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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-risk 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 April 1, 2010 to June 30, 2010 conducted by the SDSU and NOAA research team.

This report covers 4 main areas of research activity

- 1. Passive tracking**
- 2. Active tracking**
- 3. Summary of tracking activities (4/1/10 – 6/30/10)**
- 4. Upcoming objectives**
- 5. Executive summary**

The data included in this report should be cited as “Eguchi, Seminoff, Madrak, MacDonald, and Lewison, unpublished data.”

1. 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 19 fixed SUR sites in South Bay based on areas of interest, including potential foraging areas (i.e. seagrass beds) and high-risk 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).

SURs have been deployed throughout the south portion of San Diego Bay (Figure 2). Not all stations shown in Figure 2 were deployed at the same time (Figure 3). For "Sweetwater" and "Elbow" stations, the same names were used for two proximate locations. SUR deployment records are summarized in Figure 3. The locations of SURs were determined by the distribution of eelgrass in the south bay, turtle sightings in the past, and management requirements.



Figure 2. SUR locations in San Diego Bay during the 2010 study period. The numbers on location labels correspond to those in Figure 4. Green dots identify currently deployed SUR stations and red dots identify SUR stations to be deployed in August 2010 (or as soon as possible, pending equipment).

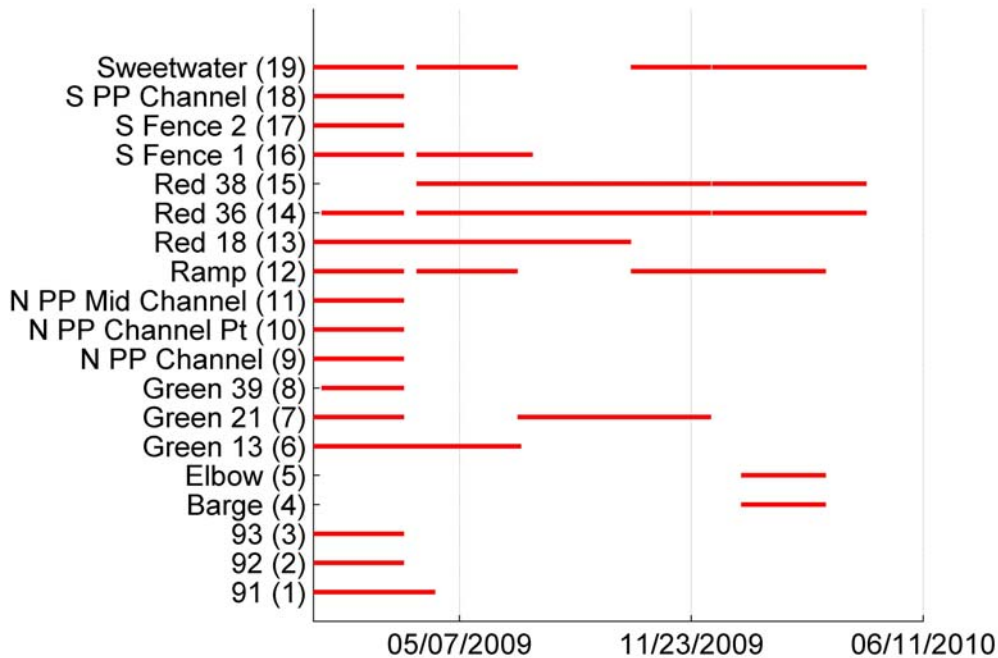
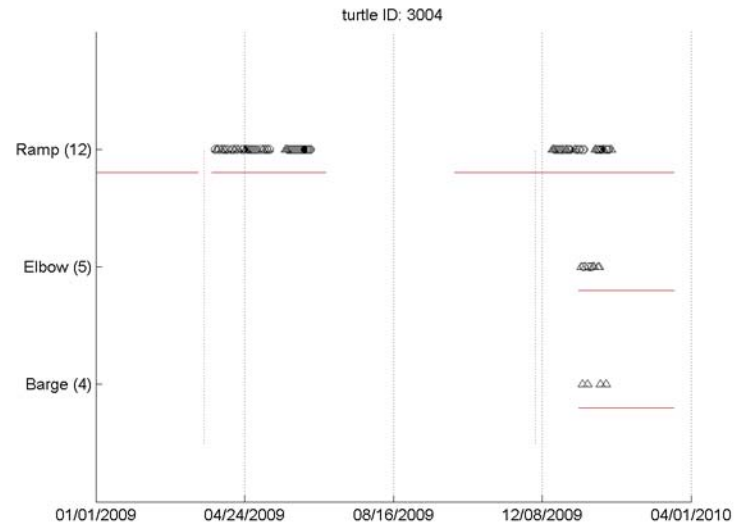
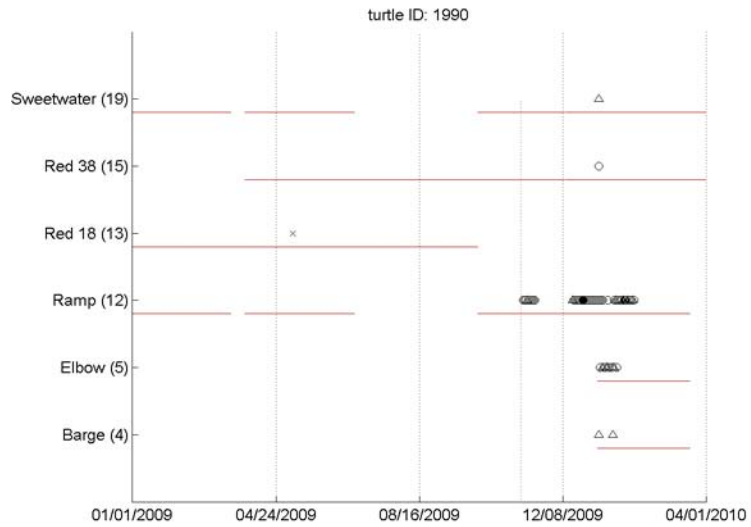
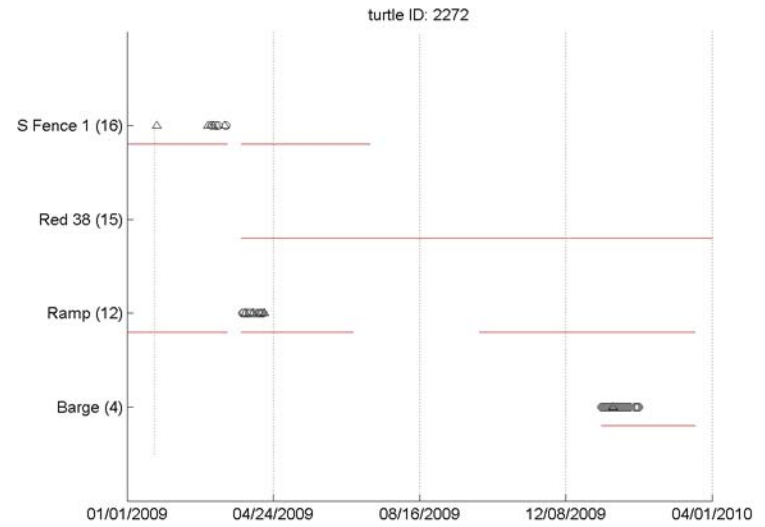
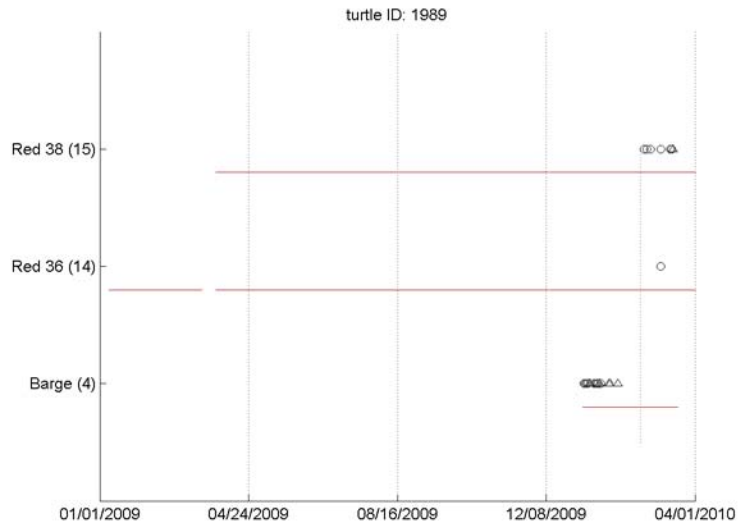
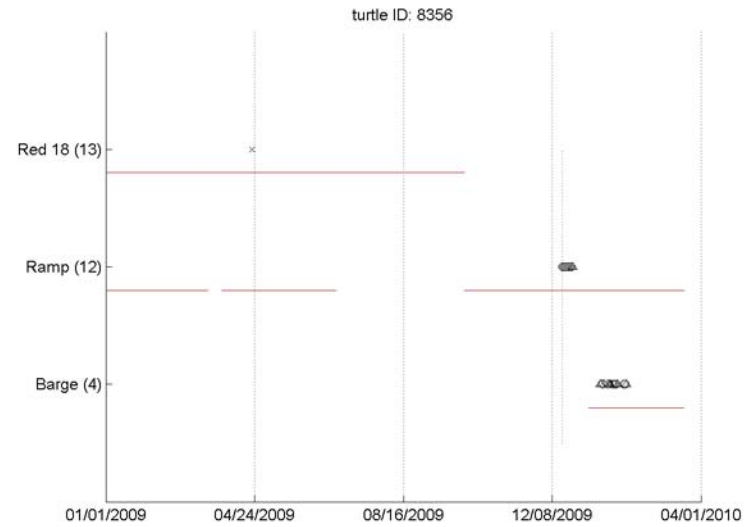
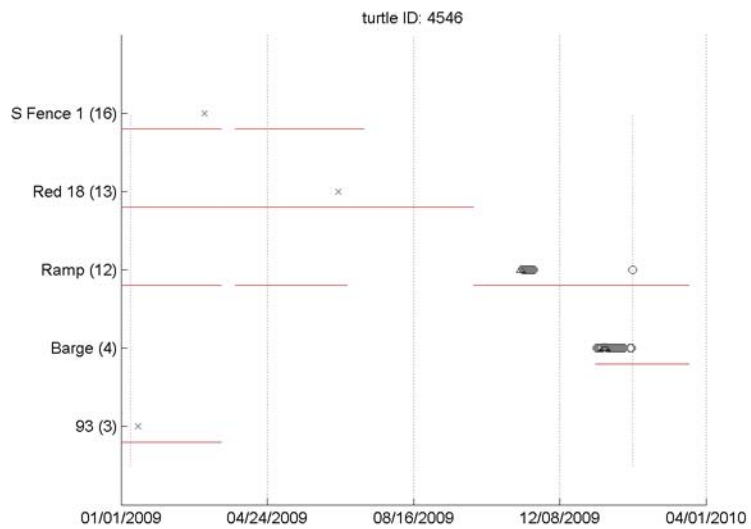
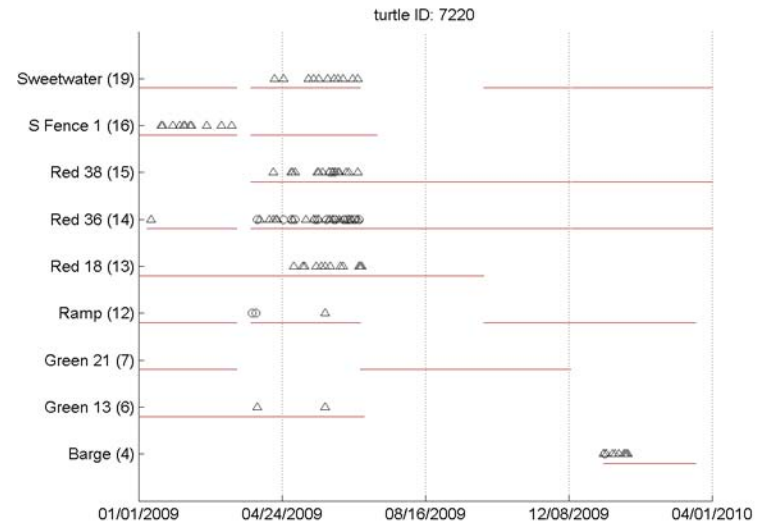
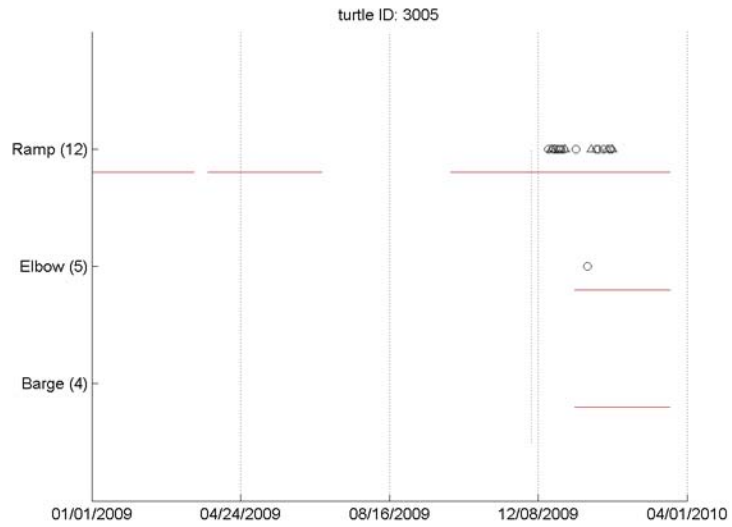
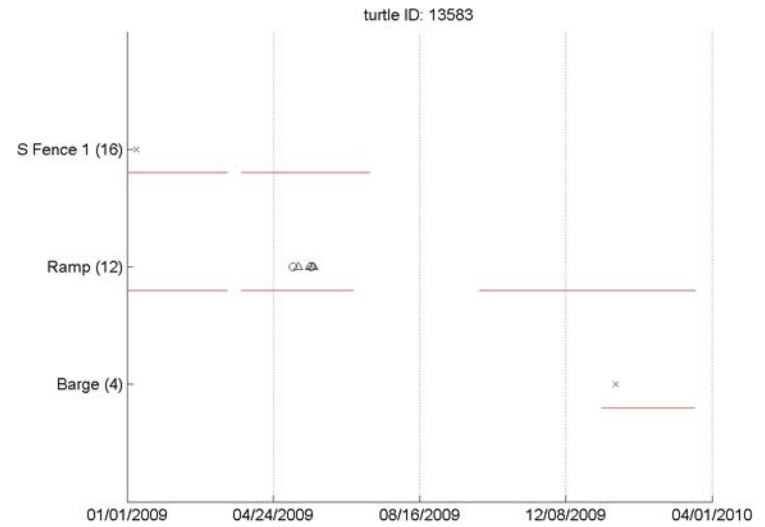
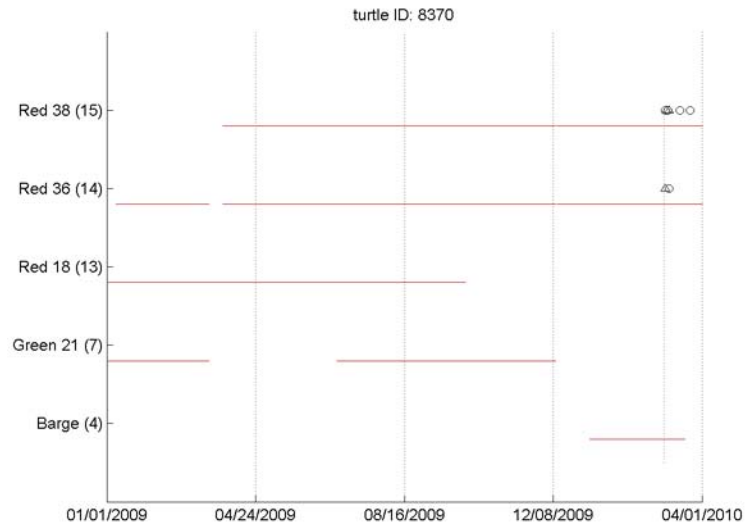
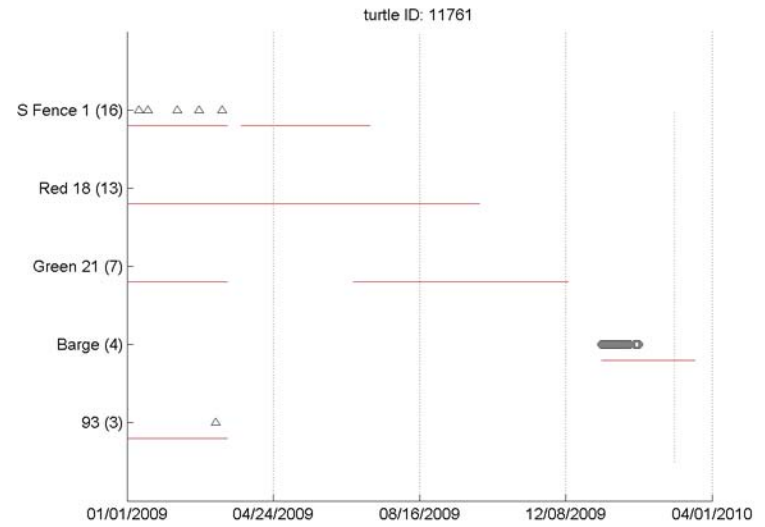
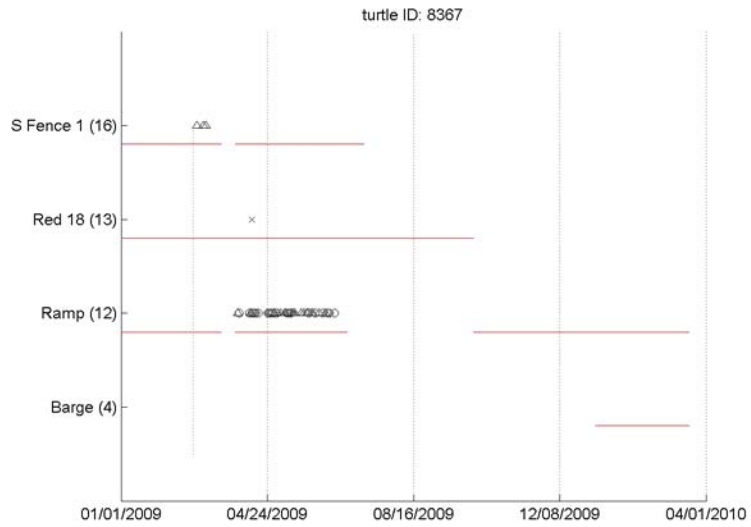


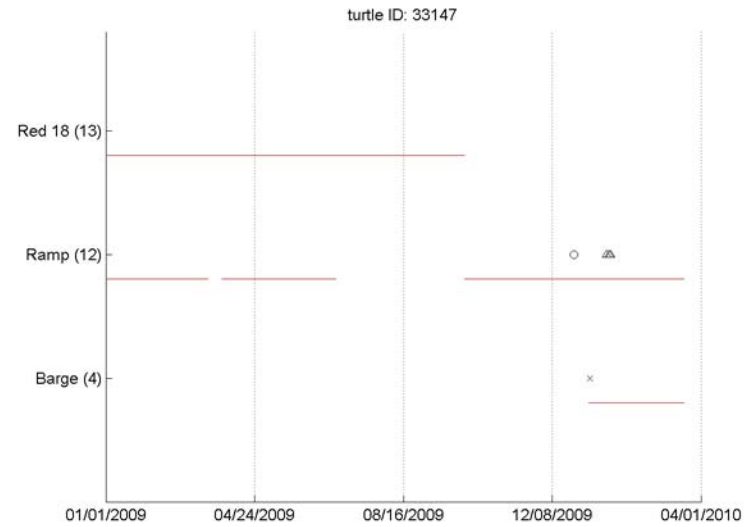
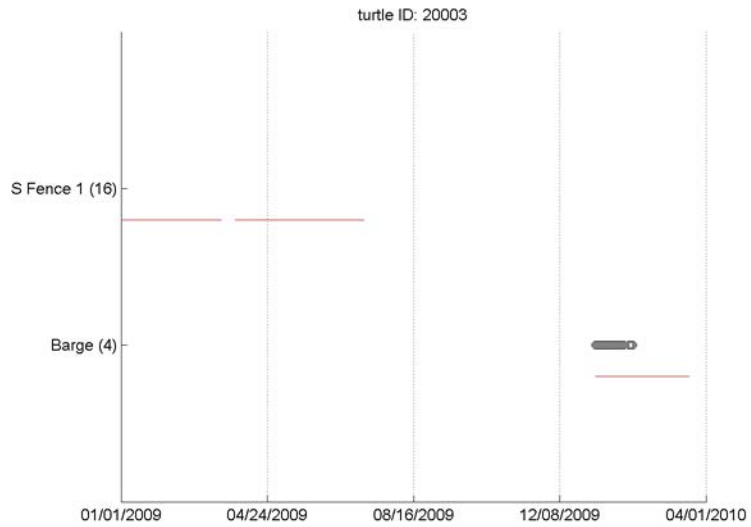
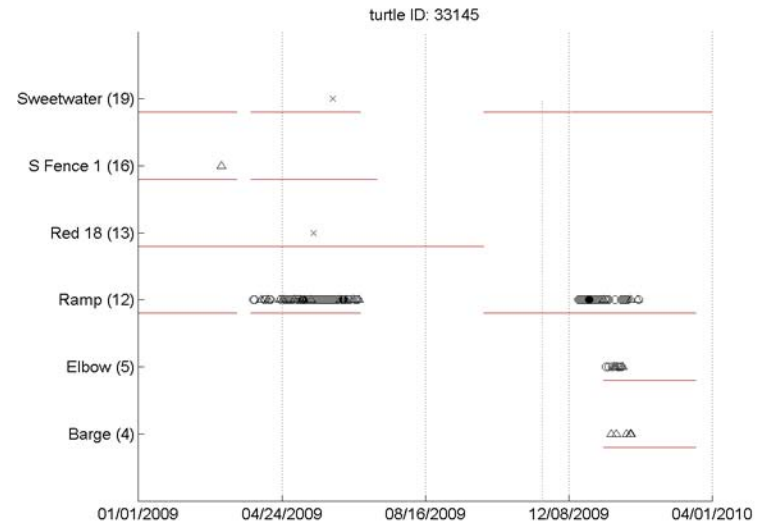
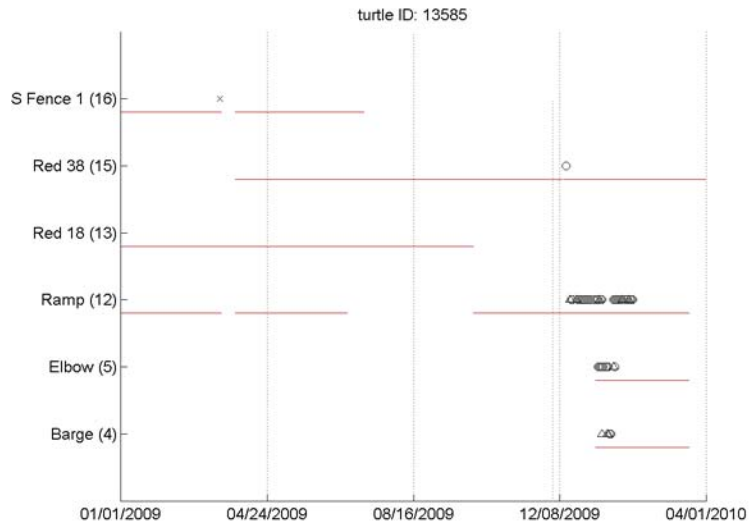
Figure 3. SUR deployment records. Horizontal bars indicate time spans in which SURs were deployed at these locations. The horizontal axis starts at January 1, 2009.

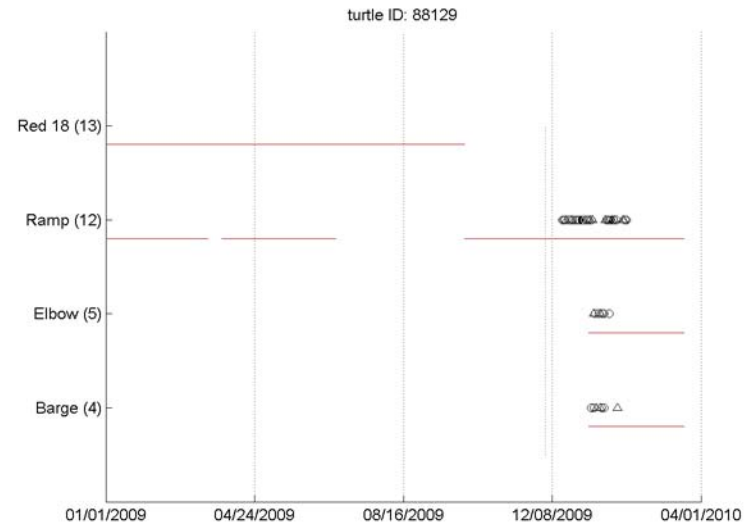
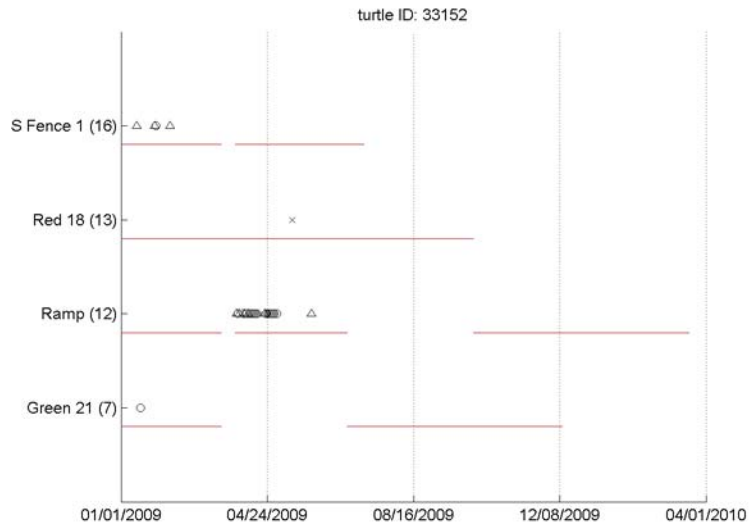
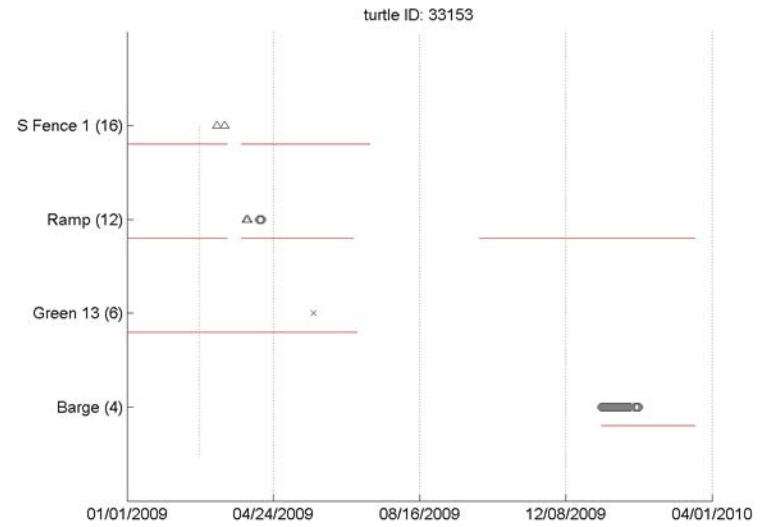
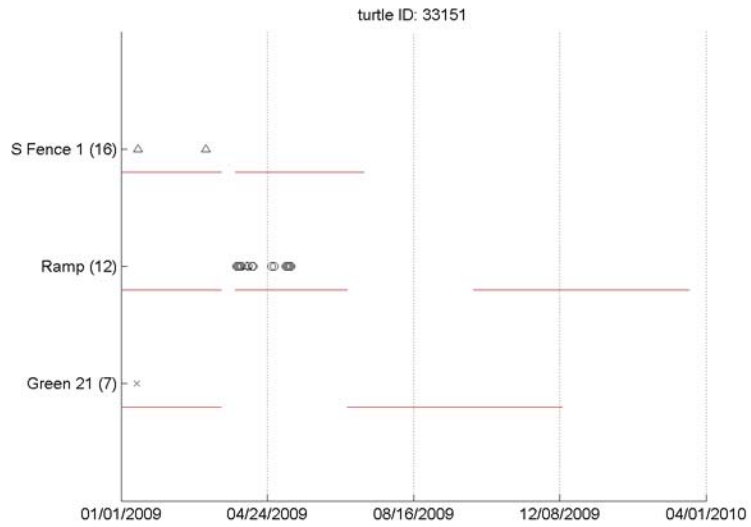
Downloaded data from each SUR were processed using SURsoftDPC (Sonotronics, Tucson, AZ), which extracted date and time of detections of all tags. Habitat use of tagged turtles was determined by compiling detections of each turtle by SURs. Useful data were retrieved for 23 turtles (Figures 4). Detections of tagged turtles by SURs throughout the south bay indicated that some turtles have affinities to certain locations (Figures 4). For example, turtle 33145 was found often at the effluent channel (Ramp and Elbow), but not found far from the effluent channel. For another example, turtle 88416 was found near the Sweetwater river outlet (Red 36, Red 38, and Sweetwater), as well as in the effluent channel (Elbow). Turtle 7220 was found at various locations. Non-detections of tagged turtles indicated that there are unmonitored areas in the bay that are used by these turtles. Seven tags were eventually found consistently at Barge and stayed in the vicinity (2272, 11761, 4546, 8356, 7220, 20003, 33153). This and the field observations indicated that the turtles are "cleaning" their carapace at the barge thereby removing the tags.











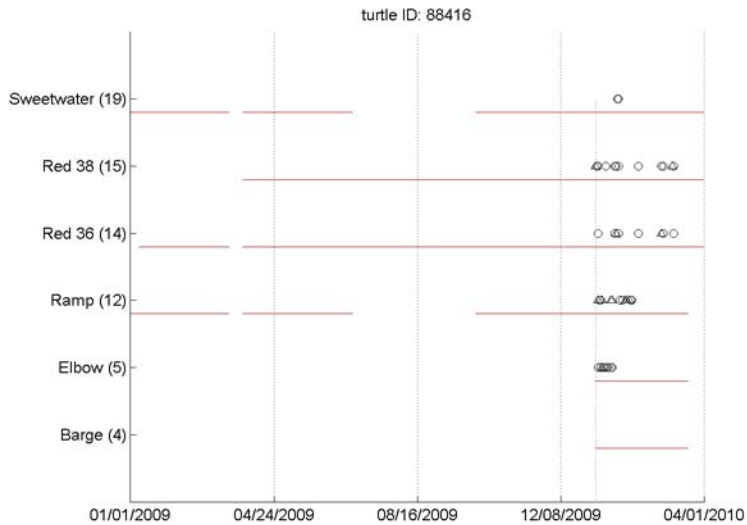
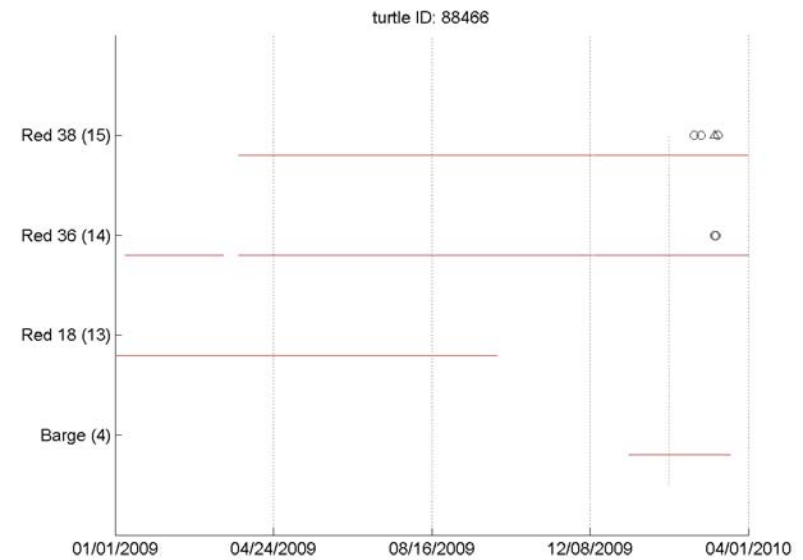
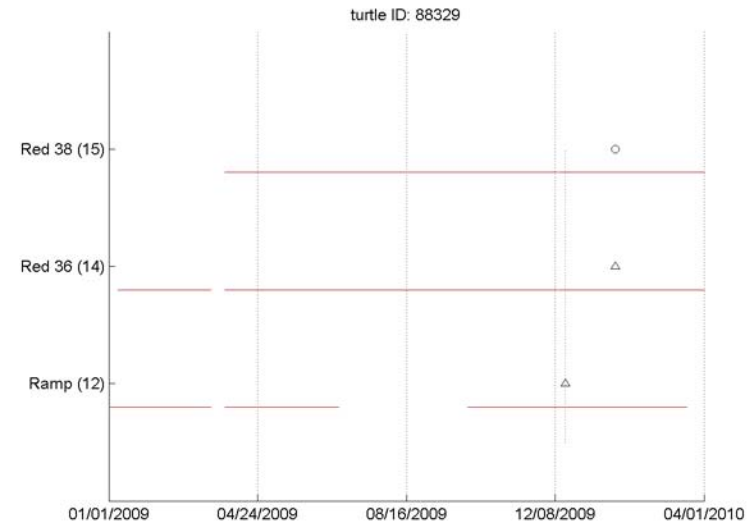
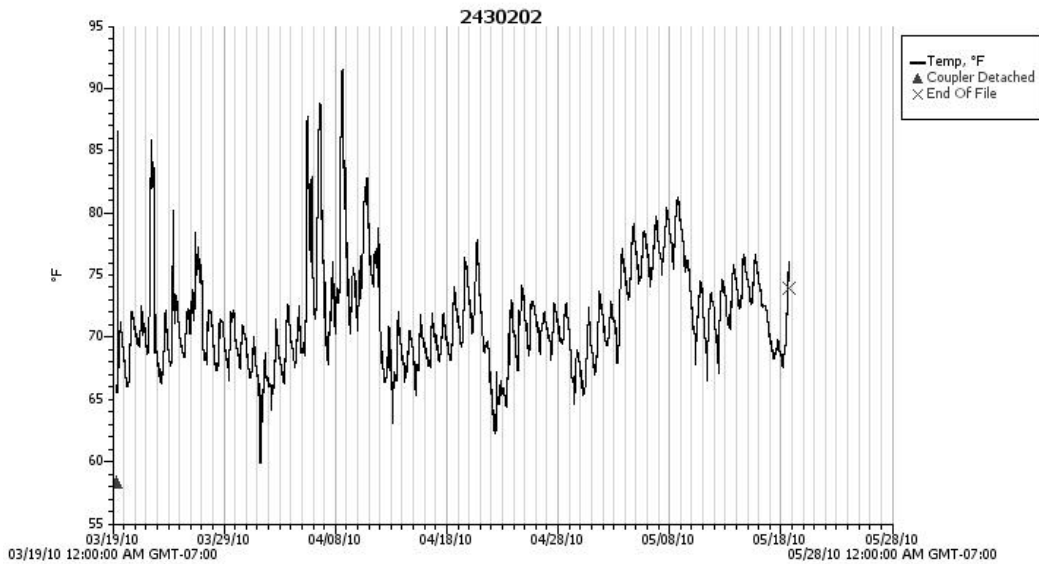
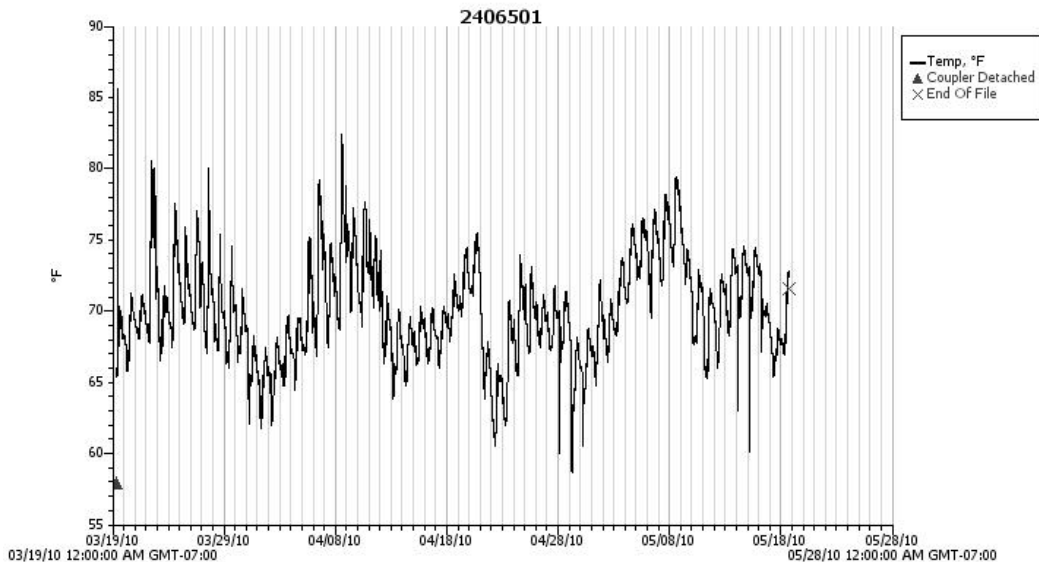


Figure 4. Detections of acoustic tags deployed on green turtles in San Diego bay. The horizontal axis is date and the vertical axis indicates SUR locations. Location names are listed in Table 1 and Figure 1. Each plot is for a particular turtle, where the identification of a turtle is shown on the top of each figure. Red horizontal lines indicate the time spans for which a SUR was deployed at a particular location. Vertical dotted lines indicate the time of acoustic deployments and replacements. A circle indicates the turtle was detected > 5 times per day, a triangle indicates >1 and < 6, and an x indicates one detection per day. Red lines with no detections indicate the turtle was detected at those locations before 1 January 2009.

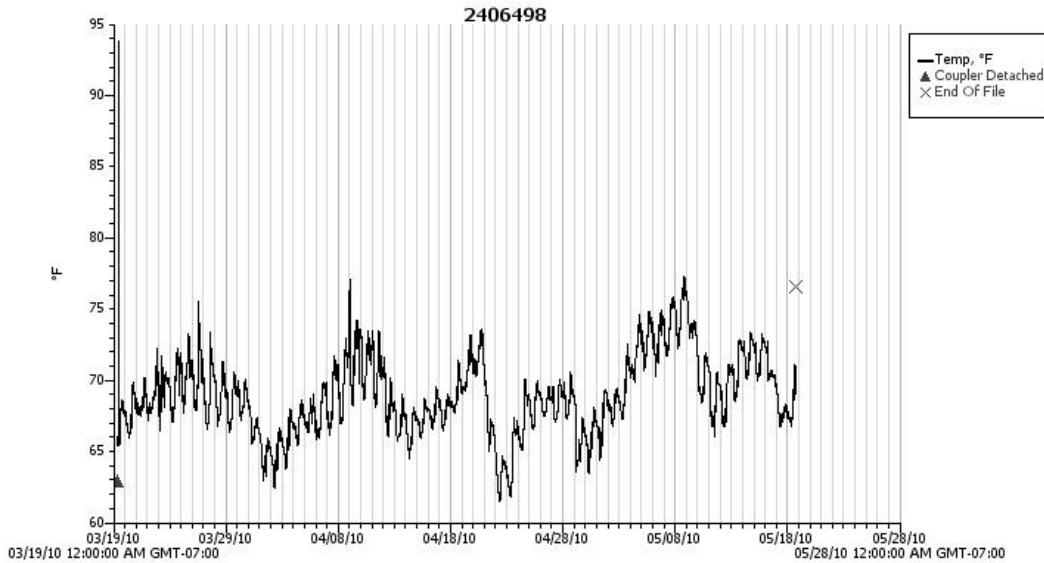
Temperature data from HOBO U22 Water Temp Pro v2 temperature data loggers were downloaded and plotted using HOBOWare Software v 3.0.0. Data loggers were set to record water temperature once every 2 minutes and at this setting were able to record data for 60 days. Data loggers that were deployed from March 19 – May 20, 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 between March 22-23, 2010 and April 8-9, 2010 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 5. Temperature data from HOBO U22 Water Temp Pro v2 temperature data loggers deployed at the “Ramp,” “Elbow,” and “Barge.” Temperature spikes between March 22-23, 2010 and April 8-9, 2010 presumably correlate with release of warm water effluent from SBPP.

2. 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.

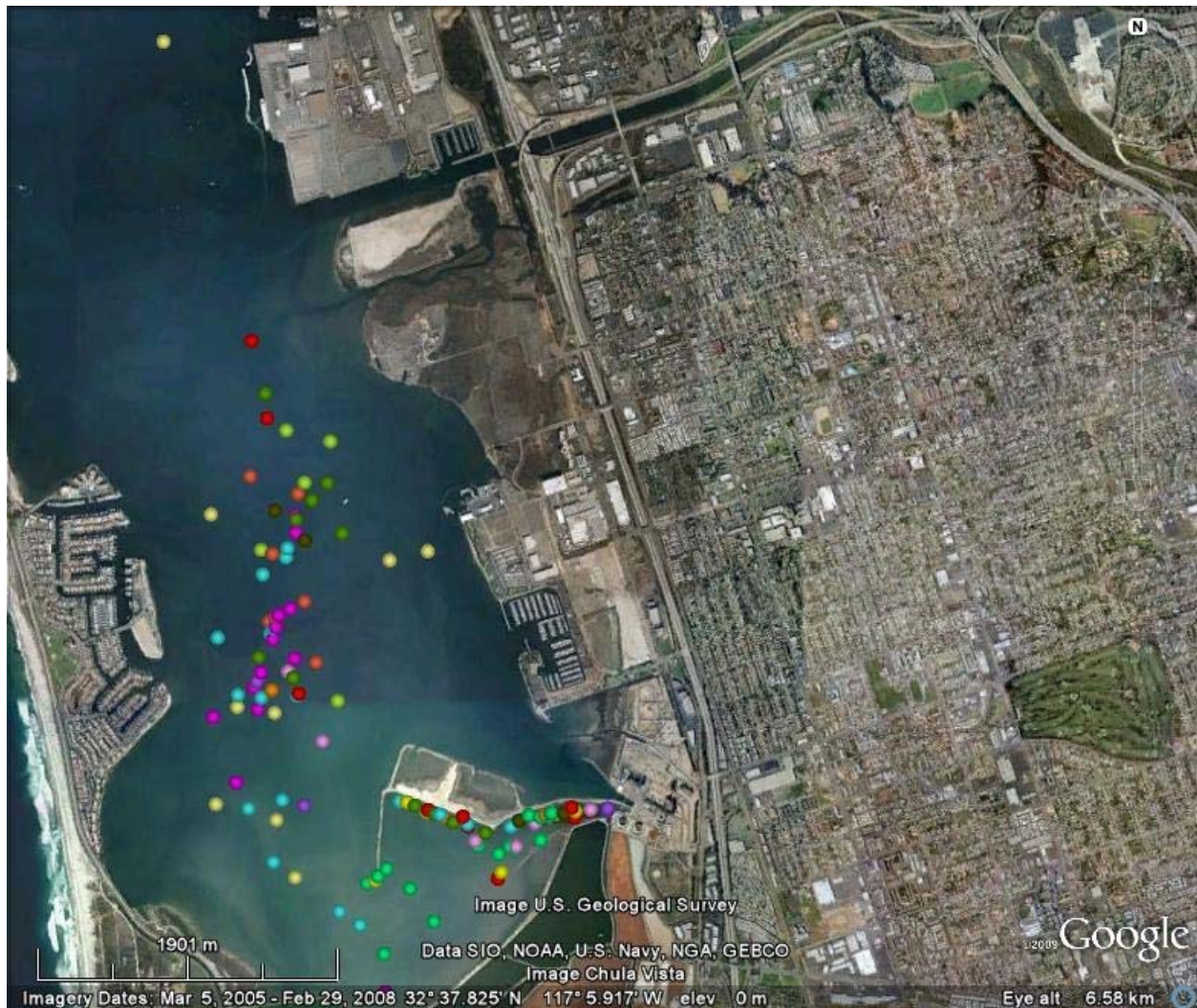


Figure 6. Turtle locations from December 2009 through May 2010 as determined through active tracking. Different colors denote individual turtles and their locales.

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. In Figure 7a & b, we provide an example of a continuous focal follow (>4 hours) and a 24-hour follow.

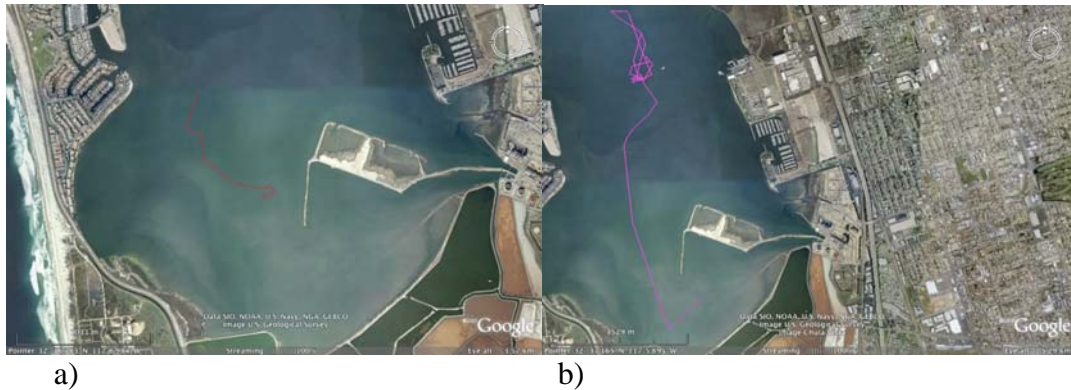


Figure 7. a) Red line represents Turtle ID 88466 tracked on 7/1/2010 for 172 minutes; individual moved 1.44 km over the period (. 50 km/hr.) b) Purple line represents Turtle ID 13690 tracked on 7/6/2010 for 380 minutes; individual moved 7.7 km over the period (1.22 km/hr.)

3. Summary of tracking work conducted to date (April 1, 2010 – June 30, 2010)

April

- Total Field Days: 11
- Capture Days: 2
- Active tracking: 8 days; 37 hours on-water (discounting 24-hour track)
- Passive tracking: SURs station maintenance on 4/22 and 4/30/2010
- 24-Hour tracking: 1 track on 4/22-4/23/2010 of Turtle 13585 (38 kHz, 3-7-7)

May

- Total Field Days: 12
- Capture Days: N/A (capture season is November-April)
- Active tracking: 10 days; 41.75 hours on-water (discounting 24-hour track)
- Passive tracking: SURs station maintenance on 5/20/2010
- 24-Hour tracking: 1 track on 5/18-5/19/2010 of Turtle 3004 (36 kHz, 4-6-6-5)
- Research presented at Joint Turtle Meeting - Southwest Fisheries Science Center on 5/27/2010

June

- Total Field Days: 12
- Capture Days: N/A (capture season is November-April)
- Active tracking: 12 days; 68.5 hours on-water
- Passive tracking: SURs station maintenance not necessary
- 24-Hour tracking: cancelled due to illness (rescheduled to July 2010)
- Research presented at SDSU Graduate Research Symposium on 3/5/2010

4. Upcoming Objectives: July-September 2010 (assuming acoustic tag retention on turtles)

Active Tracking

- 24-hour individual follows
 - Once per month as personnel and equipment (boats, vehicles, etc.) are available
 - When 24-hour tracks are not feasible, extended follows (>4 hours) of individual turtles will be conducted
- Bay-wide monitoring
 - 2-3 tracking days (approximately 8 hours per day) per week
 - Entire coordinate grid of San Diego Bay covered each week with 1 day spent at each of 2 regional sections of San Diego Bay (south and central/north)
 - When possible, a 3rd day will be devoted to extended follows (>4 hours) of individual turtles

Passive Tracking

- Currently 6 SURs deployed
- Up to an additional 10 SURs will be deployed by August 2010: equipment and supplies have been ordered

Data Analysis

- Continuing analysis of spatial and thermal data based on collection from 2009 – 2010 field seasons.

5. 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. We have followed 6 individuals for > 4 continuous hours and 4 individuals for 24 continuous hours. 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.