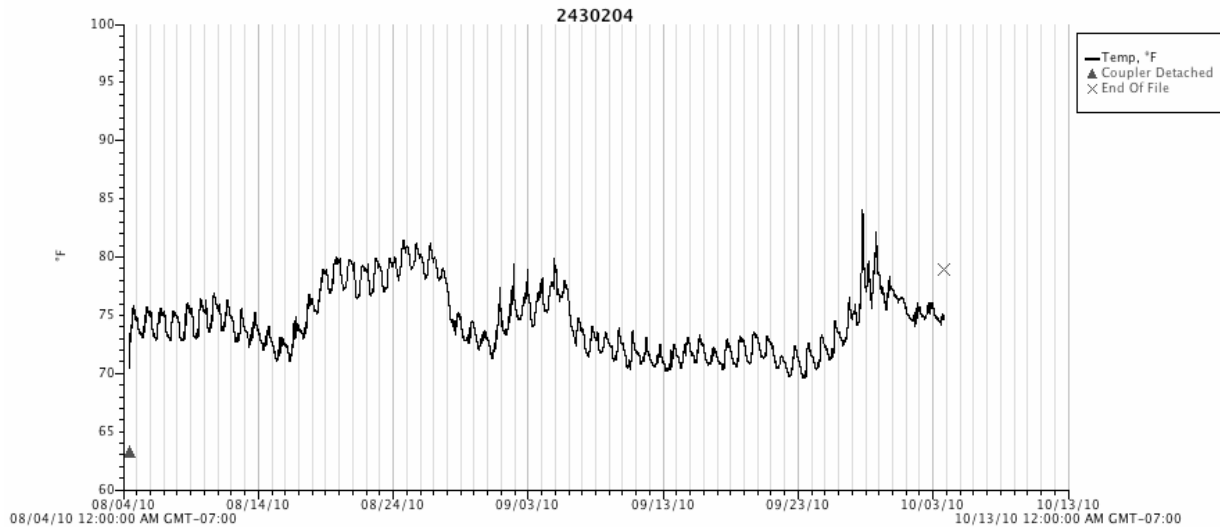
HOBO temperature data loggers that were deployed from August 4 – October 4, 2010 in the South Bay Power Plant outfall area – “Ramp,” “Elbow,” and “Barge” – demonstrated marked fluctuations in temperature, presumably associated with release of warm water effluent from SBPP (Figure 6). Temperature spikes occurred on August 24-28, 2010, September 1-4, 2010 and October 27-28, 2010. These spikes were most dramatic at the “Ramp” location – as expected, due to proximity to effluent release point. These spikes were evident at the “Elbow” and “Barge” locations, however the fluctuations were less dramatic as temperature dissipates with increasing distance from the effluent release point.



Ramp



Elbow



Barge

Figure 6. Temperature data from HOBO U22 Water Temp Pro v2 temperature data loggers deployed at the “Ramp,” “Elbow,” and “Barge.” Temperature spikes on August 24-28, 2010, September 1-4, 2010 and October 27-28, 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. Turtle locations from July 1 – August 31, 2010 were recorded based on these surveys (Figures, 7,8). **Bay-wide monitoring was suspended by the end of August 2010 in favor of individual follows as the number of turtles retaining tags was low enough that all turtles could be detected each week without need for a comprehensive survey.**

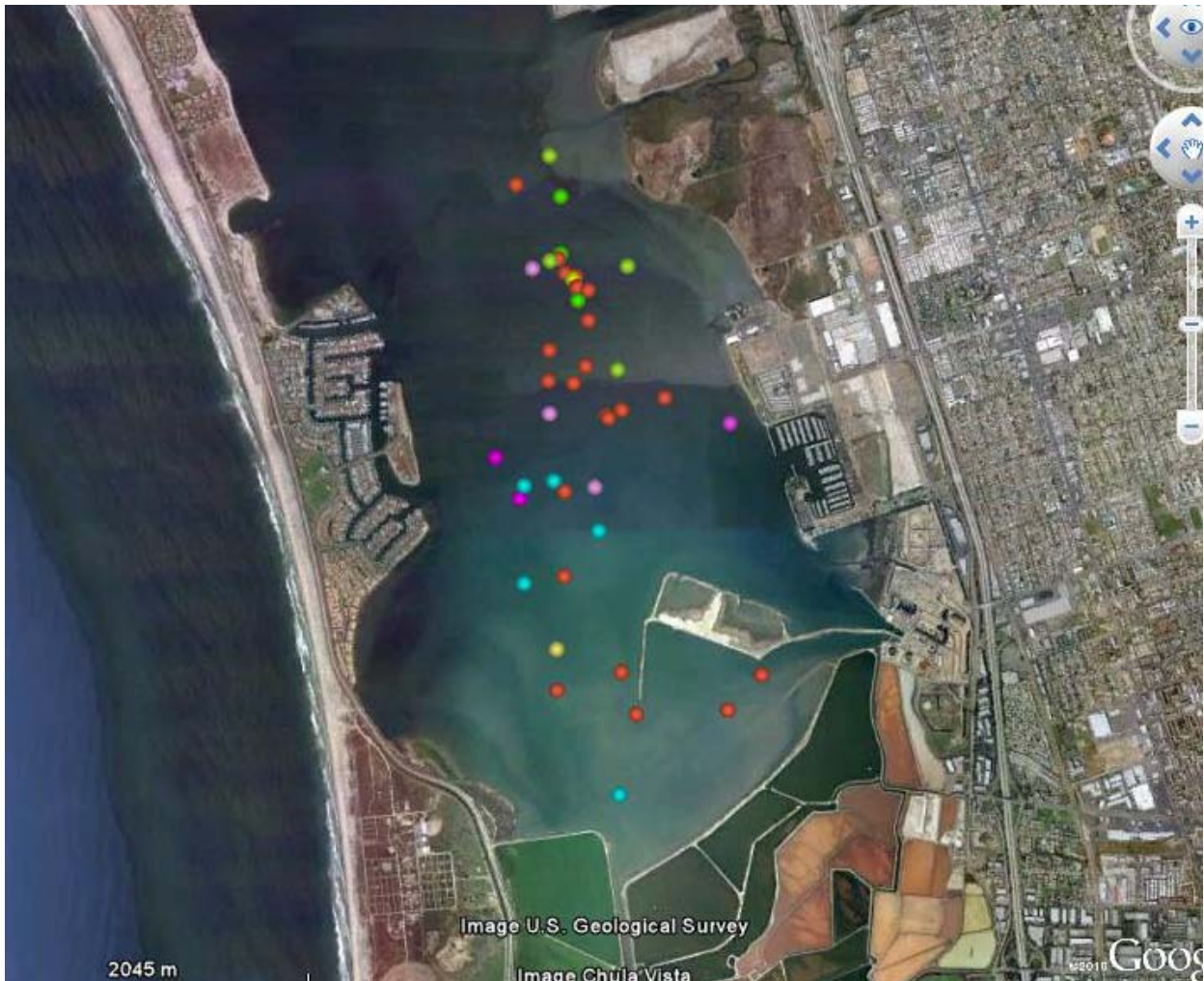


Figure 7. Turtle locations from July 1 – August 31, 2010 as determined through active tracking. Different colors denote individual turtles and their locales.

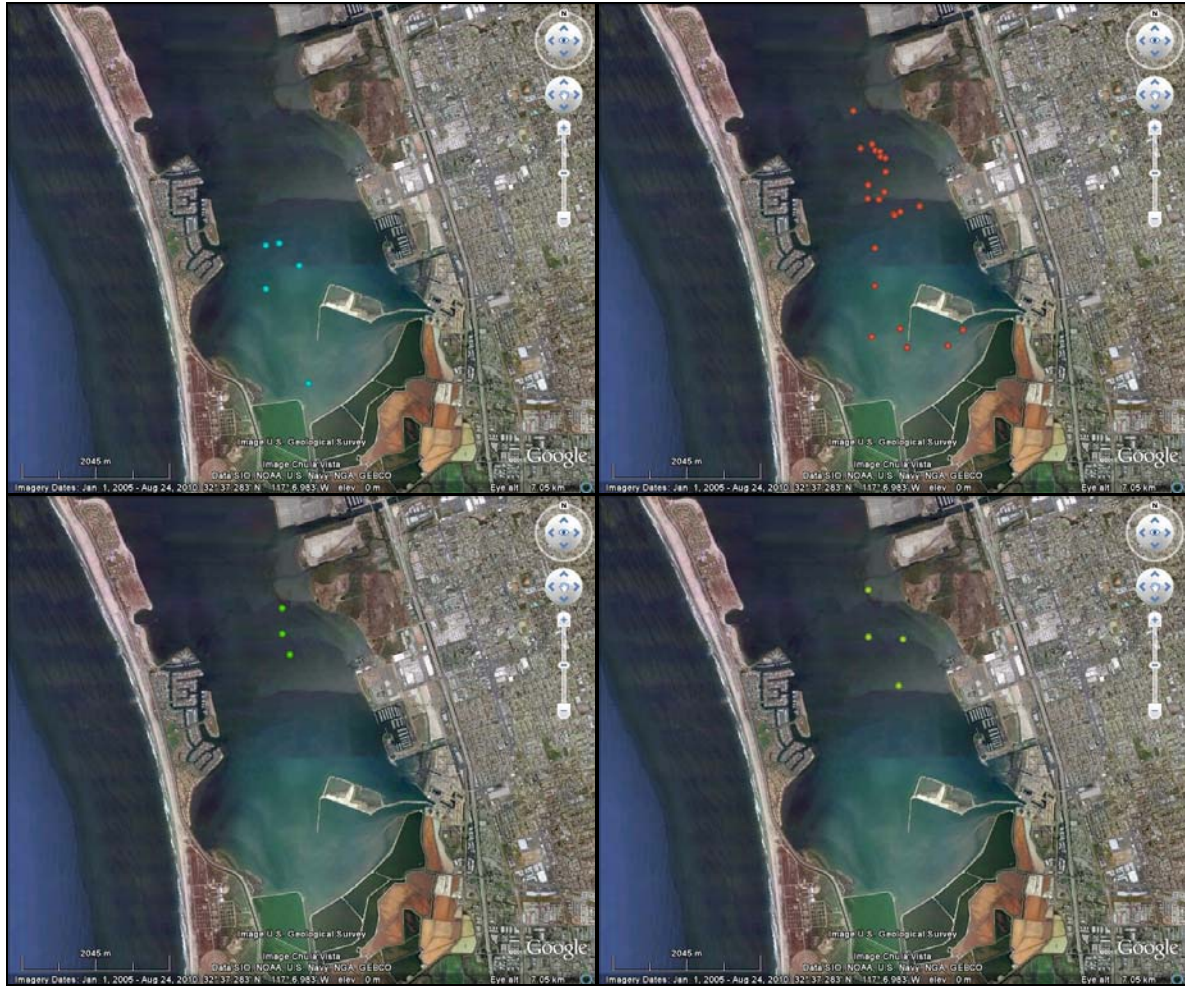


Figure 8. GPS locations from bay-wide surveys from July 1 – August 31, 2010, separated by individual turtle. From left to right and top to bottom, turtle IDs are 23648, 13690, 88416, and 11761. Individual turtles appear to show localized site fidelity within South Bay.

Individual follows

Starting Jan 1, 2010, SDSU students Madrak and MacDonald assumed all tracking responsibilities. Once monthly, they conduct 24-hour tracking periods of tagged individuals to collect high-resolution diurnal and nocturnal movement data for specific individuals. Once a tagged turtle is detected, rotating research teams continuously monitor the same individual at a distance of approximately 50m for 24-hours. GPS coordinates and water temperature are recorded at 10 minute intervals throughout the tracking period to provide high resolution data. Each month, we collect data from a continuous 24-hour period from a single tagged individual. Transmitter failure (i.e. wear and tear, battery failure) may prevent data collection on some individuals.

Beginning June 1, 2010, one field day per week is 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.

24-hour tracks were temporarily suspended as of August 1, 2010 due to limited number of tagged turtles. We continued individual follows into October although we were down to a single tagged turtle.

4. Summary of tracking work conducted to date (July 1, 2010 – October 31, 2010)

July

- Total Field Days: 10
- Capture Days: none
- Active tracking: 9 days
- Passive tracking: SUR station maintenance on 7/19/2010
- 24-Hour tracking: July 7-8, 2010, ID 13690 (“Goose”)

August

- Total Field Days: 13
- Capture Days: 1 on 8/16/2010; no new turtles
- Active tracking: 11 days
- Passive tracking: SUR station maintenance on 8/4/2010
- 24-Hour tracking: none

September

- Total Field Days: 5
- Capture Days: 1 on 9/7/2010; 3 new tagged turtles
- Active tracking: 4 days
- Passive tracking: SUR station maintenance not necessary
- 24-Hour tracking: none

October

- Total Field Days: 10
- Capture Days: none
- Active tracking: 7 days
- Passive tracking: SUR station maintenance on 10/8/2010, 10/21/2010, and 10/29/2010
- 24-Hour tracking: none

5. Upcoming Objectives: November-January 2010 (assuming acoustic tags are deployed and retained)

Turtle Capture

- Capture season commences on November 10, 2010
- Approximately 2 capture days are scheduled each month through May 2011
- Tagged turtles will be actively tracked as soon after capture as possible

Active Tracking

- Short follows 2x per 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

- Initial analysis of spatial and thermal data expected by February 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 spend large amounts of time in the SBPP outfall area, as evidenced through SURs deployed at the “Ramp,” “Elbow,” and “Barge.” Temperature data reveal fluctuations in the SBPP outfall area that are presumably correlated with release of warm water effluent. Further analysis will reveal how turtle presence correlates with temperature.
- 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 we capture turtles as soon as possible by extending capture days to include night time hours and increasing field support for the work.