Staying Close to Home:
Seasonality and Site Fidelity of an Insular Population of Texas Diamondback Terrapins as Determined by Acoustic Telemetry

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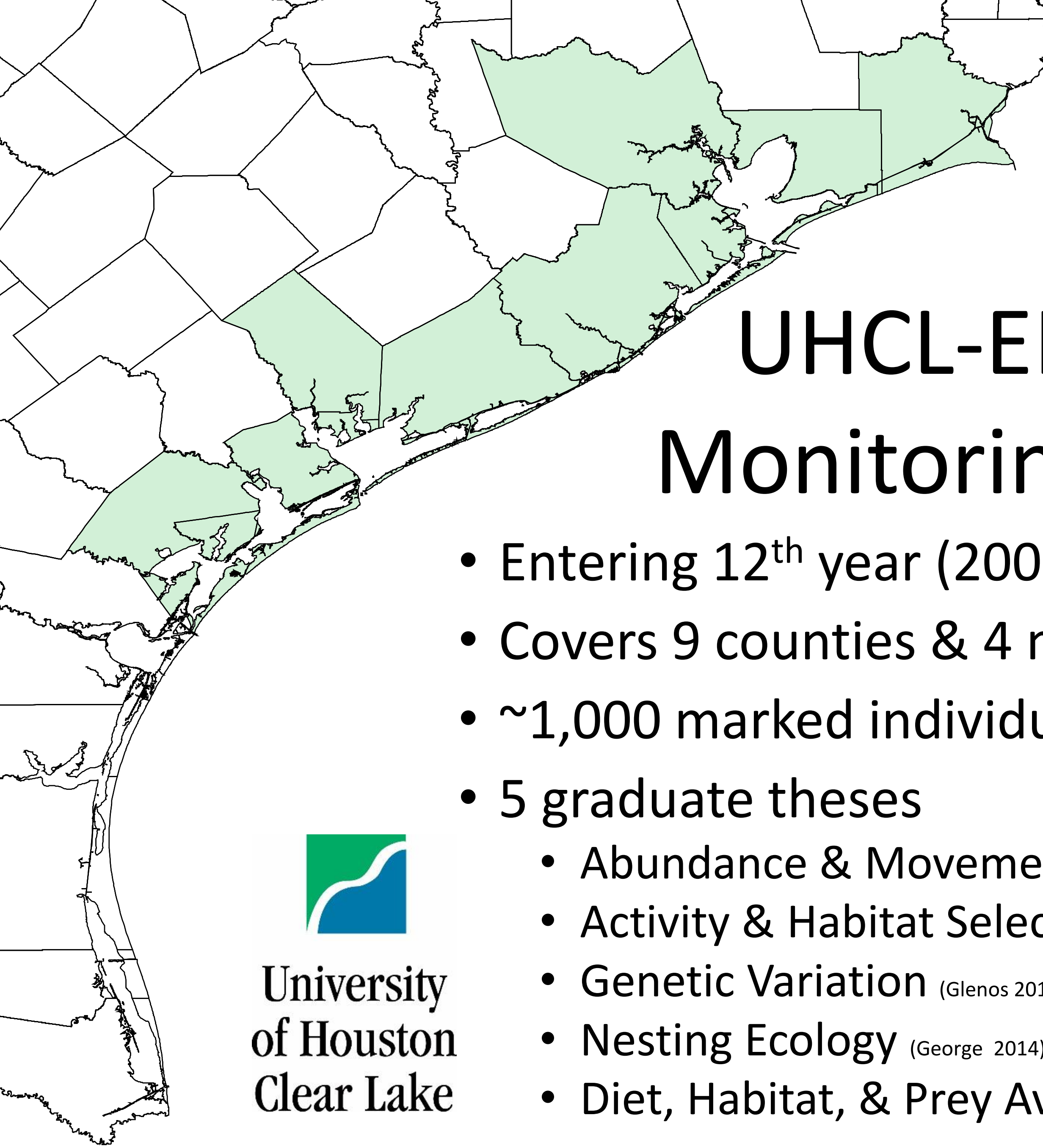
Abstract

As critical saltmarsh habitat declines and severe weather events (hurricanes, drought, etc.) become more frequent, it is important for resource managers to understand how species of greatest conservation need are utilizing available habitat. In highly urbanized bays, such as Galveston Bay, available marsh habitat is limited or declining and Diamondback terrapin (*Malaclemys terrapin*) populations exist in more isolated areas than other populations along the Gulf and Atlantic coasts. To determine seasonality and site fidelity of an insular population of terrapin, an acoustic array was installed using Vemco acoustic receivers. From March 2009-April 2014, 39 terrapin (33 female; 6 male) were fitted with V13-1H transmitters. Transmitters were detected every year and, across all years, every month. Over 62 consecutive months of monitoring, 9 showed no detections (Jan 2010; Sep 2011, Nov 2012-Feb 2013; May 2013; Jan-Feb 2014), all correlated with major weather events. Across all years, transmitters were detected at all stations from March-May and October-November, indicating periods of peak aquatic activity coincident with mating and nesting seasons. Critical aquatic habitat utilized include seagrass, open water, emergent marsh, and shallow oyster reef. Our results suggest that this Galveston Bay population is utilizing aquatic habitats year round, especially the female cohorts. This contrasts with populations in more northern latitudes where winter dormancy is prevalent and suggests that Galveston Bay may contain critical year-round habitat for Texas terrapin. Resource managers should take this into consideration when developing action plans as this may vary from other populations throughout the species range.



Environmental Institute of Houston

UHCL-EIH Terrapin Monitoring Program

- Entering 12th year (2008-present)
- Covers 9 counties & 4 major bay systems
- ~1,000 marked individuals
- 5 graduate theses
  - Abundance & Movement (Haskett 2011)
  - Activity & Habitat Selection (Clarkson 2012)
  - Genetic Variation (Glenos 2013)
  - Nesting Ecology (George 2014)
  - Diet, Habitat, & Prey Availability (Alleman 2015)

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Acoustic Telemetry

- Applied to a wide range of aquatic species
- Used to determine:
    - Home range (Topping et al. 2006)
    - Habitat use (Béguer-Pon et al. 2015)
    - Seasonality (James-Pirri 2010)
    - Migration (Huuskonen et al. 2012)
    - Movement (Reyier et al. 2011)
    - Diel activity (Christoffersen et al. 2019)
    - Behavior (Pratt et al. 2010)

Béguer-Pon et al. 2015. Large-scale, seasonal habitat use and movements of yellow American eels in the St. Lawrence River revealed by acoustic telemetry. Ecology of Freshwater Fish 24:99-111
Braun et al. 2015. Movements of the reef manta ray (*Manta alfredi*) in the Red Sea using satellite and acoustic telemetry. Marine Biology 162:2351-2362
Christoffersen et al. 2019. Using acoustic telemetry and snorkel surveys to study diel activity and seasonal migration of round goby (*Neogobius melanostomus*) in an estuary of the Western Baltic Sea. Fisheries Management and Ecology 26:172-182
Huuskonen et al. 2012. Seasonal movements and habitat use of river whitefish (*Coregonus lavaretus*) in the Koitajoki River (Finland), as determined by Carlin tagging and acoustic telemetry. Aquatic Ecology 46:325-334
James-Pirri. 2010. Seasonal movement of the American horseshoe crab *Limulus polyphemus* in a semi-enclosed bay on Cape Cod, Massachusetts (USA) as determined by acoustic telemetry. Current Zoology 56:575-586
Pratt et al. 2010. Environmental and ecological factors influencing dive behaviour in the freshwater snake *Acrochordus arafurae*: a field-based telemetric study. Marine and Freshwater Research 61:560-567
Reyier et al. 2011. Movement patterns of adult red drum, *Sciaenops ocellatus*, in shallow Florida lagoons as inferred through autonomous acoustic telemetry. Environmental Biology of Fishes 90:343-360
Topping et al. 2006. Site fidelity and seasonal movement patterns of adult California sheephead *Semicossyphus pulcher* (Labridae): an acoustic monitoring study. Marine Ecology Progress Series 326:257-267

Acoustic Telemetry

- Successfully applied to turtles
  - Hawksbill sea turtle
    (Hart et al. 2012; Scales et al. 2011)
  - Flatback sea turtle
    (Thums et al. 2013)
  - Green sea turtle
    (MacDonald et al. 2012, 2013; Lamont et al. 2015; Fujisaki et al. 2016)
  - Leatherback sea turtle
    (Gearheart et al. 2011)
  - Mary river turtle
    (Micheli-Campbell et al. 2013)
- Relatively new application to DBT
  (Winters et al. 2015, Castro-Santos et al. 2019)


Photo credit: U.S. Navy


Photo credit: Rebecca Scott

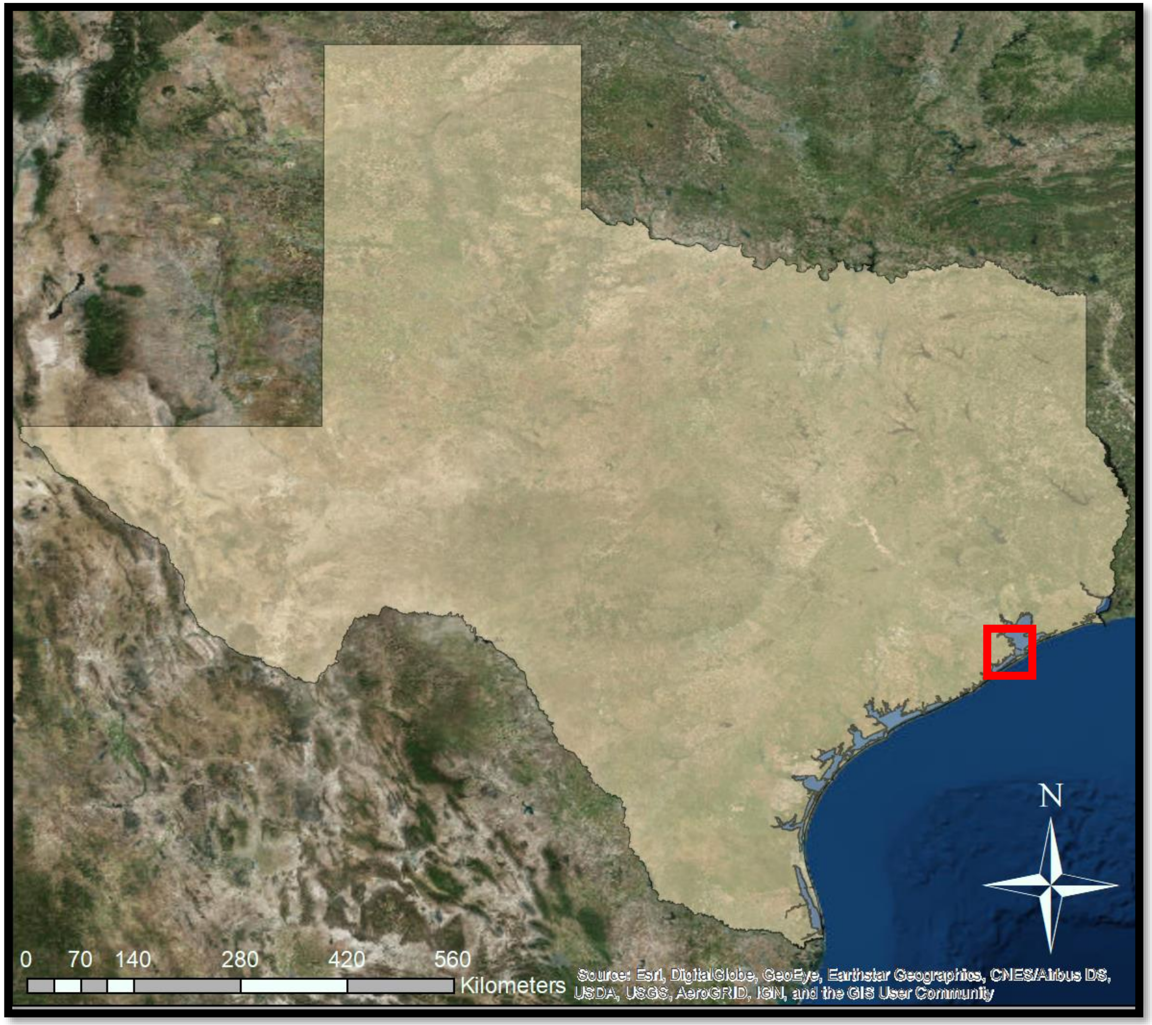
Castro-Santos et al. 2019. Assessing Risks from Harbor Dredging to the Northernmost Population of Diamondback Terrapins Using Acoustic Telemetry. Estuaries and Coasts 42:378-389
Fujisaki et al. 2016. Habitat selection by green turtles in a spatially heterogeneous benthic landscape in Dry Tortugas National Park, Florida. Aquat Biol 24:185-199
Gearheart et al. 2011. Tracking Leatherback (*Dermochelys coriacea*) Hatchlings at Sea Using Radio and Acoustic Tags. Mar Turtle Newsl 130:2-6
Hart et al. 2012. Home range, habitat use, and migrations of hawksbill turtles tracked from Dry Tortugas National Park, Florida, USA. Mar. Ecol. Progress Series 457:193-207
Lamont et al. 2015. Home range and habitat use of juvenile green turtles (*Chelonia mydas*) in the northern Gulf of Mexico. Animal Biotelemetry 3:53
MacDonald et al. 2012. Home ranges of East Pacific green turtles *Chelonia mydas* in a highly urbanized temperate foraging ground. Mar. Ecol. Progress Series 461:211-221
MacDonald et al. 2013. Fine scale diel movement of the east Pacific green turtle, *Chelonia mydas*, in a highly urbanized foraging environment. J Exp Mar Biol Ecol 443:56-64
Micheli-Campbell et al. 2013. Integrating telemetry with a predictive model to assess habitat preferences and juvenile survival in an endangered freshwater turtle. Freshwater Biology 58:2253-2263
Scales et al. 2011. Insights into habitat utilisation of the hawksbill turtle, *Eretmochelys imbricata* (Linnaeus, 1766), using acoustic telemetry. J Exp Mar Biol Ecol 407:122-129
Thums et al. 2013. Tracking sea turtle hatchlings — A pilot study using acoustic telemetry. J Exp Mar Biol Ecol 440:156-163
Winters et al. 2015. Between the bay and a hard place: Altered diamondback terrapin nesting movements demonstrate the effects of coastal barriers upon estuarine wildlife. J. of Wildlife Mgmt. 79:682-688

Objectives

- Evaluate seasonal patterns of aquatic use

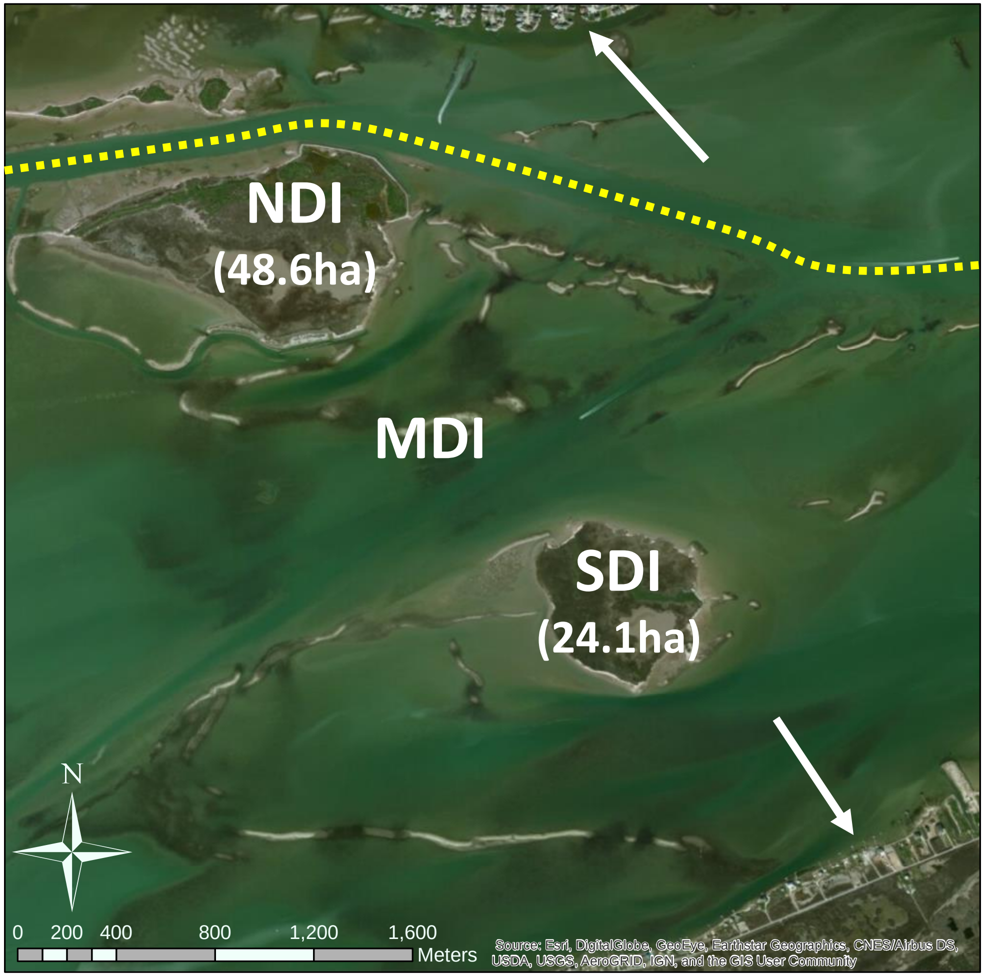
- Determine diel patterns of aquatic use

Study Area


N
0 70 140 280 420 560
Kilometers
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Deer Island Complex

- 3 Island Chain
  - North Deer (NDI)
  - Middle Deer (MDI)
  - South Deer (SDI)
- Adjacent to ICW
- Waterfront communities to North & South
- Surrounded by oyster reef habitat

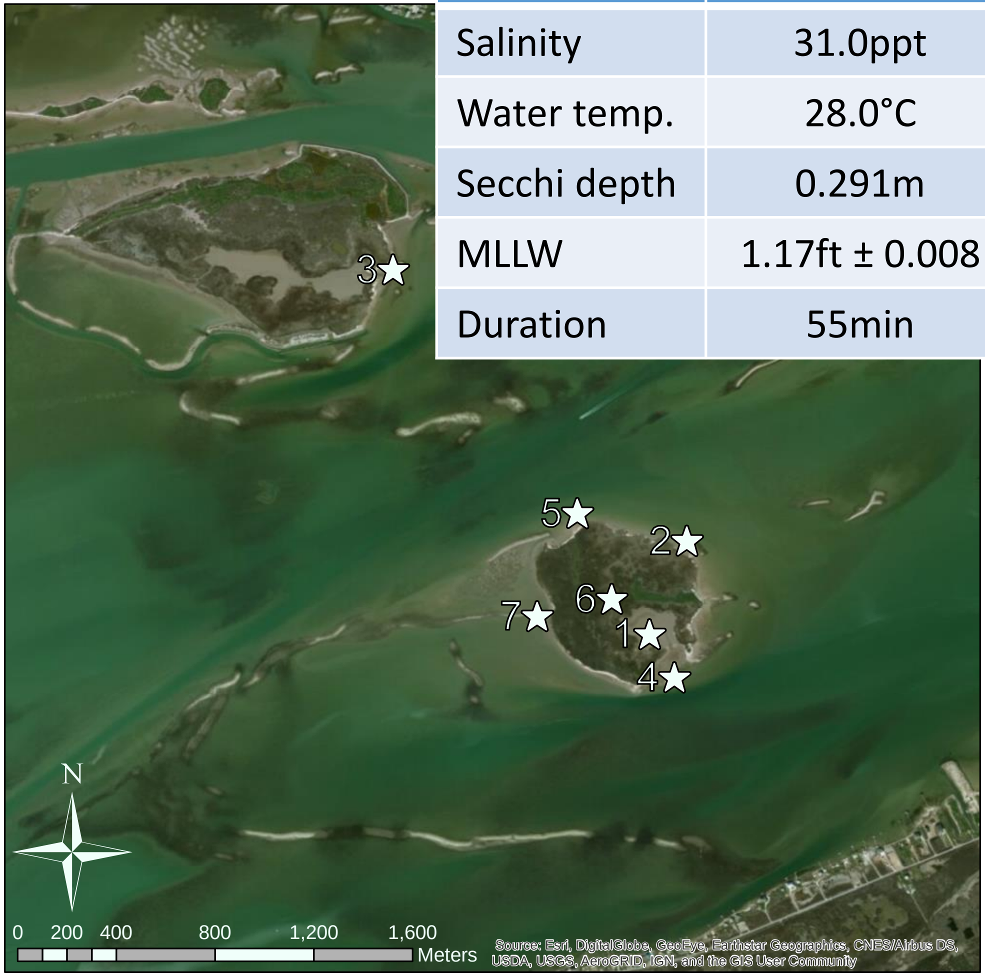


Receiver Array

- 7 fixed stations
- Targeted locations:
  - “Gates” (passages)
  - “Nodes” (wide area)
- Range test (7/15/11)
  - Max. detection distance = 1,015m
  - Average detection distance = 458m

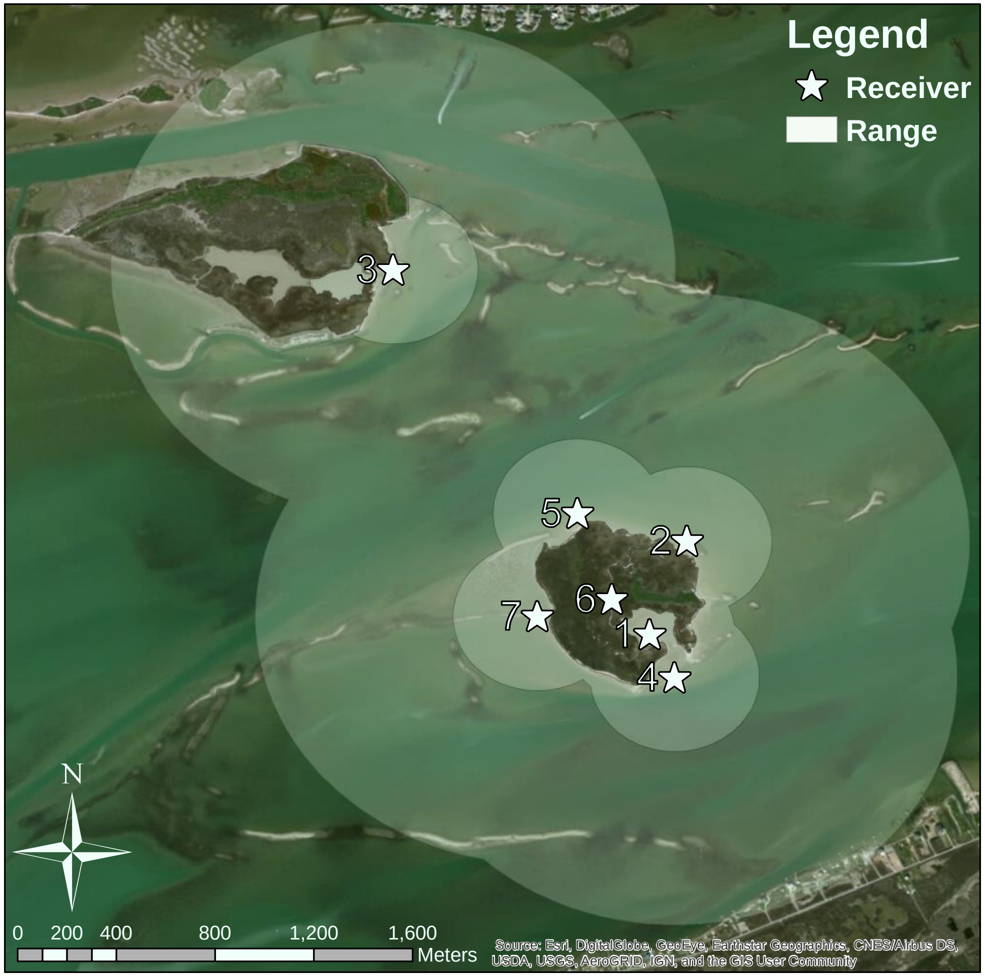
Range Test Conditions

Parameter	Result
Salinity	31.0ppt
Water temp.	28.0°C
Secchi depth	0.291m
MLLW	1.17ft ± 0.008
Duration	55min



Receiver Array

- Conservative Range:
  - 300m
  - Covers entirety of SDI and does not overlap with receiver from NDI
- Maximum Range:
  - 1,015m
  - Allows for overlap between islands



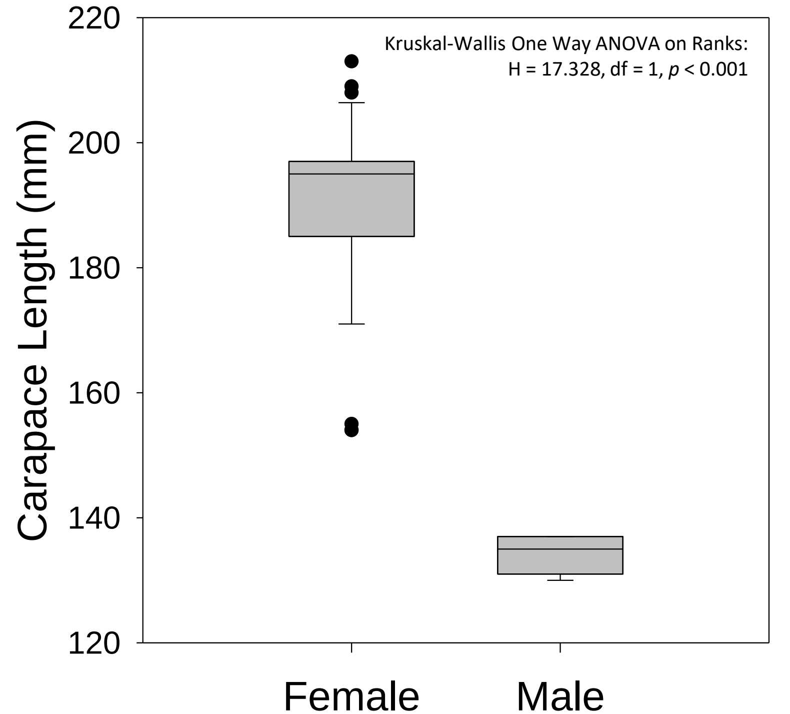
Tags & Receivers

- VR-2W coated receivers
- V13-1H coded transmitters

Results: Individuals Tracked

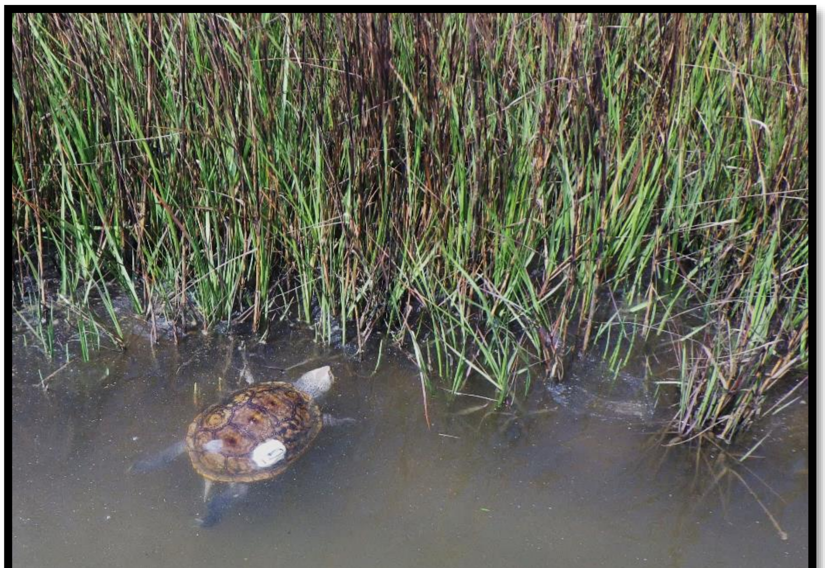
- 44 tags deployed
  - Females (*n* = 37)
    - CL: 190.6 ± 2.261mm (154-213mm)
    - March 2009-April 2014
  - Males (*n* = 7)
    - CL: 133.9 ± 1.079mm (130-137mm)
    - March 2009-June 2011
- 39 tags detected
  - 88.7% detection rate
  - 4 females & 1 male not detected during study

Size Dimorphism for Terrapin Equipped with Acoustic Transmitters (March 2009-April 2014)

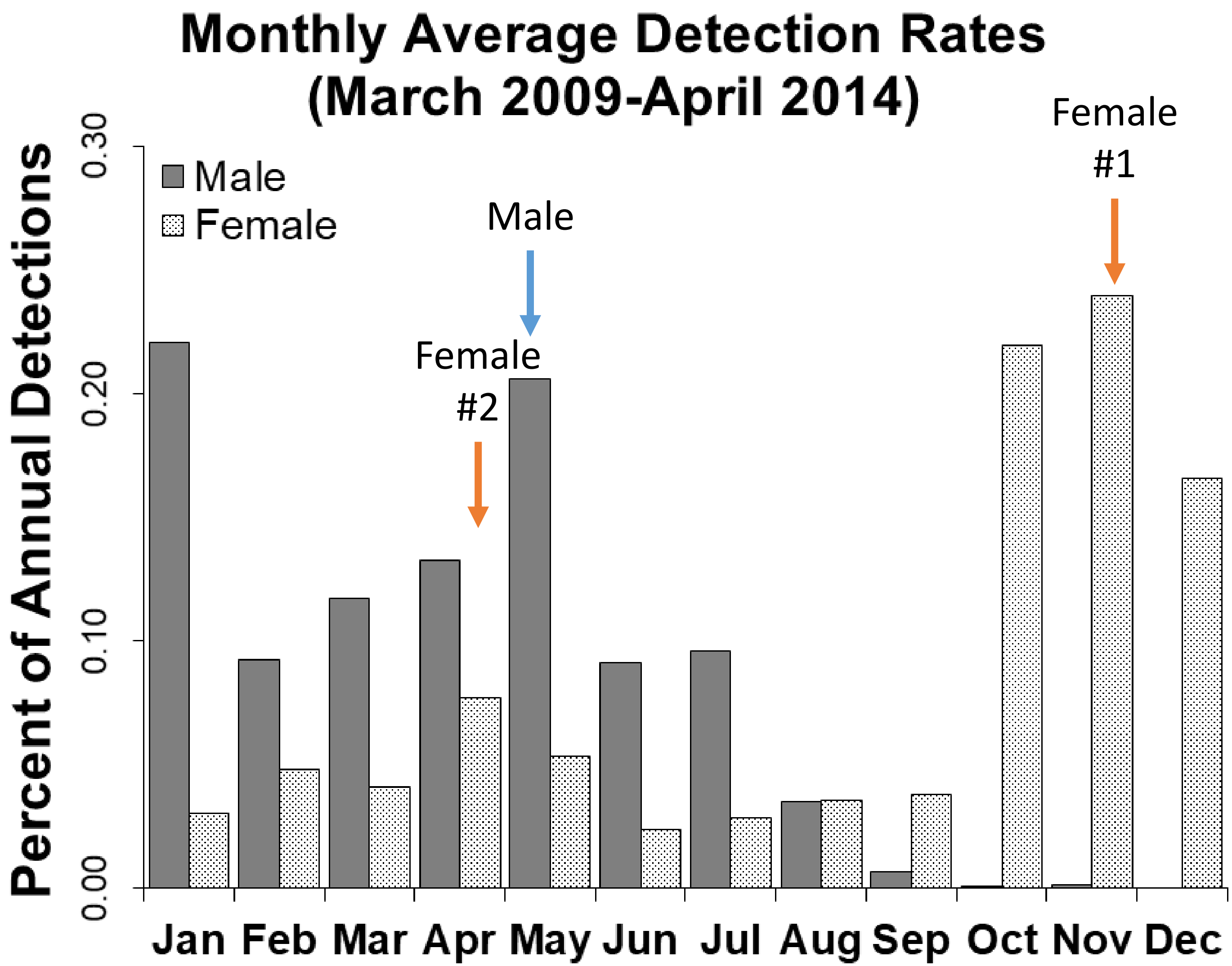


Results: Seasonal Activity

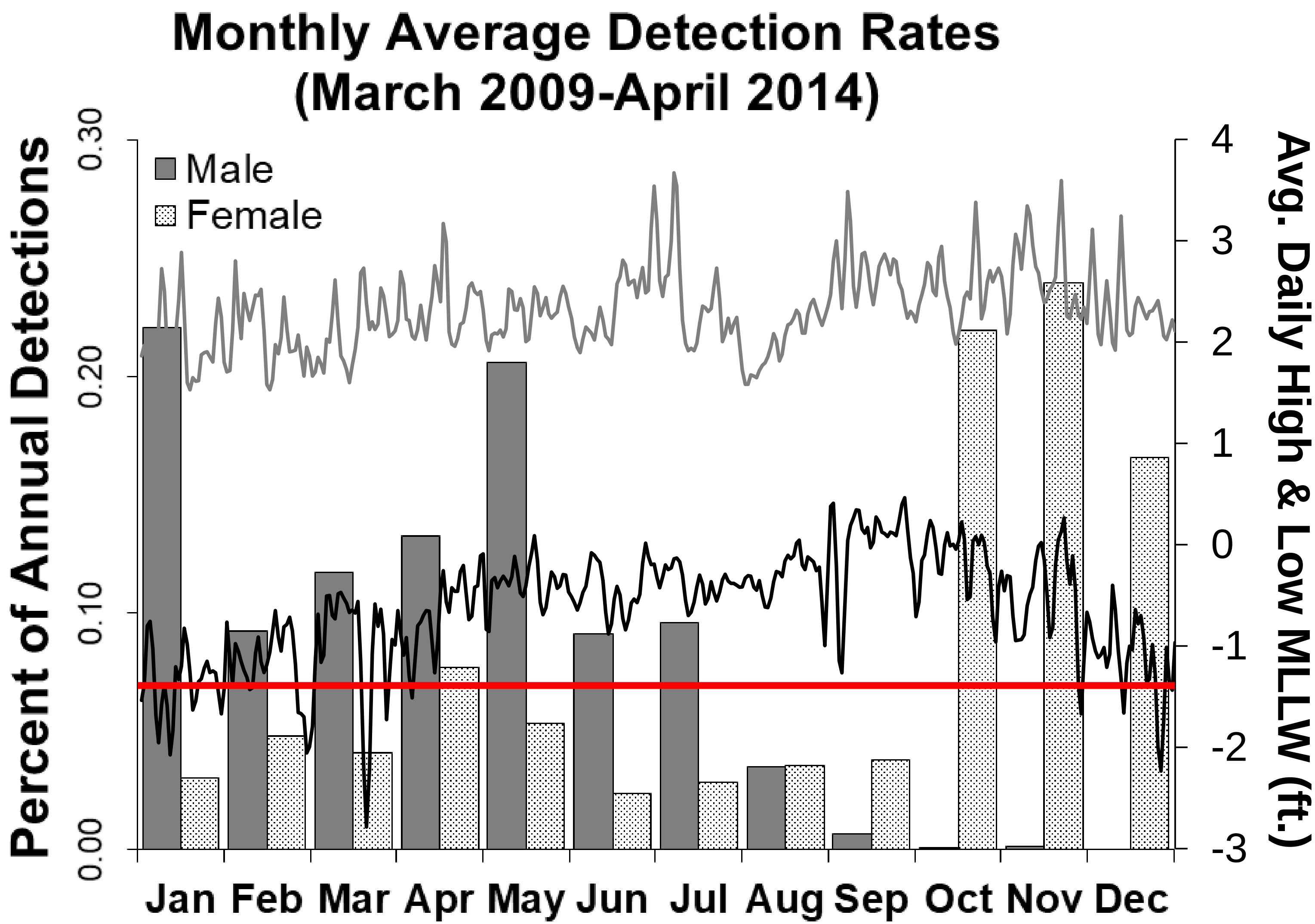
- Receivers deployed Mar 2009-Apr 2014 (62 mos.)
  - Transmitters detected every year of study
  - Across all years, transmitters detected every month



Results: Seasonal Activity

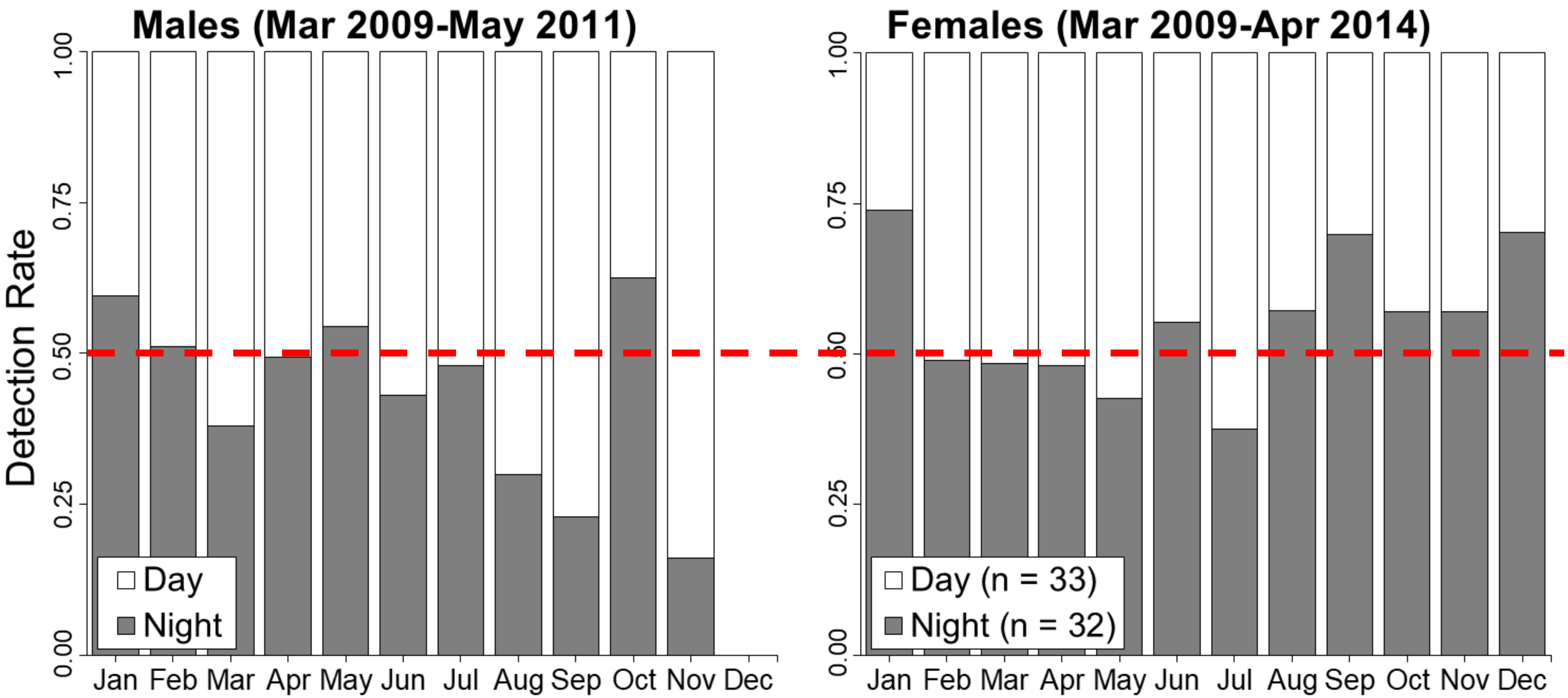


Results: Seasonal Activity



Tide data: NOAA Station 8771450 (Galveston Pier 21) https://tidesandcurrents.noaa.gov/stationhome.html?id=8771450

Results: Diel Activity



Sunrise & sunset data: https://www.timeanddate.com/sun/usa/galveston

Preliminary Conclusions

- Aquatic habitat used year-round in Galveston Bay
  - Male aquatic activity peaks in May
    - Limited activity in October and November
    - No activity observed in December
  - Female aquatic activity bimodally distributed
    - Primary peak from October-December
    - Secondary peak in April (Baxter 2015)

- Neither males nor females display a clear diel preference for aquatic activity

Baxter. 2015. Identifying Diamondback Terrapin Nesting Habitat in the Nueces Estuary, Texas, Texas A&M Unviersity - Corpus Christi Center for Coastal Studies, Corpus Christi, Texas

Future Work

- Spatial analyses
- Temperature correlations and modelling
- Hazard identification (similarly to Castro-Santos et al. 2019; McAuley et al. 2016)

Castro-Santos et al. 2019. Assessing Risks from Harbor Dredging to the Northernmost Population of Diamondback Terrapins Using Acoustic Telemetry. Estuaries and Coasts 42:378-389
McAuley et al. 2016. Evaluation of passive acoustic telemetry approaches for monitoring and mitigating shark hazards off the coast of Western Australia. Report No. Report No. 273, Western Australian Fisheries and Marine Research Laboratories, North Beach, Western Australia

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  - TPWD permit #SPR-0504-383
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TEXAS PARKS & WILDLIFE

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

HOUSTON ZOO

Sea Grant Texas

- Staff members, graduate students, undergraduate students, interns, and field volunteers


Questions?

Interesting Notes

- Of all individuals tagged, only 2 females migrated between SDI and other sample areas
  - N168: hand captured at SDI and Sweetwater Preserve ~2.5 years after last acoustic transmission
  - N180.1: originally captured at NDI ~1.25 years prior to being fitted with acoustic transmitter; every capture and all transmissions since initial event located at SDI
- Tags with no detections
  - 3 females from Sportsman's Marsh (~1.5km from southern most receiver)
  - 1 male & 1 female from SDI

Benefits…and Cautionary Notes

- Preferred over radio tracking for aquatic use studies
  - Pros: relatively little effort compared to other methods
  - Cons: estimates location; limited by size/weight
  - Best use: compliment to other tracking methods
- Environmental interference (Mathies et al. 2014)
- Electronic tag limitations and strengths (review by Cooke et al. 2013)

Cooke et al. 2013. Tracking animals in freshwater with electronic tags: past, present and future. Animal Biotelemetry 1:5

Mathies et al. 2014. Environmental interference factors affecting detection range in acoustic telemetry studies using fixed receiver arrays. Marine Ecology Progress Series 495:27-38