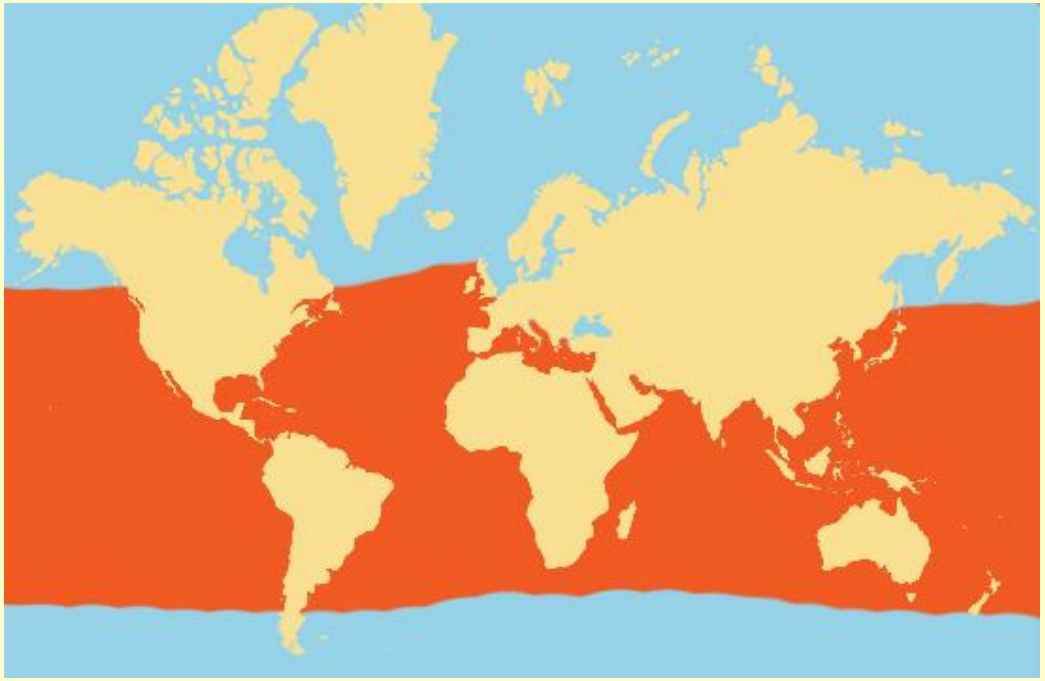
The Seal and the Turtle



Green Sea Turtle

(Chelonia mydas)

Weight:	300-350 pounds (135-160 kg) for adults; hatchlings weigh 0.05 lbs (25 g)
Length:	3 feet (1 m) for adults; hatchlings are 2 inches (50 mm)
Appearance:	top shell (carapace) with shades of black, gray, green, brown, and yellow; bottom shell (plastron) yellowish white
Lifespan:	unknown, sexual maturity occurs between 20-50 years

Green Sea Turtle Life-Cycle

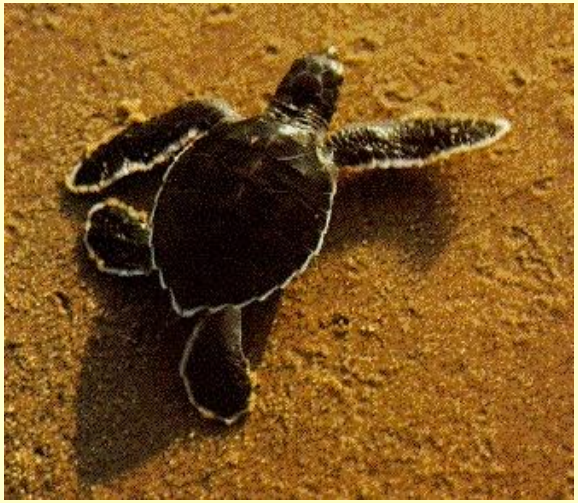
Green sea turtles move across three habitats, depending on their life stage

(1) They lay eggs on beaches

(2) Hatchlings move into pelagic habitat in oceanic waters ("lost years")

(3) Juveniles settle into benthic habitat, where they spend 15 - 25 years

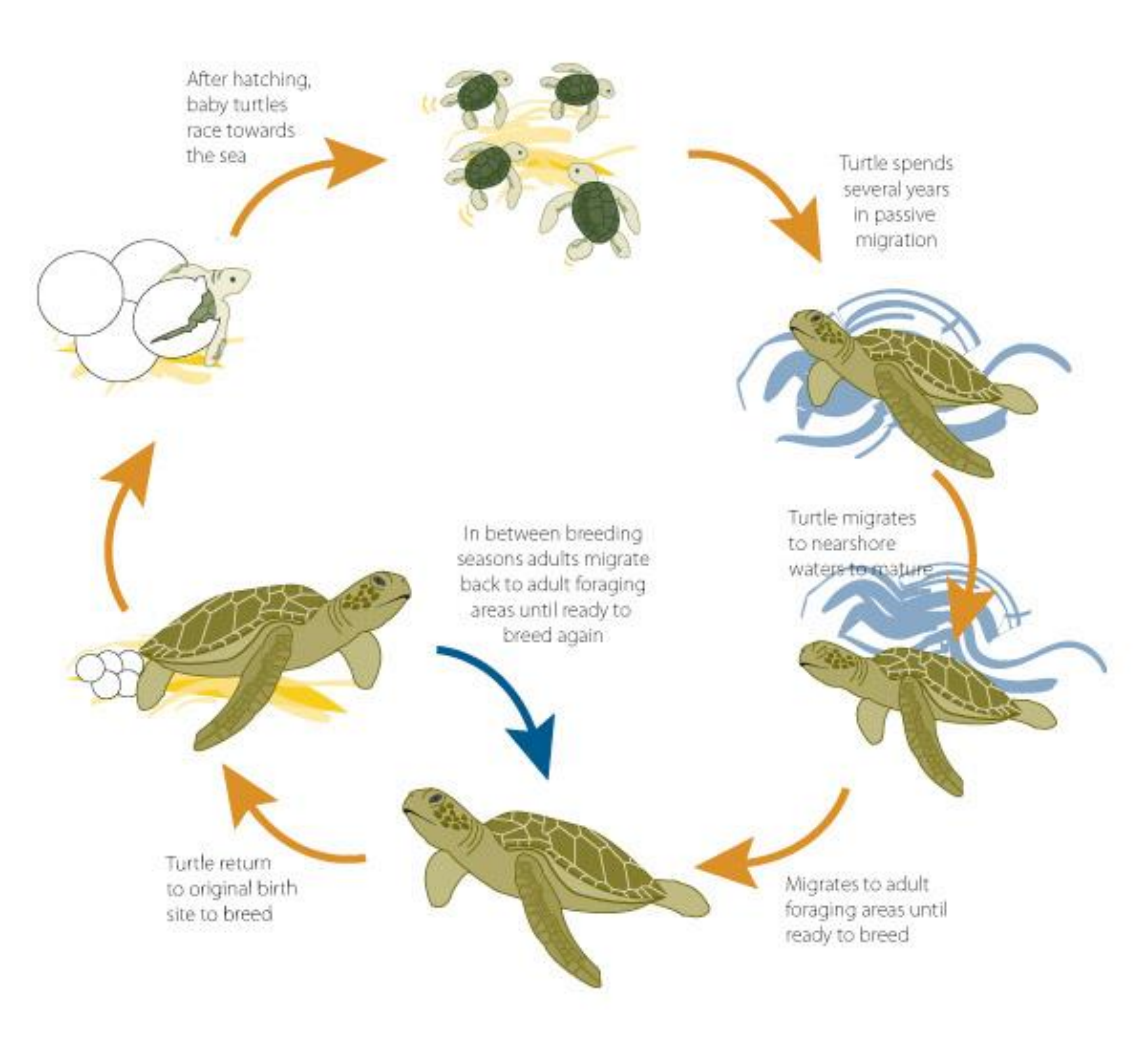
Mature turtles spend most of their time in shallow, coastal waters with lush seagrass and algal beds. Migrate between feeding and nesting areas



Green Sea Turtle Life-Cycle

Green sea turtles move across three habitats, depending on their life stage

- Nesting: 99% in FFS (NWHI)
- Lost years: oceanic
- Juveniles: coastal (MHI)
- Adults: coastal (MHI) and breeding (NWHI)



Green Sea Turtle Genetics

To address evolution and natural history of green turtles, we assayed mitochondrial (mt) DNA genotypes from 226 specimens from 15 major rookeries around the world.

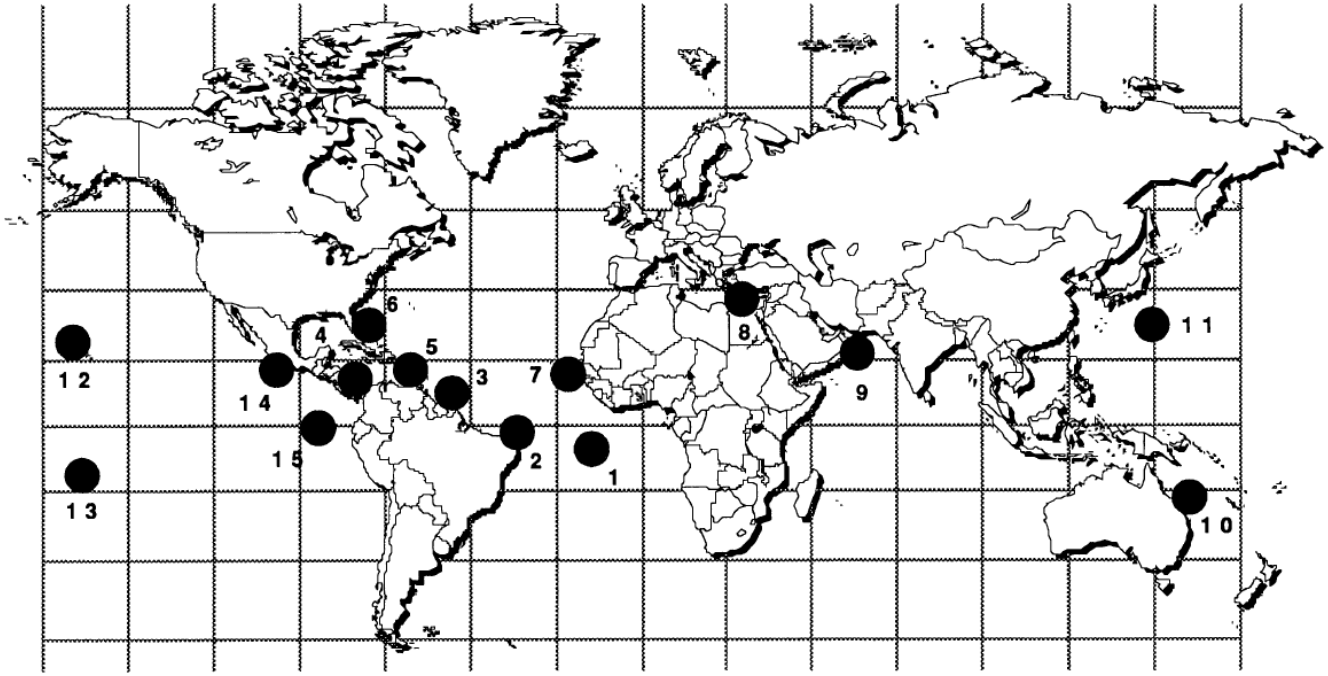


FIG. 1. Collection locales for *Chelonia mydas*. Numbers refer to localities described in Table 1.

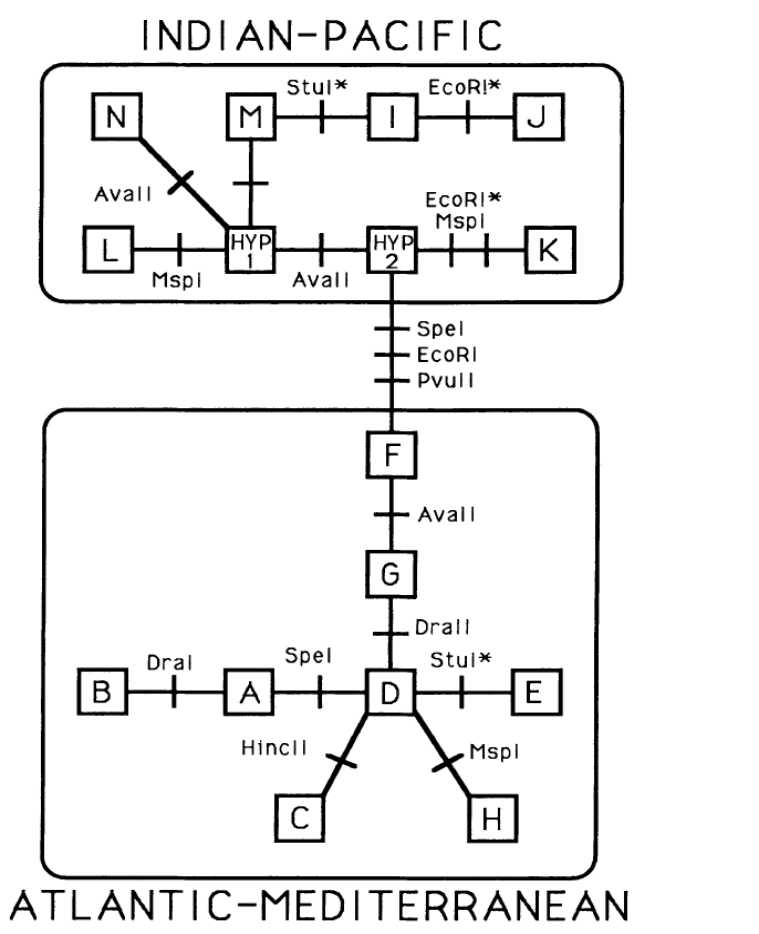
(Bowen et al. 2011)

Turtle Genetics – Ocean Basins

Phylogenetic analyses of these data revealed:

(1) low level of mtDNA variability and a slow evolutionary rate (relative to other vertebrates);

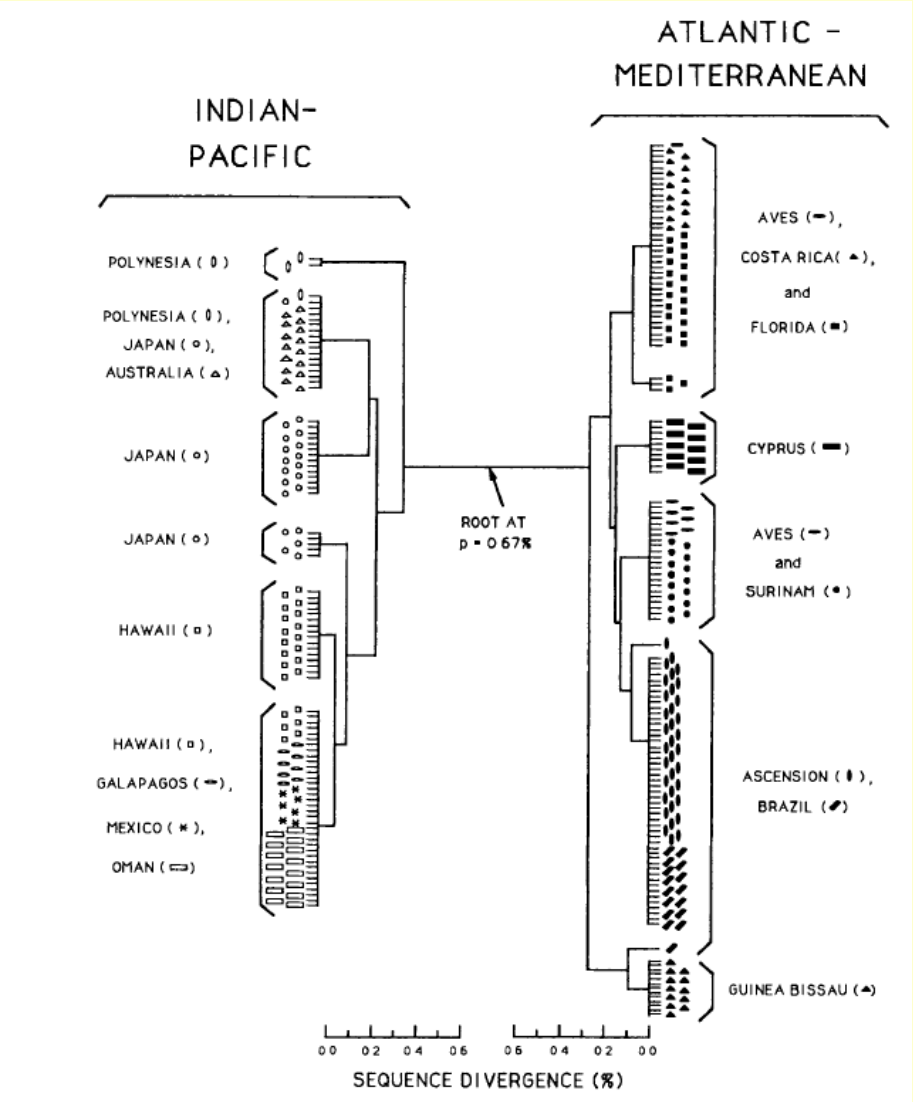
(2) fundamental phylogenetic split distinguishing all turtles in Atlantic-Mediterranean from Indian-Pacific;



(Bowen et al. 2011)

Turtle Genetics – Populations

(3) geographic population substructure within each ocean basin that suggests strong natal homing by females



(Bowen et al. 2011)

Turtle Genetics – Populations

Overall, the global matriarchal phylogeny of *Chelonia mydas* shaped by both geography (ocean basin separations) and behavior (natal homing on regional or rookery scales)

Small population structure within basins from demographic turnover (extinction and colonization) of rookeries

Implication:
Hawaiian Green Sea Turtle Recognized as Unique Species

Perhaps there were other populations in NWHI / MHI (extirpated by harvesting)

Kure – Midway: nests of unfertilized eggs

Green Sea Turtle Trends

The green turtle has a long history of exploitation with some stocks going extinct.

99% of Hawaii stock breeds in FFS (NWHI)

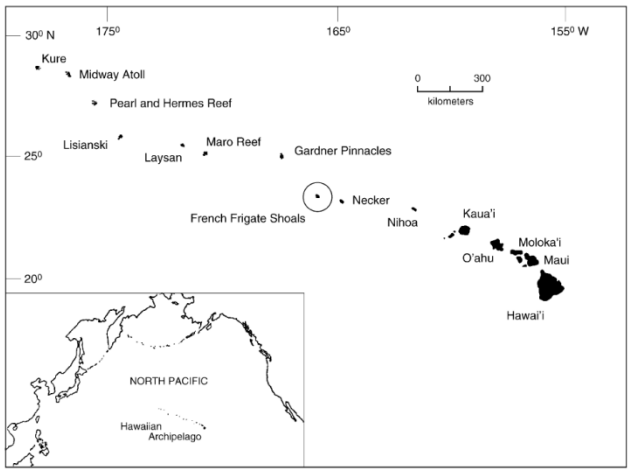


Fig. 1. Location of the Hawaiian Archipelago. The major rookery of Hawaiian green sea turtle genetic stock is at the French Frigate Shoals atoll located in the middle of the Archipelago.

(Balazs & Chaloupka 2004)

Report on a 30-year study of the nesting abundance of the endemic green turtle stock at FFS, NWHI

There has been a substantial long-term increase in abundance of this once seriously depleted stock following cessation of harvesting since the 1970s

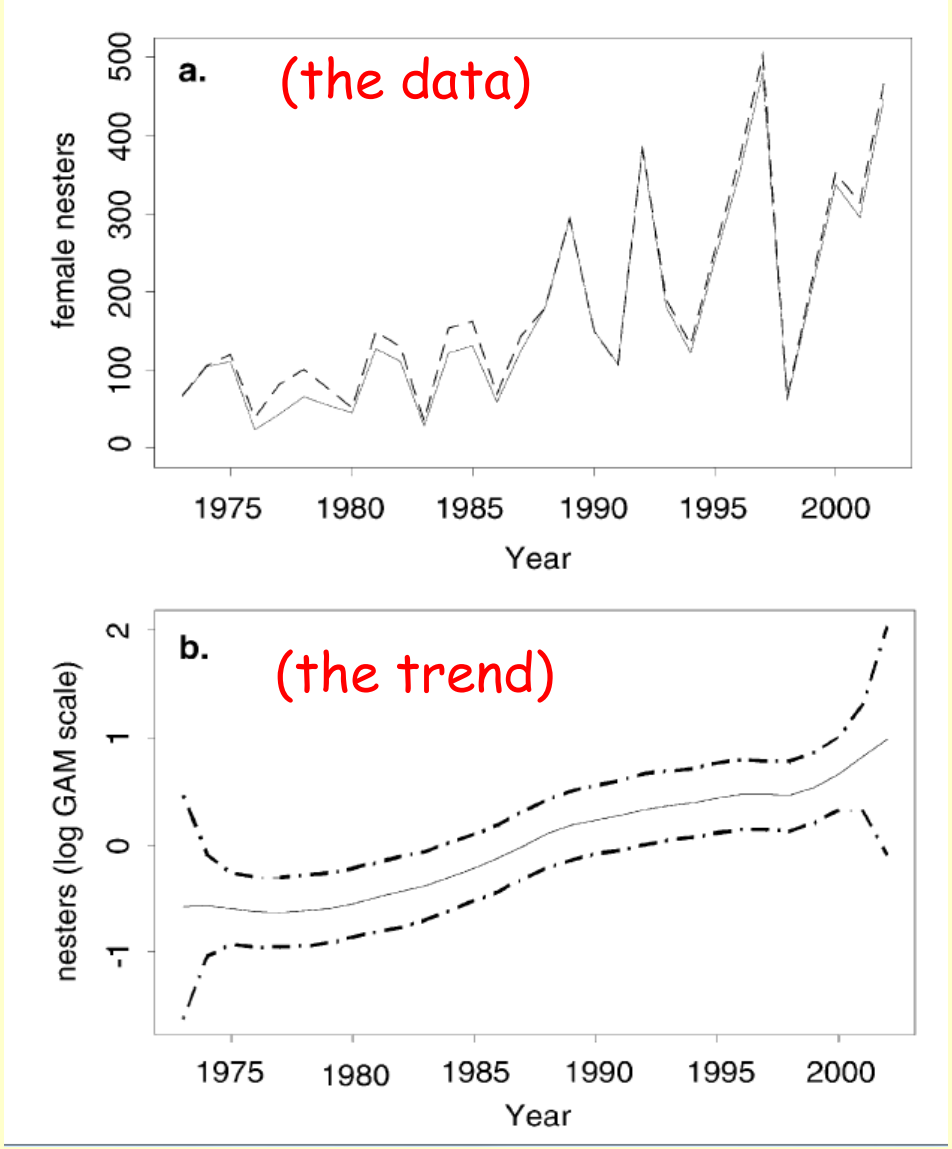
Green Sea Turtle Trends

After lag, population started to grow

There is distinct 3–4 year periodicity in annual nesting abundance

Might be function of regional environmental stochasticity that synchronizes breeding throughout archipelago

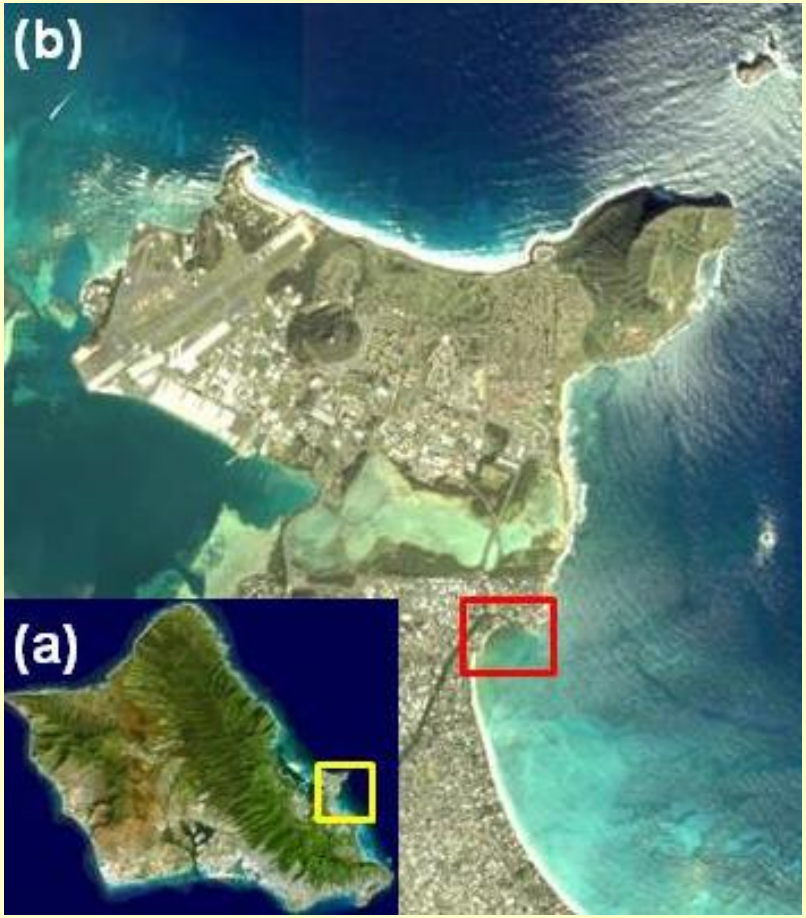
(Balazs & Chaloupka 2004)



Research Findings

Juvenile Green Sea Turtle Habitats in North Kailua Bay

- HPU graduate student Brenda Asuncion
- Balazs & Hargrove (NOAA MTRG)
- Vetter (HPU) & Friedlander (USGS)

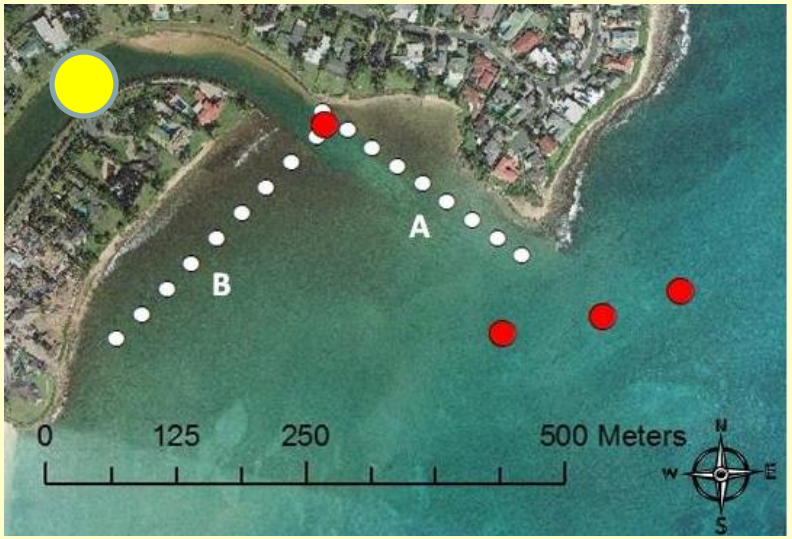


Research Findings

12 turtles

VemcoTags

(NOAA)



Results of standardized detections (# time area)

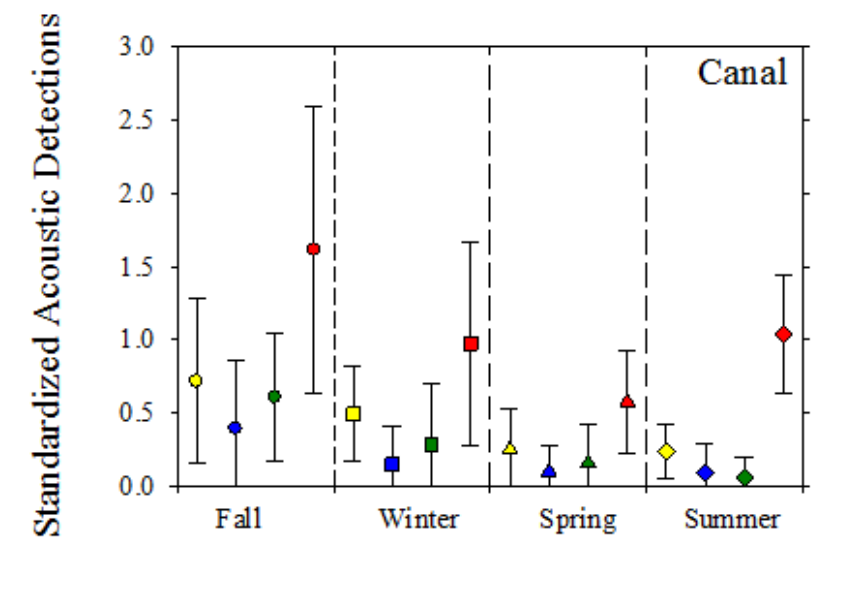
Outcome:

Higher in canal

Higher in fall / winter

Higher at night

3 Night Periods (18 – 6)

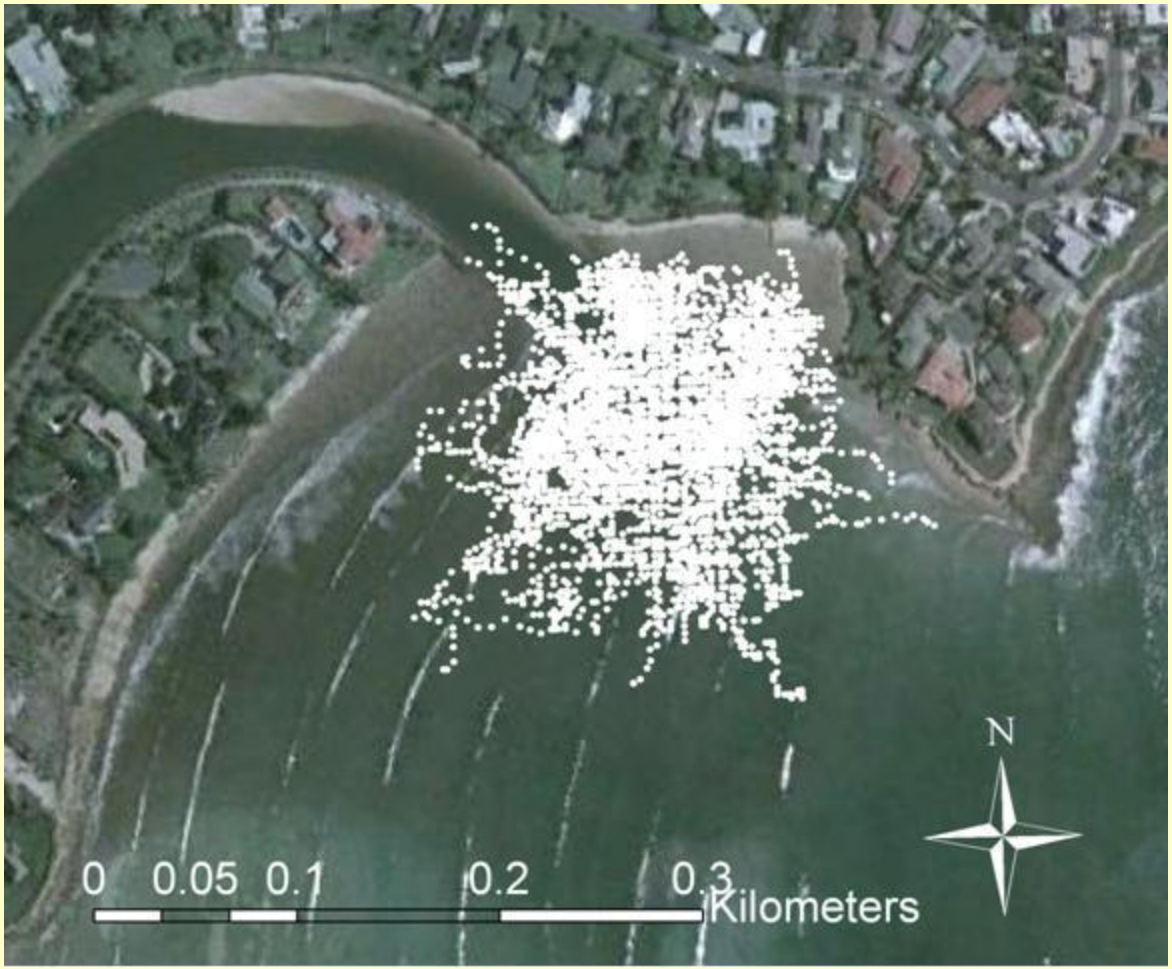


Research Findings

Sea Turtle Diving and Movements

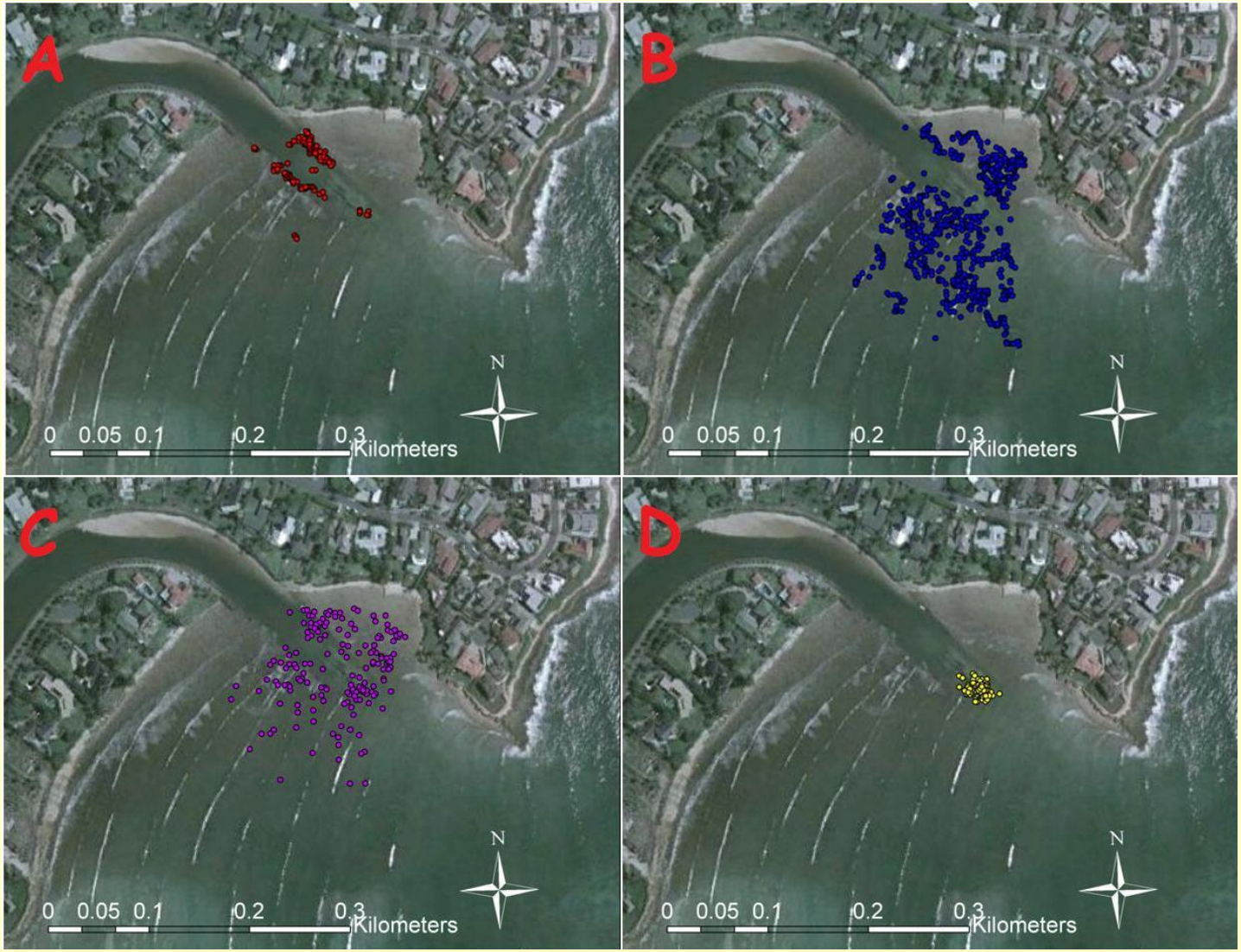
(March – Sept, 2010)

- Graduate student Devon Francke
- Balazs & Hargrove (NOAA MTRG)



GPS points during 251 individual turtle behavior videos (n = 7480 points)

Research Findings



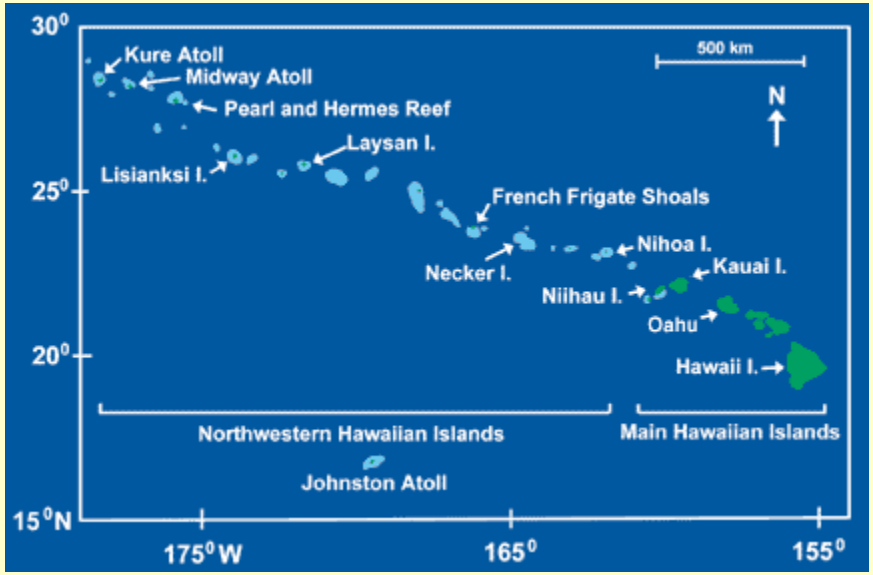
Turtle behavior (n = 7480)

A) Resting (n = 672)

B) Foraging (n = 1000)

C) Breathing (n = 176)

D) Posing (n = 228)



Hawaiian Monk Seal

(Monachus schauinslandi)

Hawaiian monk seal females reach length of 2.3 m and weigh up to 273 kg; males are slightly smaller, measuring up to 2.1 m and weighing about 230 kg

The breeding season occurs between December and mid-August. Most pups born from March to June

Hawaiian Monk Seal Life History

- Sexual maturity reached at the age of 5-10 years
- Thought that individuals live up to 30 years of age

Colony-specific differences

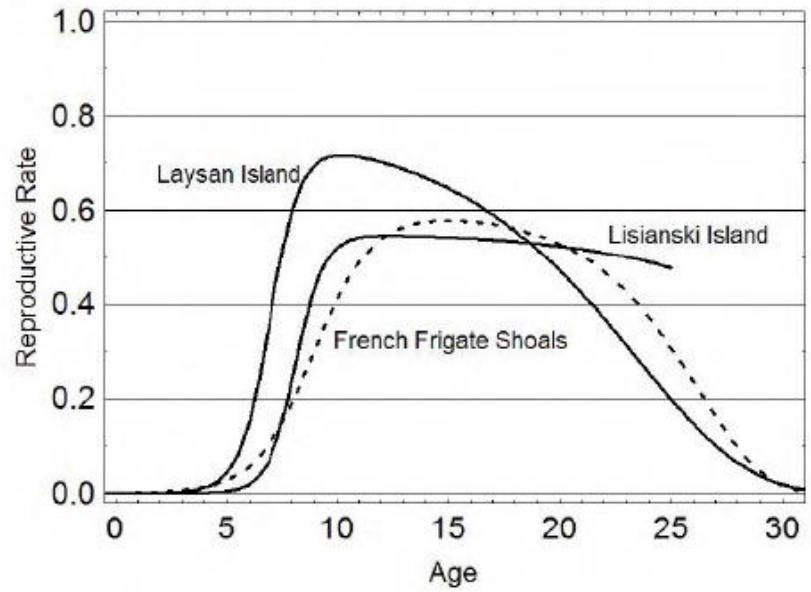


Figure I.D.1. Age-specific reproductive rates for Hawaiian monk seals at FFS, Laysan Island, and Lisianski Island. Curves are reproductive functions to fit observed reproductive frequencies for known-age seals pooled over all years. Figure is modified from Harting et al., 2004.

(Antonelis et al. 2004)

Hawaiian Monk Seal Life History

- Variable survivorship from weaning to age 1
- More predictable survivorship from age 1 to age 2

Colony-specific differences ?

Year-to-year differences ?

(Antonelis et al. 2004)

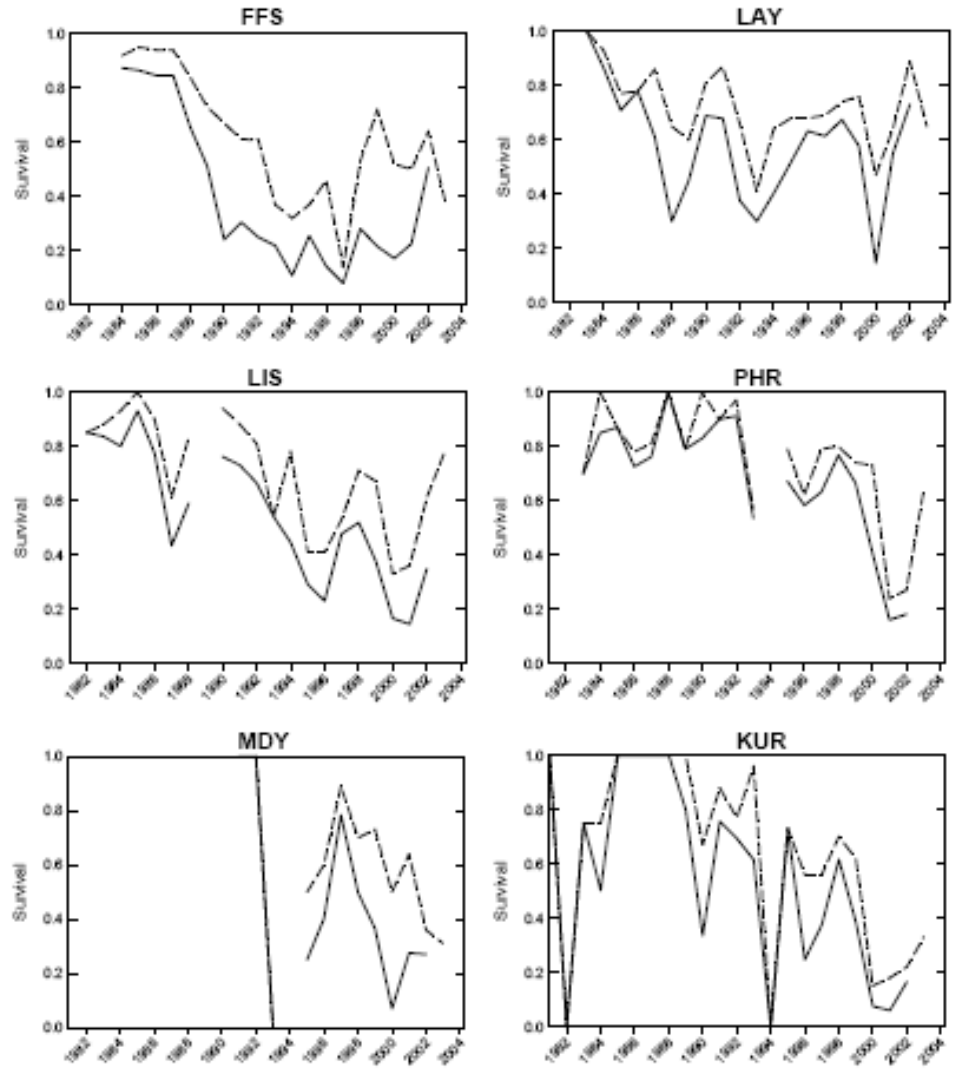


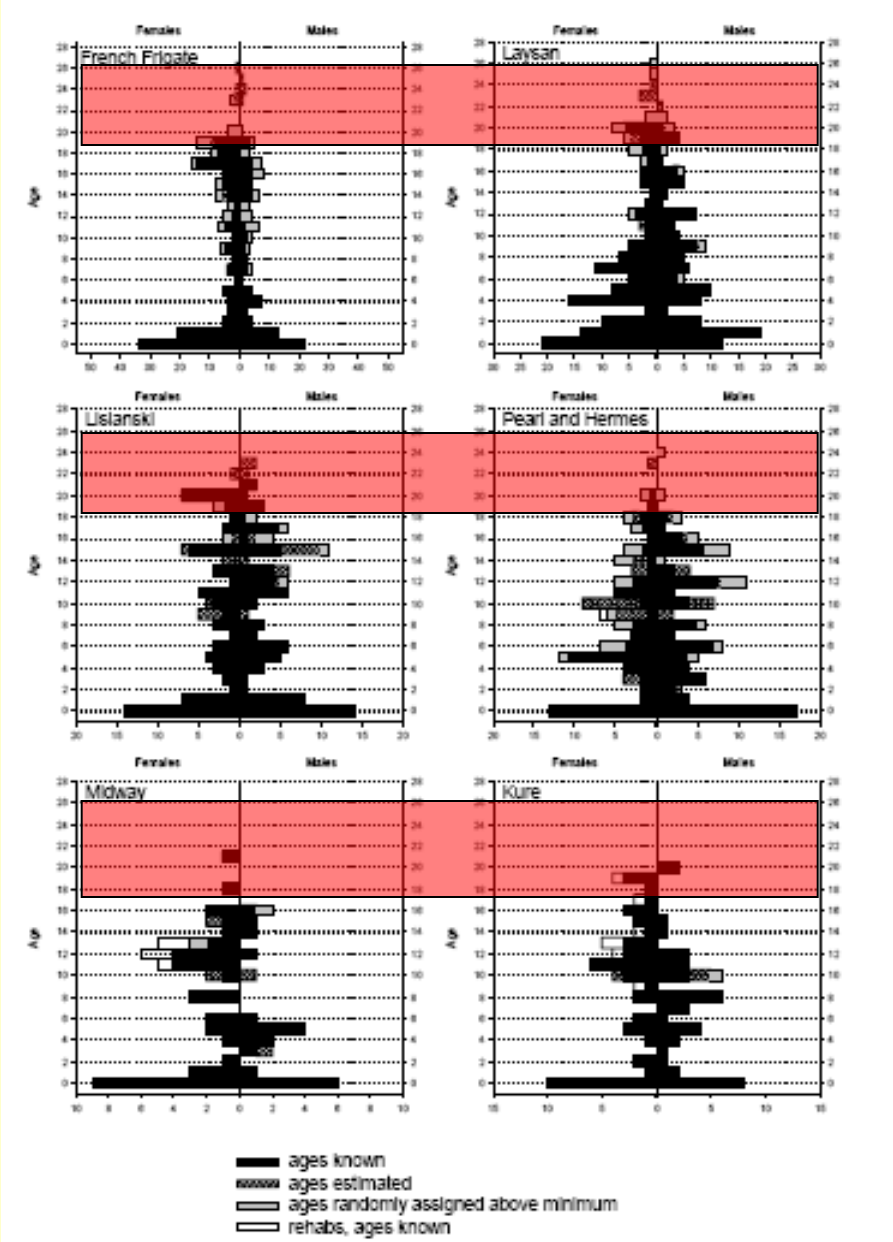
Figure 5. Cohort survival (weaning to age 1 and weaning to age 2) for the six primary breeding subpopulations (----- Survival to 1 year of age, —— Survival to 2 years of age).

Hawaiian Monk Seal Life History

- Population structure reflects poor recruitment
- Biased sex ratio

Colony-specific differences ?

Year-to-year differences ?



Hawaiian Monk Seal Life History

Hawaiian monk seal population severely depleted by commercial sealers and other opportunistic hunters in the 19th century

Monk Seal Genetics

Both Monk Seal populations characterized by extremely low variability at all genetic markers

The Hawaiian monk seal has no spatial population structure throughout its range (*F*ST = 0.00)

Eastern Mediterranean and Western Saharan *M. monachus* populations reproductively isolated (*F*ST = 0.56), though the allele distribution suggests a contiguous range split by extirpation of geographically intermediate subpopulations

Implication:
Hawaiian Monk Seal Recognized as Unique Species

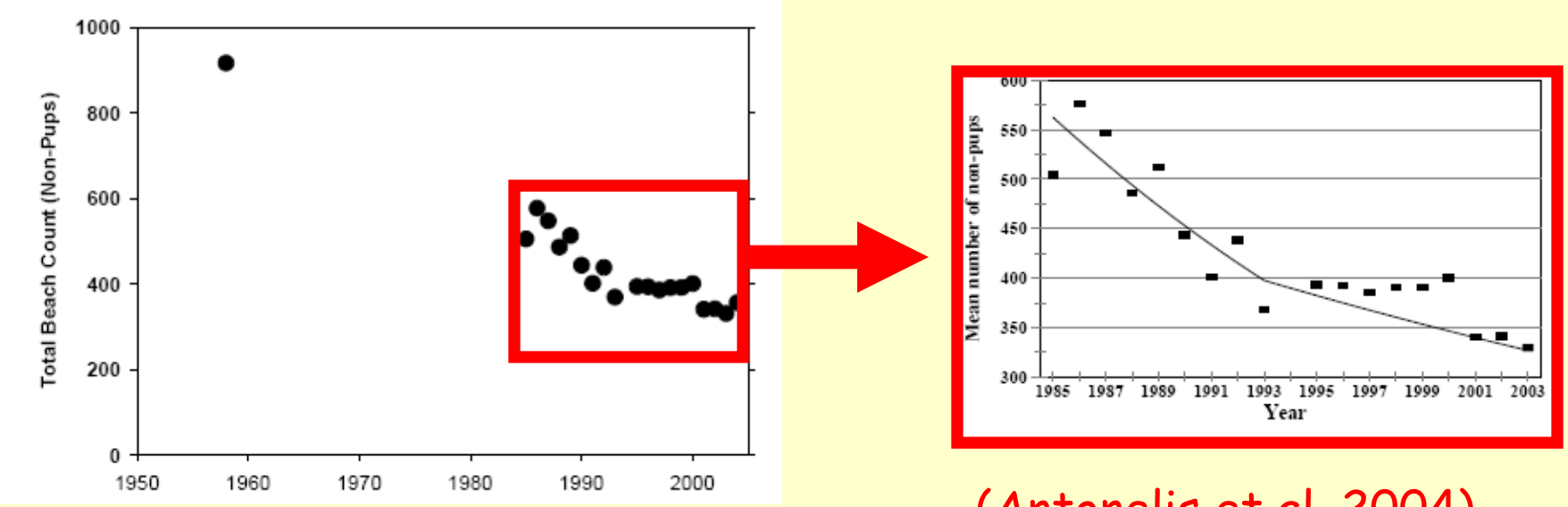
MHI and NWHI form an unique stock

(Schultz 2011)

Hawaiian Monk Seal Status

Past and present sources of anthropogenic impacts to monk seals include hunting (during 1800s, early 1900s), disturbance (e.g., prior military activities in WWII), entanglement in marine debris, and fishery interactions.

Counts declined ~ 40% between late 50s – mid 80s



(Antonelis et al. 2004)

Species Status – 2004 update

From late 80s until early 90s numbers declined due to sharp reduction in number of seals at the French Frigate Shoals colony

Primary natural factors affecting monk seal recovery: shark predation, aggression by adult males, reduction of habitat and prey from environmental change

Identification and mitigation of possible factors (e.g., disease, pollutants) limiting population growth are primary objectives of conservation and recovery effort

(Antonelis et al. 2004)

Species Status – 2007 update

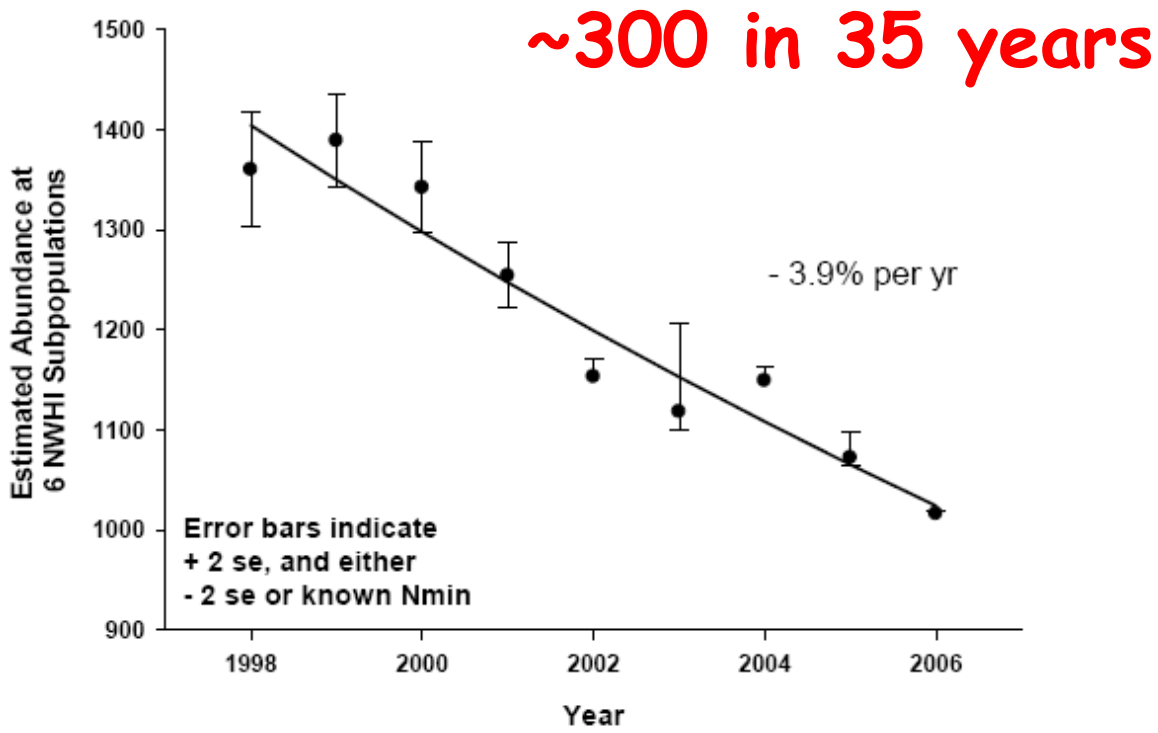


Figure I.C.7. Trends in abundance of Hawaiian monk seals at the six main NWHI sub-populations combined, 1998-2006. This graph does not include abundance estimates for Necker, Nihoa or the main Hawaiian Islands. Error bars indicate + 2 standard errors and either – 2 standard errors or known minimum abundance. The fitted trend line reveals an estimated decline of 3.9% per year (NMFS).

(NOAA 2007)

Species Status in 2007

Significant threats face this species:

- Very low juvenile and sub-adult survivorship due to starvation persists across much of the population
- Entanglement in marine debris results in seal mortality
- Juvenile predation by sharks has significantly increased

Species Status in 2007

Hawaiian monk seal haul-out and pupping beaches being lost to erosion in NWHI. Prey resources in the NWHI reduced as a result of climate cycles and other factors

Human interactions in MHI, including fishery interactions, mother-pup disturbance and potential disease transfer

Monk Seal Population Shift

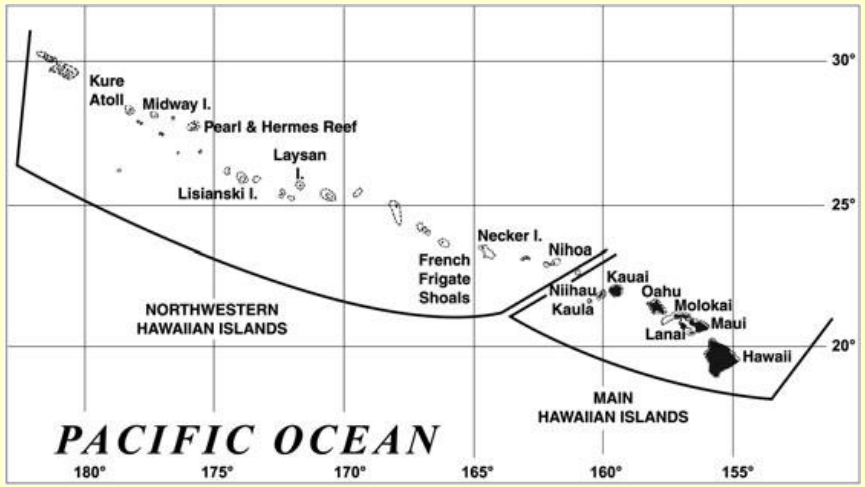


Table 1. Comparison of factors relevant to conservation of Hawaiian monk seals in the Northwestern Hawaiian Islands (NWHI) and main Hawaiian Islands (MHI).

	NWHI	MHI
Habitat		
Accessibility	Extremely remote	Highly accessible
Physiography	Small atolls/islands	Large, high islands
Area	8 km^2	16,000 km^2
Shoreline length[a]	80 km	2,304 km
Human population	<100	1.3 million residents, >7 million visitors annually
Fish competitors[b]	Abundant	Relatively few, removed by fishing
Monk seal populations		
Abundance	Approximately 1,100[c]	>113
Trend	4.1%/yr decline[c]	Unknown, presumed increasing
Threats[d]	Food limitation, shark predation, male aggression, entanglement in derelict marine debris, sea-level rise	Disturbance, disease, direct fisheries interactions, intentional killing, pollution

Total estimated abundance of Hawaiian monk seals was 1,200 individuals in 2008

Most monk seals (~ 90%) reside in the remote NWHI where the decline is approximately 4% / yr

10% of monk seals inhabit MHI, where the population is growing

(Baker et al. 2011)

Monk Seal Demography

Estimated MHI intrinsic rate of population growth:

1.07 in MHI 0.89 – 0.96 in NWHI

Projections indicate that if current demographic trends continue, abundance in NWHI and MHI will equalize in approximately 15 yrs

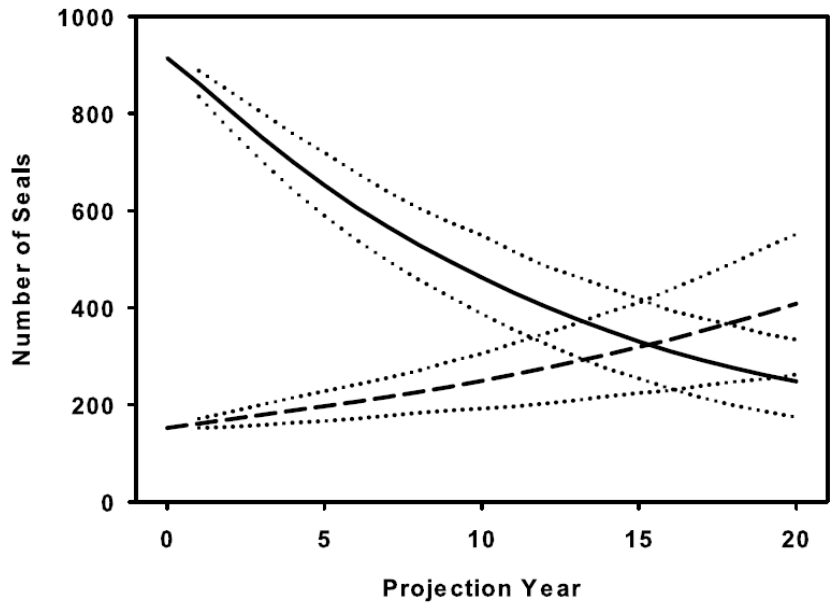


Figure 4. Population projections (20 yr) for Northwestern Hawaiian Islands (NWHI) and main Hawaiian Islands monk seal subpopulations. The six NWHI subpopulations were projected separately, and results were summed for display.

(Baker et al. 2011)

Monk Seal Demography

Estimated survival from weaning to age 1 yr is 77% in MHI, much higher than NWHI estimates (42% to 57%)

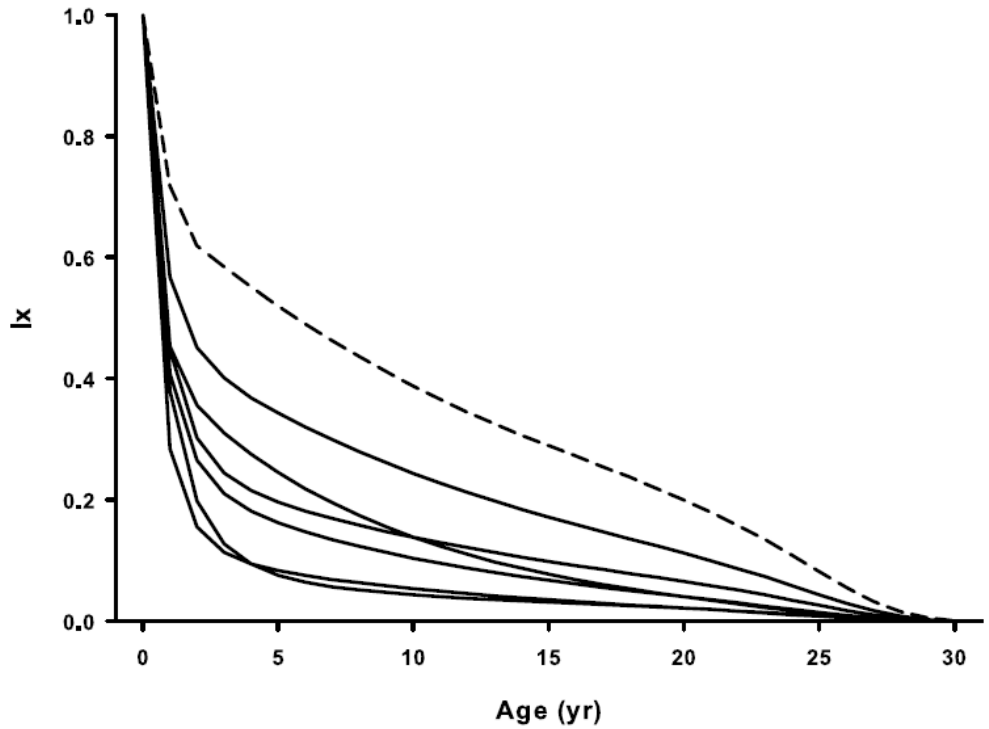


Figure 5. Cumulative survival probability curves (*lx*) for the six Northwestern Hawaiian Islands subpopulations (solid lines), based upon recent (2006–2008) rates, and all available data in the main Hawaiian Islands (dashed lines).

(Baker et al. 2011)

Monk Seal Demography

MHI females begin reproducing at younger age and attain higher birth rates than observed in NWHI

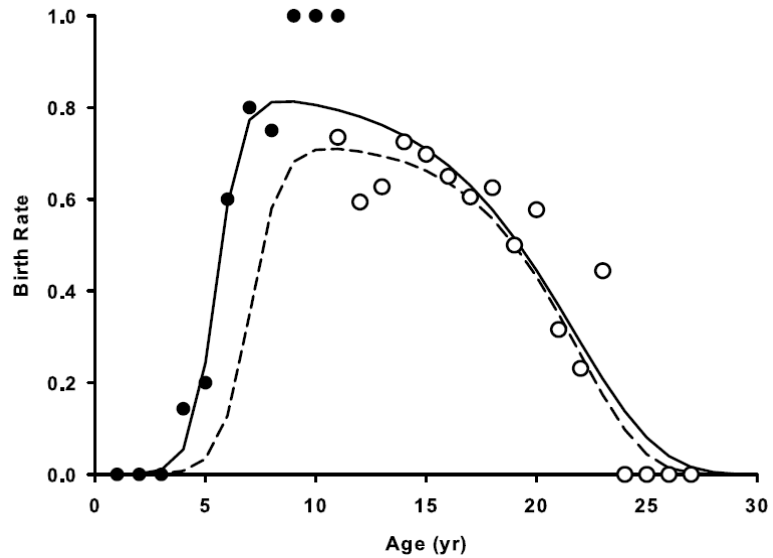


Figure 3. Observed and fitted reproductive rates for the main Hawaiian Islands (MHI). Closed circles are MHI observations (single observation for an age 11 female is displayed, but was not used for fitting curve). Open circles are Laysan Island observations. The MHI curve (solid line) was derived by fitting Equation 1 to the composite sample from both sites. The Laysan Island curve (dashed line) is shown for comparison.

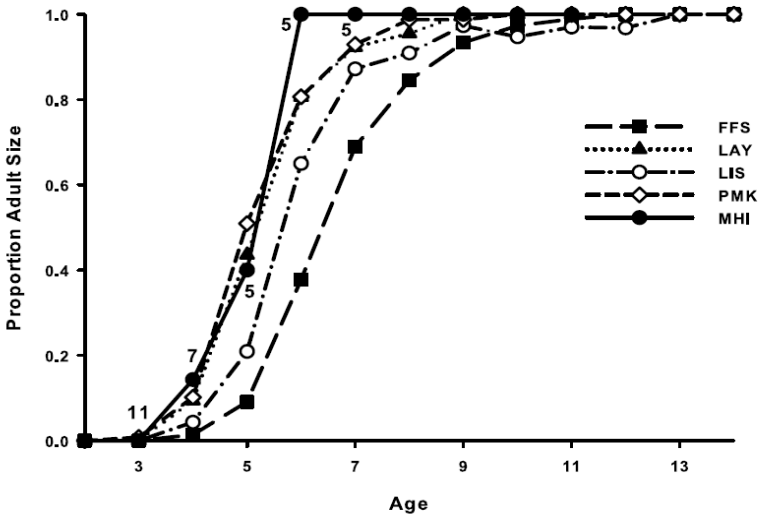


Figure 2. Proportion of female Hawaiian monk seals by age, which were adult size in the main Hawaiian Islands and at four Northwestern Hawaiian Islands areas, 1990–2008. Sample sizes of young known-aged females in the main Hawaiian Islands during this period are indicated. Locations are abbreviated as follows: FFS (French Frigate Shoals), LAY (Laysan Island), LIS (Lisianski Island), PMK (Pearl and Hermes, Midway and Kure combined), and MHI (main Hawaiian Islands).

(Baker et al. 2011)

Research Findings

Study Debunks Myth of Lobster Importance in Monk Seal Diet

The Northwestern Hawaiian Islands lobster fishery was closed in 2000 due to uncertainty in the model used to determine bank specific quotas for the fishery.

The long awaited Hawaiian monk seal fatty acid study, which began in 1998 and was designed to characterize the seal's diet, has been completed. The study included a long process to develop the diet estimation model, which involved diet trials and model validation exercises. There are many caveats associated with interpretation of the results.

Samples to run the study were obtained from 248 seal blubber samples, including 15 samples from the main Hawaiian Islands (MHI), and 3,310 prey samples. The outcome is the most comprehensive marine mammal fatty acid library in existence.

Preliminary results suggest that adult and juvenile diets are different, both within atolls and islands and across the geographic range of the archipelago. Moreover, each individual seal appeared to have its own diet, which was found to change over time. The diets of MHI and Northwestern Hawaiian Islands seals were similar.

The study found that lobsters are not as important in the Hawaiian monk seal diet as has been argued by environmental activists who have blamed the decline of the Hawaiian monk seal population on the lobster fishery. This conclusion is similar to the findings in a study on monk seal scats published in *Marine Biology* in 1998, which found crustaceans comprised 5.7 percent of the Hawaiian monk seal diet and finfish comprised 78.6 percent.

The recent fatty acid study unexpectedly found that the seal diet included deepwater species (including snappers). The findings highlight new areas for future work, including the collection of additional deepwater prey species to further quantify diet composition.

Monk Seal Decline not caused by crash of the lobster fishery

http://www.wpcouncil.org/outreach/newsletters/2007q1spring.pdf

Research Findings

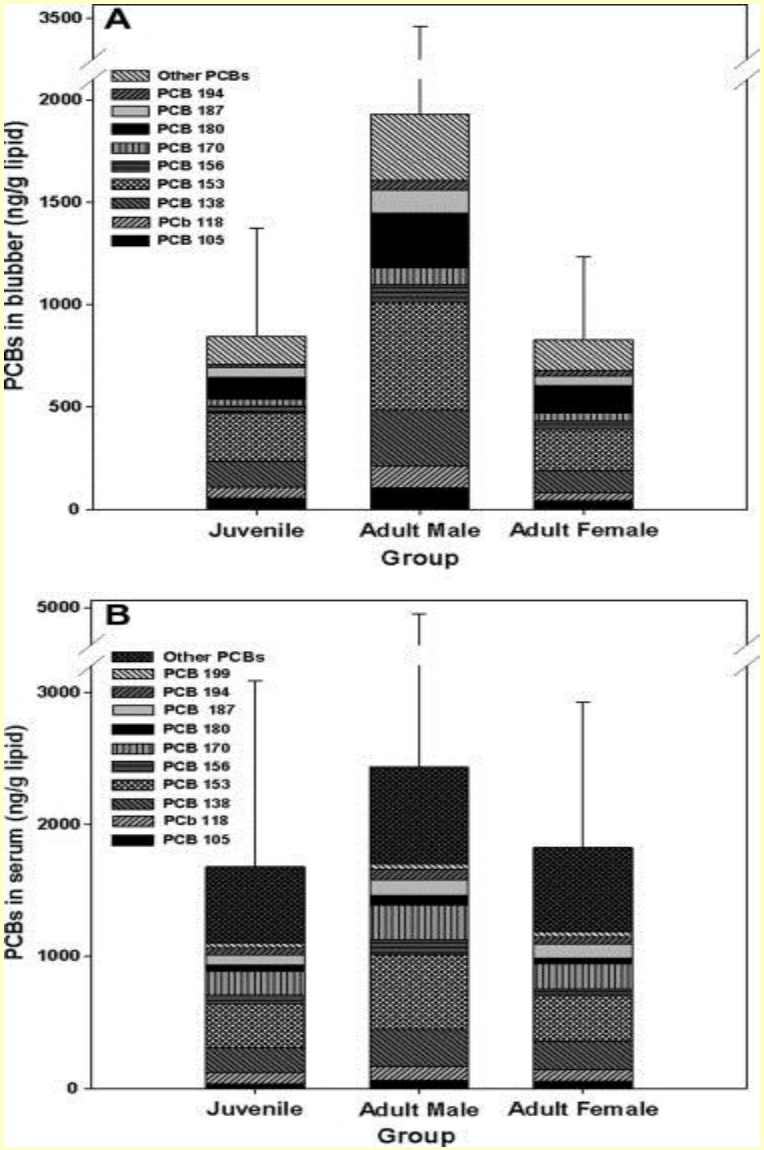
Hawaii monk seals face rivals for food
Honolulu Advertiser (Dec 17, 2007)

NOAA Fisheries research biologist Frank Parrish said studies using "Crittercams" allowed researchers to see the animal's underwater habitat and observe their foraging behavior and interactions with fish

Research took place over an 8-year period during which devices were attached to 42 seals in French Frigate Shoals

The cameras collected 69 hours of footage, including scenes of sharks, snapper and ulua accompanying seals to foraging areas

Research Findings



- HPU graduate student Jessie Lopez
- Littnan (NOAA MSRP)

Mean concentration (SD) of PCBs in:

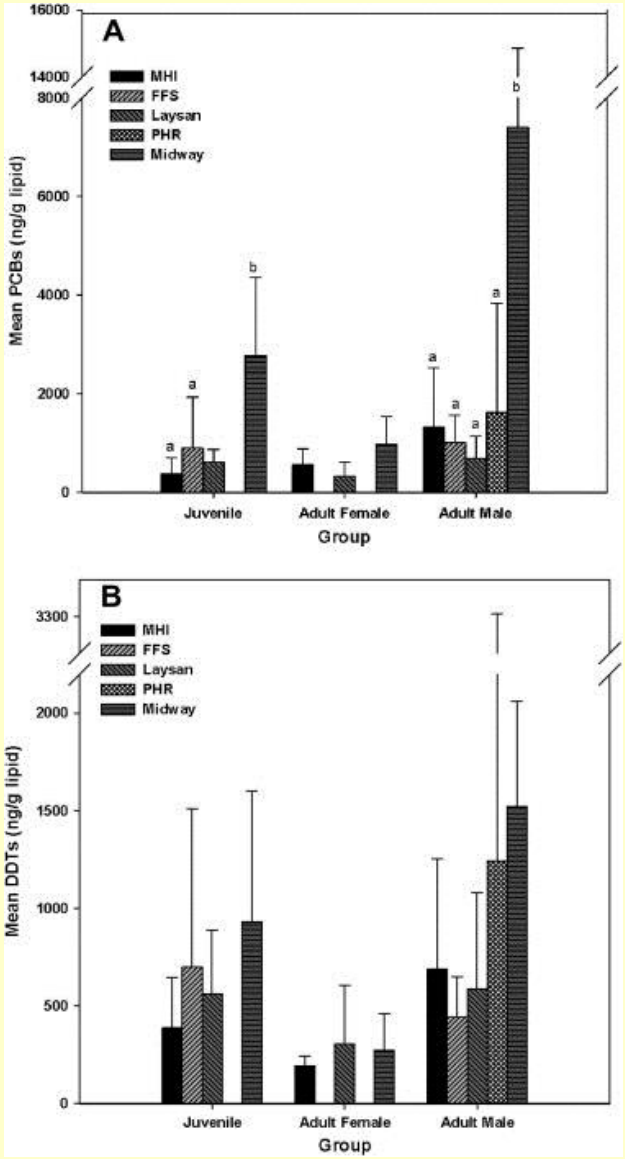
(A)blubber

(B)serum

of juvenile, adult male, and adult female Hawaiian monk seals

(Lopez et al. 2012)

Research Findings



Mean concentrations (SD) of lipid (ng/g lipid) in seal blubber:

(A) 8 PCB congeners (B) 5 DDTs

at 5 sites:

Main Hawaiian Islands (MHI)
French Frigate Shoals (FFS)
Laysan Island (Laysan)
Pearl and Hermes Reef (PHR)
and Midway Atoll (Midway)

Bars with unlike letters differ significantly.

(Lopez et al. 2012)

Latest Research in the MHI

Tracked MHI Monk Seals move from island to island, and forage in deep water habitats

References

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