

## **Project Annual Report**

# Habitat Use and Behavioral Monitoring of Hawaiian Monk Seals in Proximity to the Navy Hawaii Range Complex

**Report Period:** July 2011 – June 2012

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**Permit:** National Marine Fisheries Service Permit No. 10137 TO TAKE PROTECTED SPECIES FOR SCIENTIFIC RESEARCH AND ENHANCEMENT PURPOSES

## Activities and Findings as of June 2012

The primary objectives of this cooperative research project were threefold:

- 1) Deploy cell phone tags on monk seals in the main Hawaiian Islands.
- 2) Monitor monk seal habitat use and behavior: determine home range sizes, foraging areas, and identify potential foraging hot spots of seals in the MHI.
- 3) Identify potential changes in monk seal behavior relative to Navy activities in the MHI.

### *Objective 1: Cellphone Tag Deployments in MHI*

A total of 21 seals were instrumented for this project. During the first year of deployment, three, week-long trips were made to Kauai where we deployed 4 instruments, two trips were made to Molokai with 4 instruments deployed, and 3 instruments were deployed opportunistically on Oahu (Table 1). As of August 2011, 10 additional tags were deployed as part of the 2<sup>nd</sup> year of funding. Tags were deployed on Kauai (3), Oahu (2) and Molokai (5).

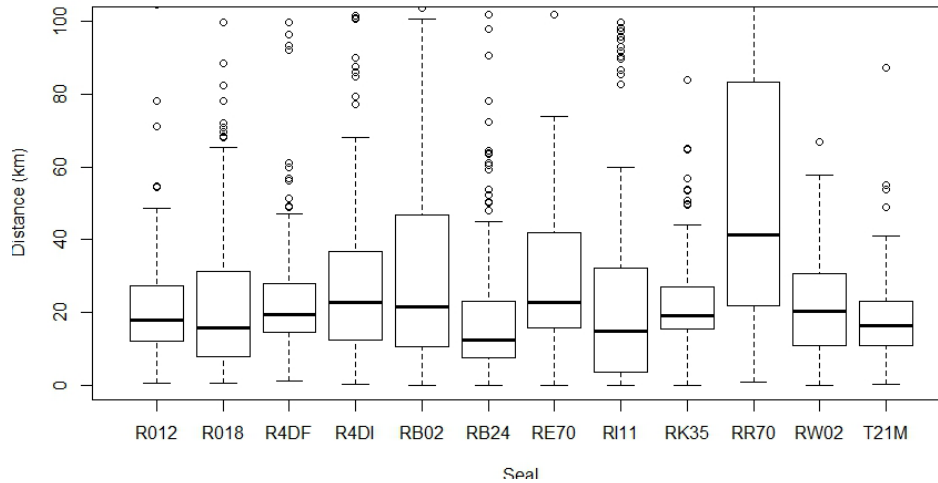
**Table 1. Hawaiian monk seals instrumented for this study. Bold font indicates seals used in analyses.**

Seal ID	Tag #	Age	Sex	Deploy Site	Deploy Date	Comments
<i>2010</i>						
<b>R012</b>	<b>11393</b>	<b>Adult</b>	<b>M</b>	<b>Oahu</b>	<b>3.1.2010</b>	
<b>R018</b>	<b>11478</b>	<b>Adult</b>	<b>M</b>	<b>Kauai</b>	<b>6.9.2010</b>	
<b>R4DI</b>	<b>11337</b>	<b>SubAdult</b>	<b>M</b>	<b>Kauai</b>	<b>2.9.2010</b>	<b>tag fell off</b>
<b>RE70</b>	<b>11420</b>	<b>Adult</b>	<b>M</b>	<b>Molokai</b>	<b>3.27.2010</b>	
<b>RI11</b>	<b>11419</b>	<b>Adult</b>	<b>M</b>	<b>Molokai</b>	<b>3.26.2010</b>	
RI13	11392	Adult	M	Molokai	3.26.2010	tag fell off
RK05	11475	Adult	M	Kauai	2.10.2010	tag fell off
RO28	11423	SubAdult	F	Kauai	2.11.2010	tag fell off
<b>RR70</b>	<b>11396</b>	<b>Adult</b>	<b>M</b>	<b>Oahu</b>	<b>6.29.2010</b>	
unk	11170	Adult	M	Molokai	3.28.2010	No permanent ID
<b>R4DF</b>	<b>11476</b>	<b>SubAdult</b>	<b>F</b>	<b>Oahu</b>		
<i>2011</i>						
RH42	11666	A	M	Molokai	1.21.2011	no dive data
RW30	11626	SubAdult	F	Molokai	1.22.2011	
<b>RB24</b>	<b>11424</b>	<b>SubAdult</b>	<b>F</b>	<b>Kauai</b>	<b>1.25.2011</b>	
<b>R018</b>	<b>11668</b>	<b>A</b>	<b>M</b>	<b>Oahu</b>	<b>2.18.2011</b>	
<b>RB02</b>	<b>11660</b>	<b>Adult</b>	<b>M</b>	<b>Molokai</b>	<b>6.12.2011</b>	
<b>RW02</b>	<b>11799</b>	<b>S3</b>	<b>M</b>	<b>Kauai</b>	<b>7.13.11</b>	
<b>T21M</b>	<b>11813</b>	<b>A</b>	<b>M</b>	<b>Oahu</b>	<b>7.15.11</b>	
<b>R4DI</b>	<b>11805</b>	<b>A</b>	<b>M</b>	<b>Kauai</b>	<b>6.15.11</b>	
R306	11662	A	M	Molokai	5.31.11	no dive data
RO36	11801	A	M	Molokai	5.31.11	no dive data

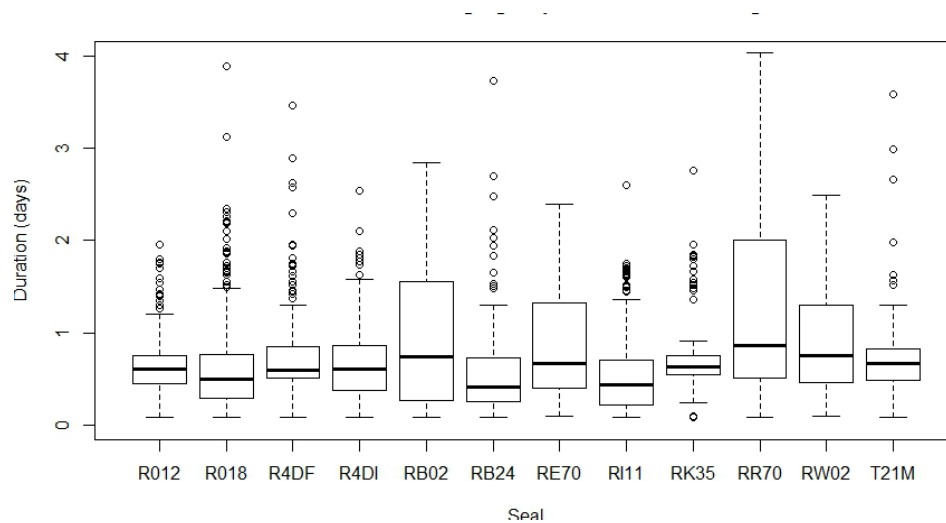
*Objective 2: Determination of Home ranges, foraging trip characteristics, and dive behavior*

Analyses were completed in February, 2012 after all of the tags had ceased recording data. Most of the seals made regular foraging trips out to sea where they traveled, on average,  $29.7 \pm 101.92$  km in  $0.79 \pm 1.4$  days (Figures 2 & 3).

**Figure 2: Foraging trip distance for monk seals, excluding extreme outliers.**

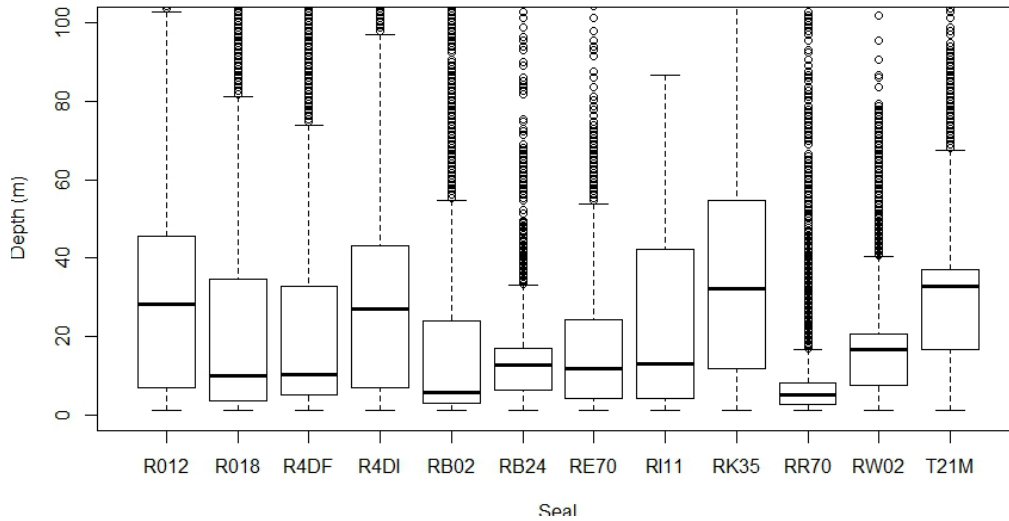


**Figure 3: Foraging trip duration for monk seals, excluding extreme outliers.**

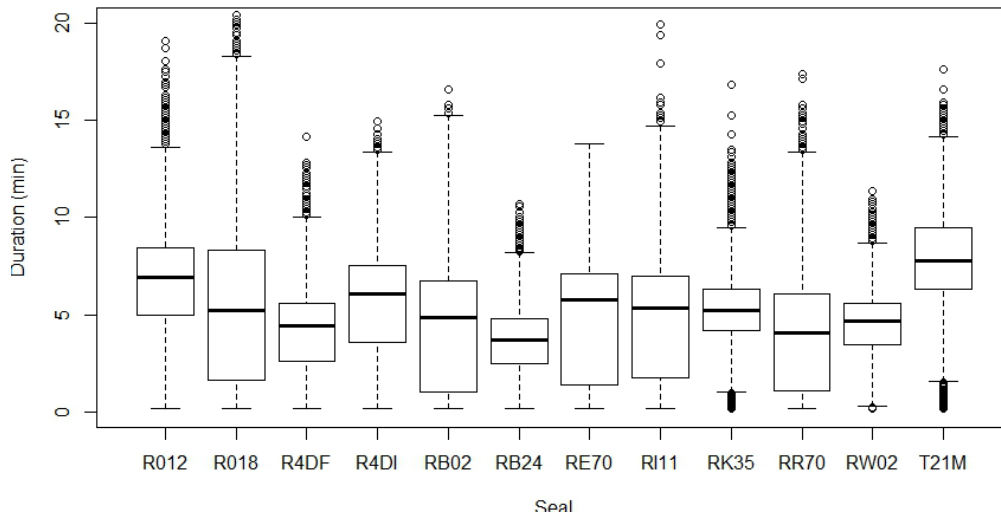


Mean foraging trip distance and duration, as well as maximum dive depth are similar between seals (Figures 2, 3, & 4). However, there were multiple outlying data points for all seals which varied by individual (Figures 2 - 5). Excluding R012's extended pelagic foraging trip, none of the seals traveled more than 300 km per trip and most traveled less than 50 km (Figure 2). The mean dive depth was  $27.03 \pm 44.97$  m with a maximum of 529.4 m and a median depth of 14.4 m during the deployment period. The average dive duration was  $5.006 \pm 3.10$  min with a median of 5.07 min and. The longest recorded dive, from an adult male, was 49.16 min with a maximum depth of 2.4 m indicating that it was likely not a foraging dive.

**Figure 4: Monk seal dive depths less than 100 m.**



**Figure 5. Monk seal dive durations, excluding outliers**

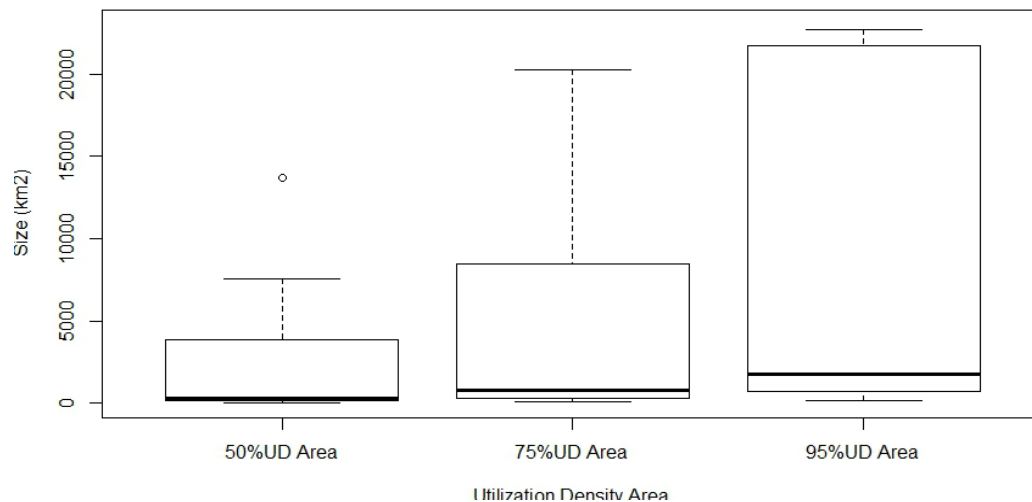


Fixed kernel density home range and core area estimates (utilization density estimates) were calculated for all 11 seals (Table 3). Utilization density estimates offer a good summary of the data, but do not have predictive capabilities. This type of analysis gives the probability of finding an animal in a particular location and also creates contour isolines encompassing areas of equivalent probability. The 95<sup>th</sup> percentile contour is considered the animal's home range, where there is a 95% probability of finding the animal in that area at any given time; the 50<sup>th</sup> percentile contour is considered the core area of use, where there is a 50% probability of finding the animal. While most of the seals reported previously had core areas on one island regardless of their inter-island travels; all four of the seals presented here had segmented core areas that spanned multiple islands (Figures 6 - 9).

Core area sizes were similar between seals, while home range sizes were more variable (Table 3, Figure 6). The variable home range sizes are likely due to the increased area traveled by some animals (R4DF & R018) and the pelagic foraging trip of R012.

**Table 3. Utilization density estimates of home range (95%), core area (50%), and mid-level area (75%) sizes.**

SealID	Age	Sex	# Locations Used	50% UD (km <sup>2</sup> )	75% Area (km <sup>2</sup> )	95% Area (km <sup>2</sup> )
R012	A	M	19887	13708.65	59958.01	221623.1
R018	A	M	36970	4109.261	8782.538	22708.37
R4DF	A	F	23764	7532.983	20287.24	62177
R4DI	S4	M	20950	493.4262	1174.526	2834.659
RB02	A	M	12932	317.9353	722.7949	1596.29
RB24	S4	F	30920	153.4154	468.8894	1538.476
RE70	A	M	6909	31.61681	67.35755	190.6173
RI11	A	M	25236	167.665	441.1831	1064.712
RR70	A	M	19803	109.1716	214.0432	410.8865
RW02	S3	M	12176	323.116	799.287	1908.085
T21M	A	M	12031	48.37863	101.2165	213.0342

**Figure 6. Fixed kernel density estimates for monk seal home ranges and core areas**

Although foraging trip distances and durations were similar among seals, there were high levels of individual variation in where the seals travelled. Since our last report, additional data was collected for 4 seals, each of which exhibited individual preferences in foraging areas (Figures 7 – 10). T21M traveled extensively between Oahu and Kauai, with some additional travel to the north east corner of Niihau. Conversely, over a five month period, RW02 did not leave the north shore of Kauai. A number of seals have shown fidelity to a single island, but this is the first to remain exclusively on one side of a single island (Figure 8). RB02, an adult male, had not been seen in over a year before he was instrumented on Molokai. His movements revealed that although he visited Laau point on Molokai, he actually spent more time foraging off the coast of Lanai (Figure 9). The last seal, R4DI was tagged in both 2010 and 2011 and had behaviors very similar to other seals tagged on Kauai. He spent most of his time circumnavigating Kauai with additional trips to the northeastern point of Niihau.

Figure 7. Map of movements and home range areas for T21M from June – December 2011

## Movements and Utilization Areas of T21M

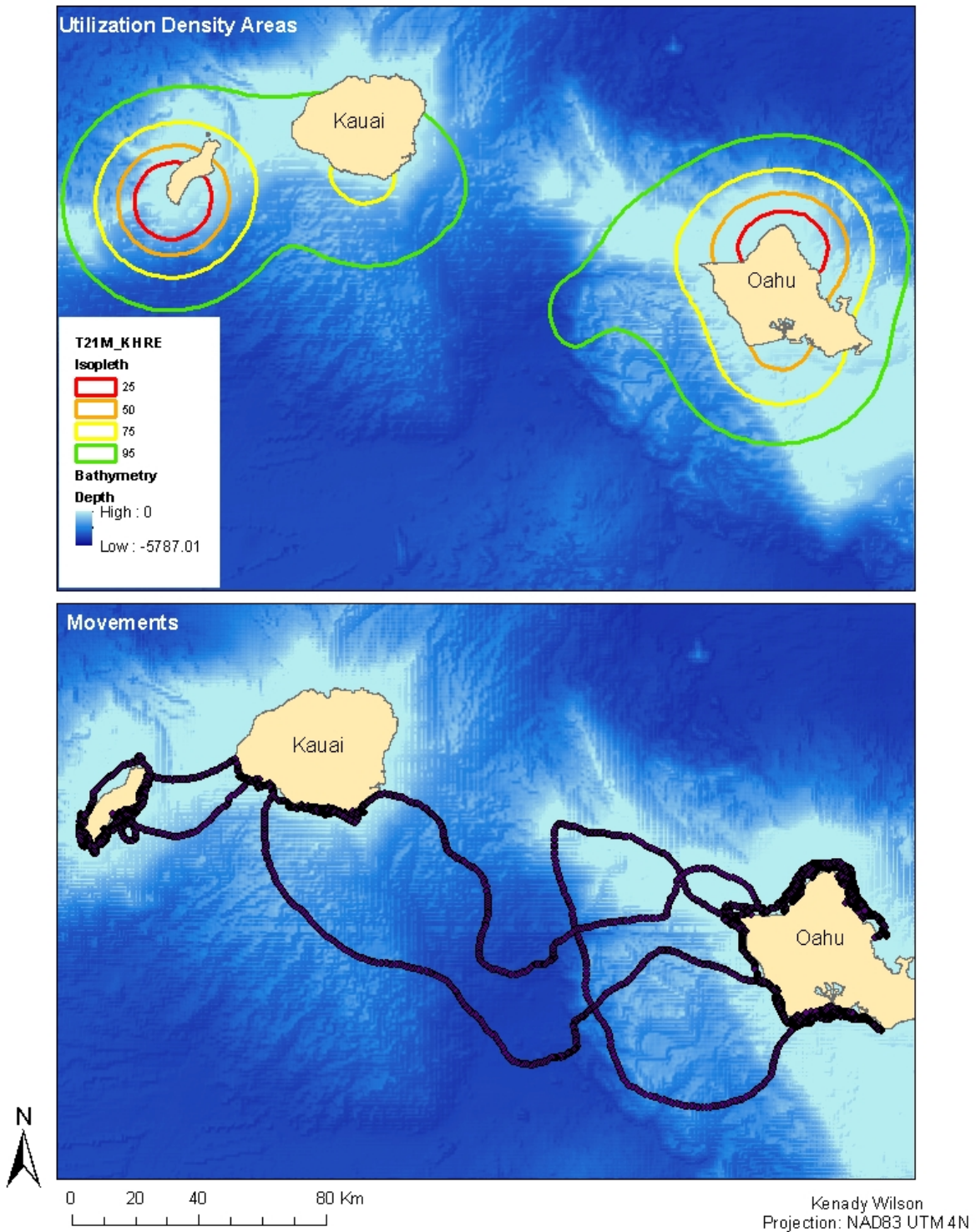
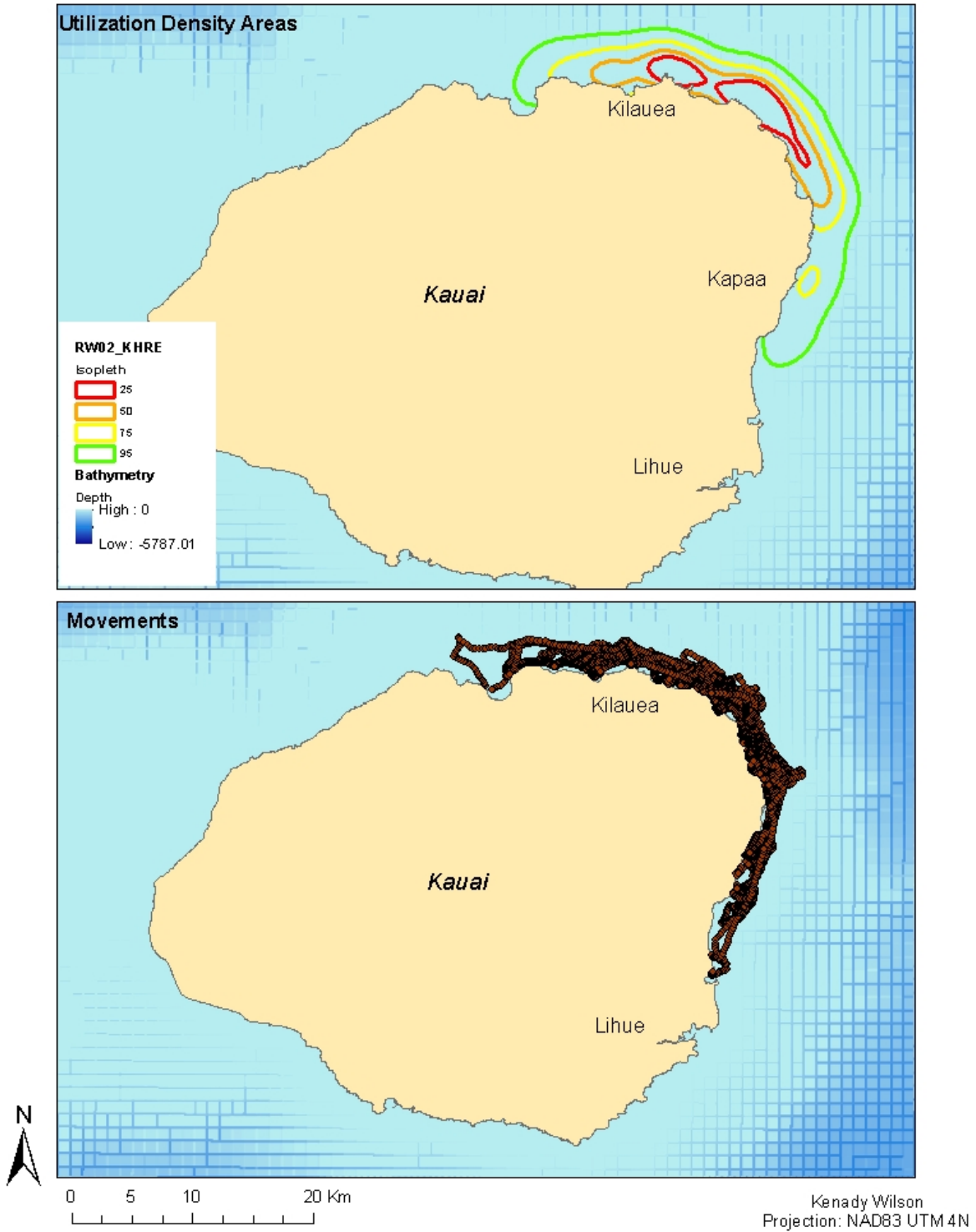


Figure 8. Map of movements and home range areas for RW02 from July – October 2011

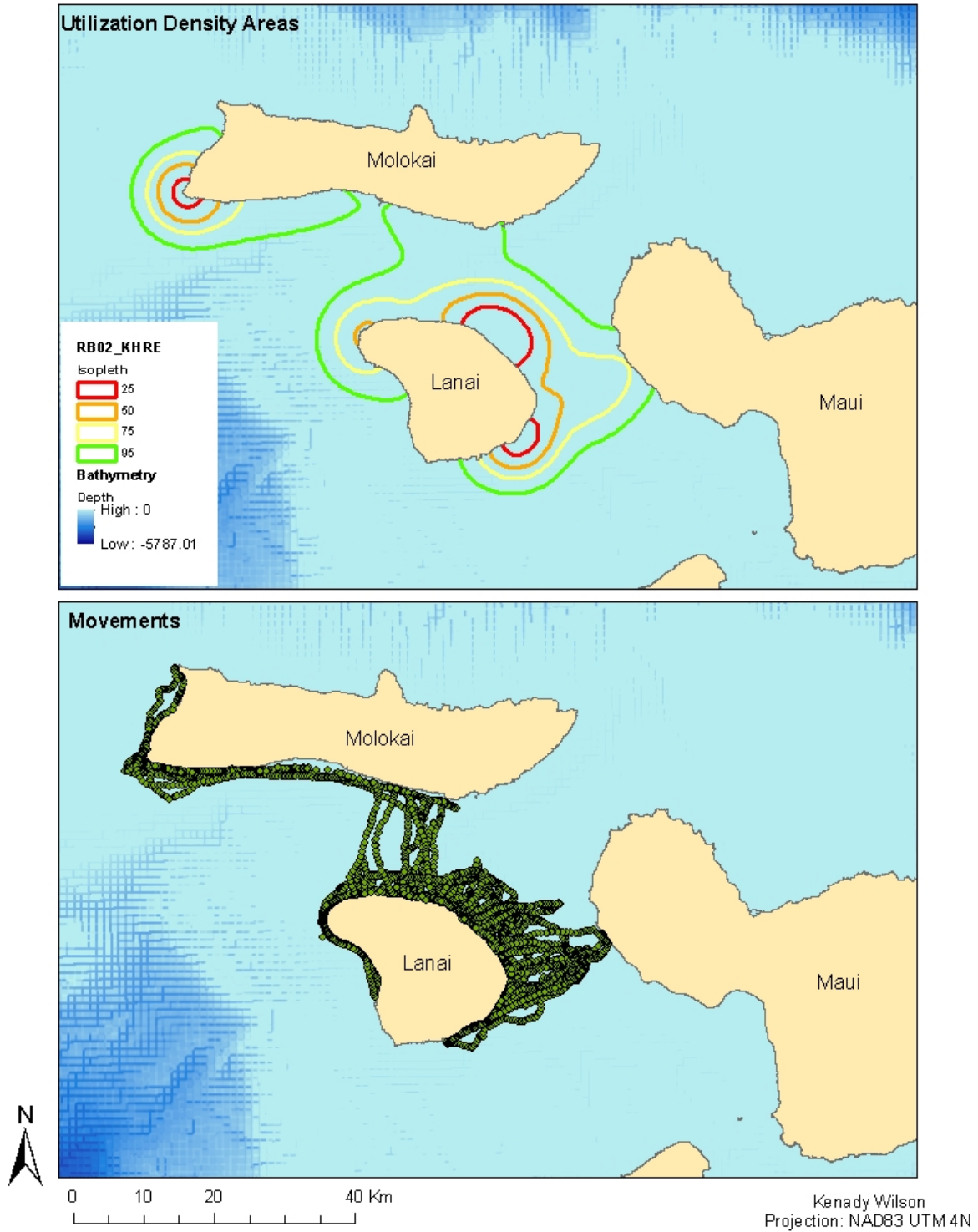
## Movements and Utilization Areas of RW02





**Figure 9. Map of movements and home range areas for RB02 from June – October 2011**

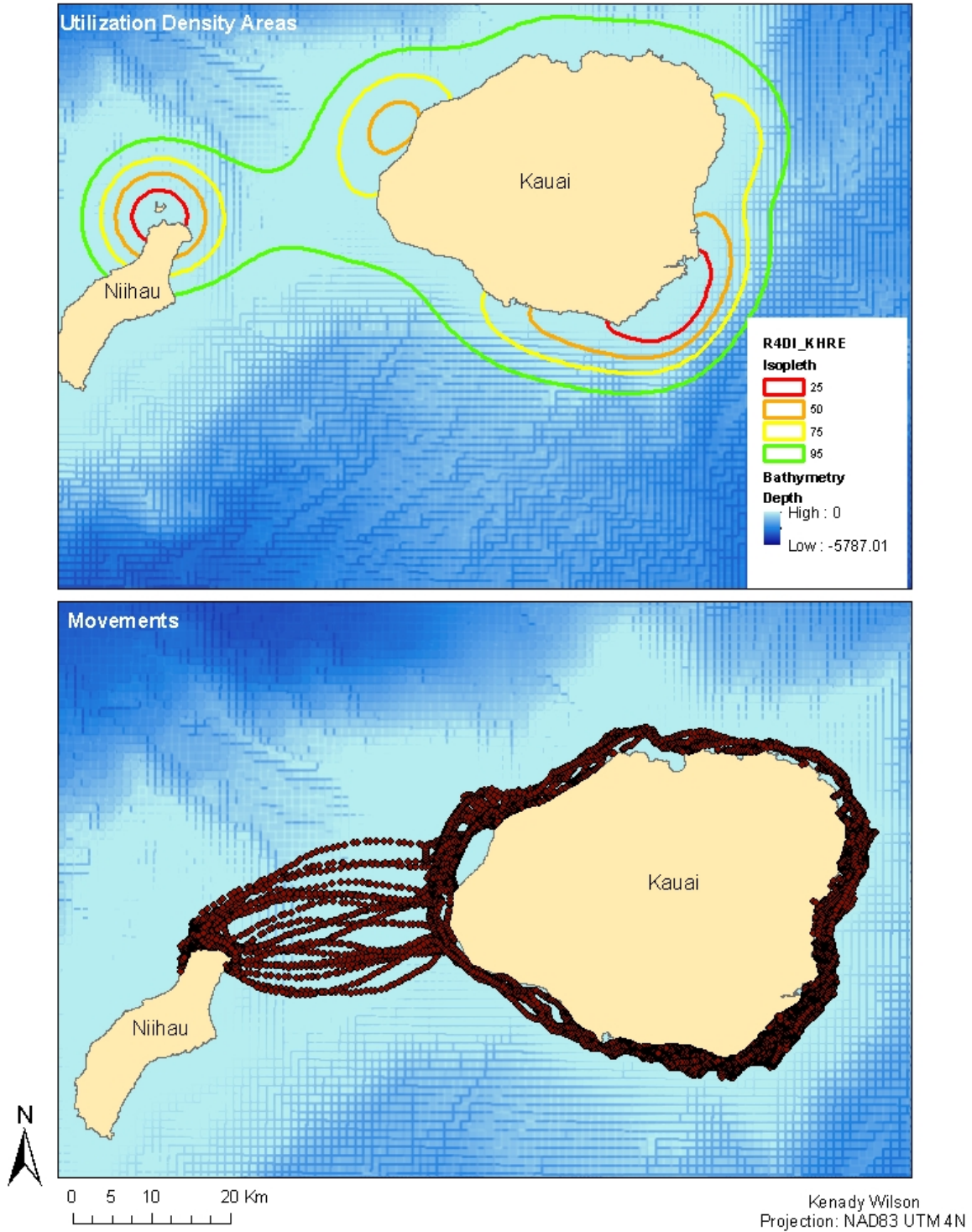
## Movements and Utilization Areas of RB02





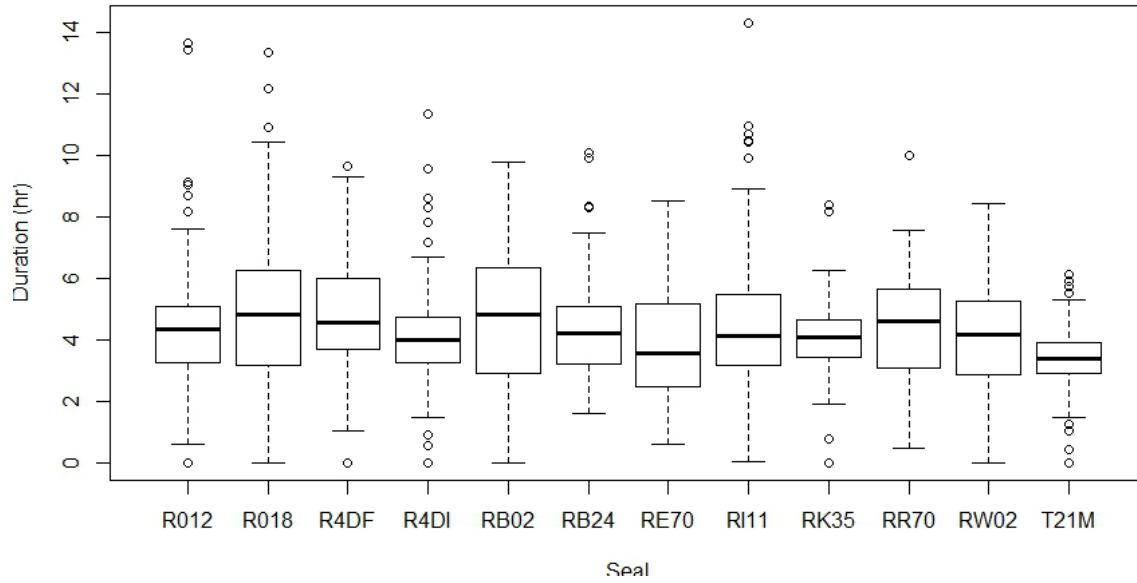
**Figure 10. Map of R4DI movements and home range areas in February 2010 and from June – October 2011.**

## Movements and Utilization Areas of R4DI

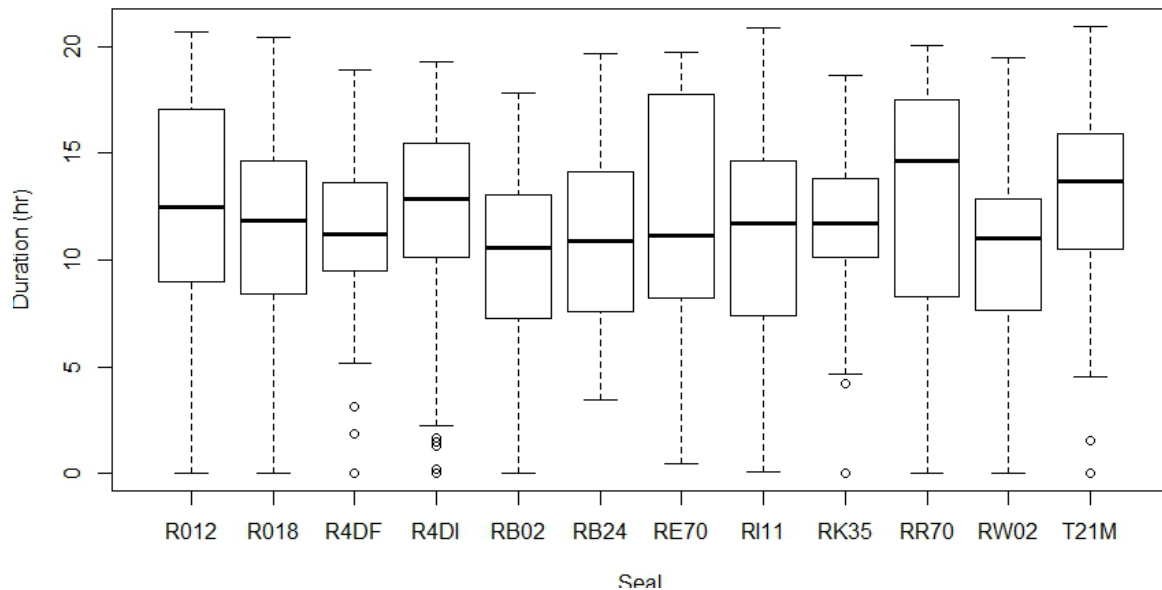


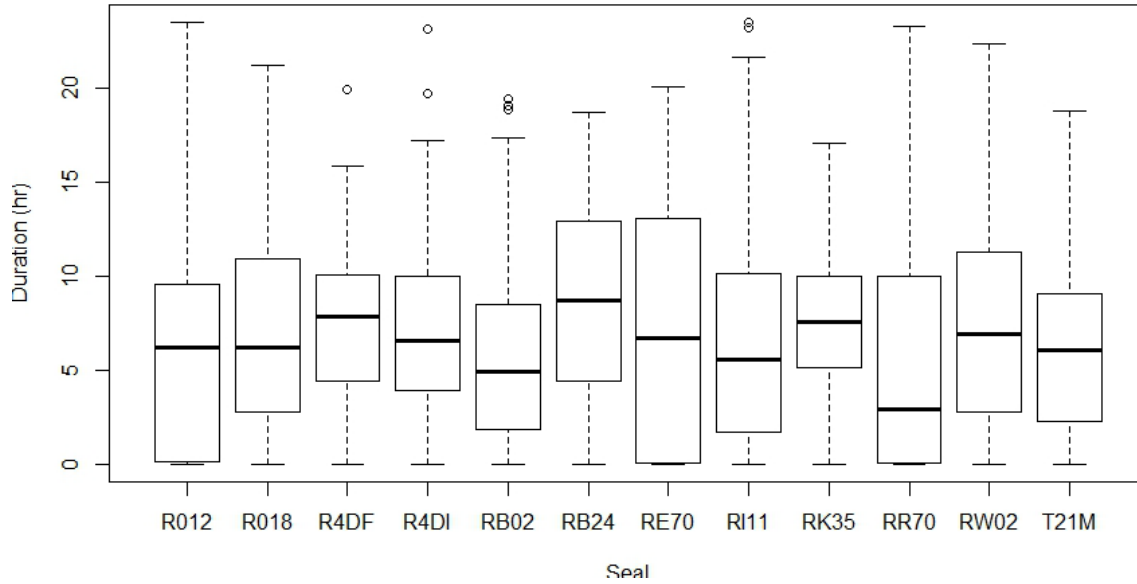
Activity budgets were calculated for all 11 seals detailing how much time was spent diving, at the surface, and hauled-out over a one day period. On average, seals spent  $4.4 \pm 1.9$  hours at the surface,  $11.6 \pm 4.4$  hours diving, and  $7.0 \pm 5.1$  hours hauled-out on land. The proportions of time spent on each of these activities were similar among all seals with fewer outlying data points than observed for other behavior metrics (Figures 11 – 13).

**Figure 11. Time spent at the surface over a one day period**



**Figure 12. Time spend diving over a one day period**



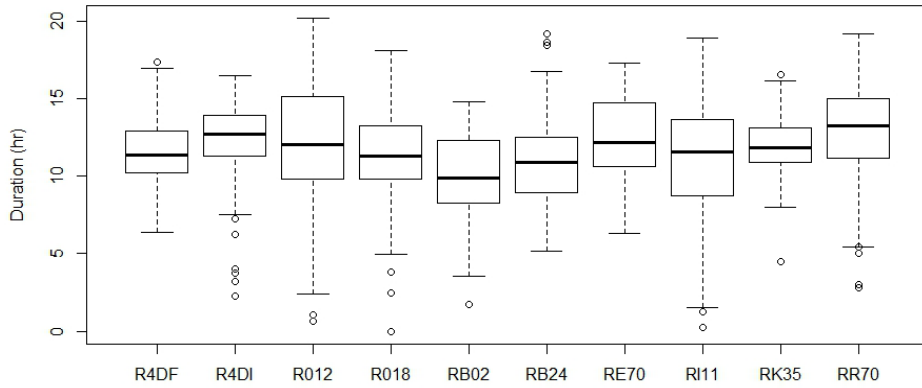
**Figure 13. Time spent hauled-out on land over a one day period**

*Objective 3: Identify potential changes in monk seal behavior relative to Navy activities in the MHI.*

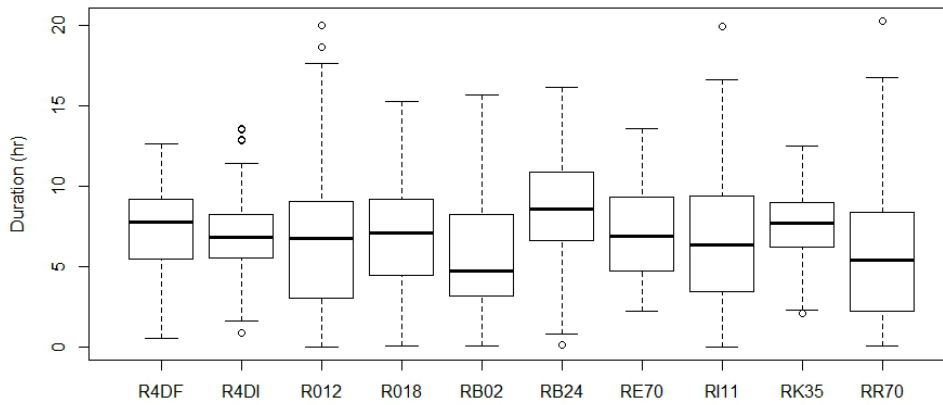
### **Data Preparation:**

To analyze the effects of Navy activities on monk seal behavior we identified specific dates where behaviors differed dramatically from ‘normal’ for each individual. We chose to use three-day averages to represent what was normal in order to avoid any bias associated with individual variability from one day to the next, and also to account for the duration of Navy activities. The dates of these abnormal activities were determined in a step-wise fashion by first calculating the amount of time spent doing each behavior over the course of one day (24 hour period). Next, a moving window spanning three days was passed over the data to determine the three-day average of each behavior. The three-day averages were very similar to the previously reported values for both the activity budget and foraging trip characteristics (Figures 14 – 18). Lastly, these averages were compared for each behavior and any point occurring outside the interquartile range of the data was identified as an outlier (Figures 14 – 18). The start date of every outlying group was used to identify changes in monk seal behavior. These steps were repeated for every individual for the following behaviors: foraging trip distance and duration, and the duration of time spent diving, hauled-out, or at the surface over the course of a day. If Navy activities are disruptive, the seals may adjust their physical location in order to use natural barriers, such as islands, to buffer the effects. In order to capture this potential behavior, using manual observation of the movement paths, we documented the dates where seals made directed movements between islands or around to the opposite side of an island. The resulting dates of these movements and the dates of abnormal behaviors were then sent to Angela D’Amico for comparison with Navy activities in the region.

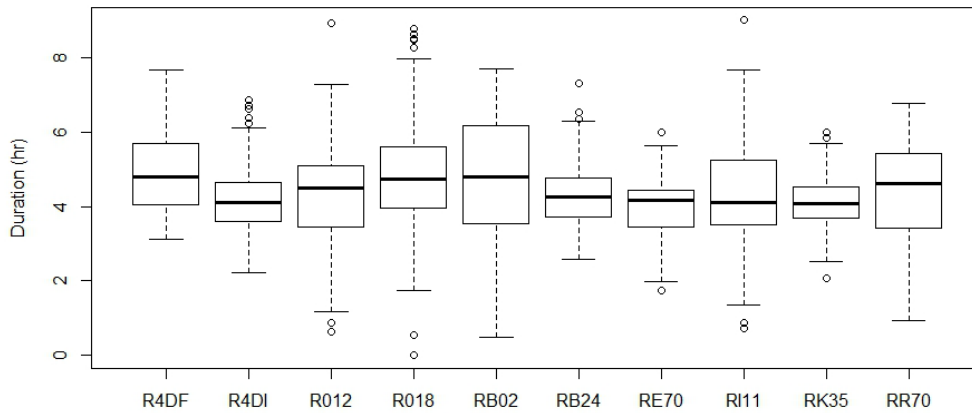
**Figure 14. Mean time spent diving over a 3-day period. Outliers are the points occurring above or below the whiskers for each individual.**



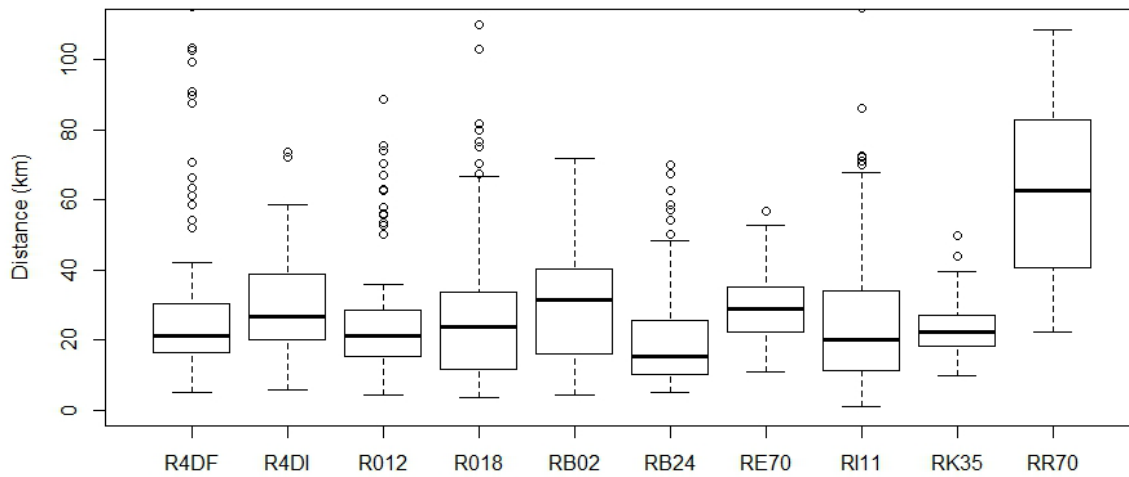
**Figure 15. Mean time spent on land over a 3-day period. Outliers are the points occurring above or below the whiskers for each individual.**



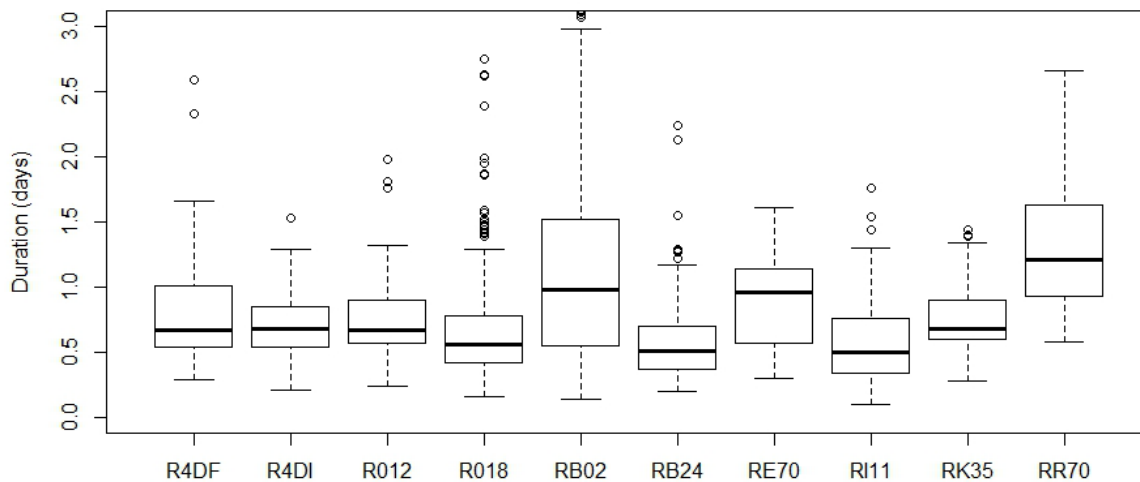
**Figure 16. Mean time spent at the surface over a 3-day period. Outliers are the points occurring above or below the whiskers for each individual.**



**Figure 17. Mean foraging trip distance over a 3-trip period. Outliers are the points occurring above or below the whiskers for each individual.**



**Figure 18. Mean foraging trip duration over a 3-trip period. Outliers are the points occurring above or below the whiskers for each individual.**



**Analysis of monk seal behavior relative to Navy activities:**

Positional data obtained from the monk seal tag data (latitude, longitude and time) while it was on the surface was input into the system to determine 1) if there were any operational platforms within specified range bins (described below) and 2) if there was any sonar activity during those times the animal was in the range bin. Time periods (if any) for overlap were compared to the outlier data provided by Duke.

The range bins from the seal to operational units were derived from the Hawaii Range Complex Final EIS/OEIS (May 2008) Table 4.1.2.4.9.7-1 (Harassments at each received level band). It was determined if the monk seal was within the following ranges, this table provides an expected range of received levels in 10 dB re 1 $\mu$ P at 1 m increments. A better estimate for received level for a specific time and animal depth can be determined however this is out of the scope of the current analysis, which determines a preliminary received level.

The monk seal data was cataloged using the following range bins as defined in the HRC EIS, note that for a 1 second pulse, the TTS level for monk seals is defined as 204 dB re 1 $\mu$ P at 1 m, the PTS level is 224 dB re 1 $\mu$ P at 1 meter. For purposes of this analysis, the closest range bin calculated was when the animal received over 190 dB re 1 $\mu$ P at 1 m, or was within 180 m of an operating sonar.

**Table 4. Harassments at Each Received Level Band (Table 4.1.2.4.9.7-1 from the HRC EIS/OEIS, 2008)**

<b>Received Level (re 1<math>\mu</math>Pa at 1 meter)</b>	<b>Distance at which levels occur in HRC</b>
< 140 dB SPL	36-125 km (did not consider these ranges)
>140 - 150 dB SPL	15 - 36 km
>150 - 160 dB SPL	5 - 15 km
>160 - 170 dB SPL	2 - 5 km
>170 - 180 dB SPL	0.6 - 2 km
>180 - 190 dB SPL	180 – 560 m
> 190 dB SPL	0 – 180 m (includes TTS and PTS)

Once the animal was determined to be within one of the range bins listed above, a separate data base was queried to see if there was any recorded sonar activity (i.e., if there was a tactical sonar transmitting during the time period the animal was within this range bin). For those times when there was a sonar transmitting within 36km, the outlier data provided by Duke was queried to see if there were any time periods when there was an overlap of sonar transmissions and an identified change in behavior as defined in 5 categories: dive, haul out, surface and trip duration and trip distance.

Analysis is ongoing and results will be provided in the Pacific Fleet's Comprehensive Monitoring Report to be submitted to NMFS in November 2012.