How to Find What You Cannot See: Telemetry Technology in Marine Applications

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Why Understanding Animal Movements Are Important

- Population Management
 - Population Size Estimation
 - Hunting/Fishing Regulation
 - Bag sizes/Catch limits
 - License distributions
 - Number/Location
- Environmentally Aware Construction Practices
 - Terrestrial
 - Highways
 - Housing
 - Power Infrastructure (e.g. wind turbines, powerline placement)
 - Marine
 - Oil rigs
 - Communication Infrastructure
 - Shipping Lanes



https://www.industryleadersmagazine.com/

What Questions Do We Need To Answer?

- Where do they go?
- How do they get there?
- How quickly do they get there?
- Why do they go there instead of somewhere else?
- Who (or what) else is there?

Drosophila tracking – Tracking In A Closed Environment

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Branson, K., Robie, A., Bender, J., Perona, P., Dickinson, M., 2009. High-throughput ethomics in large groups of Drosophila, Nature Methods, 6(6): 451-457.

What about when it isn't a small, closed environment?

- Telemetry Tagging
 - Technology which tracks animals' movements over an extended period of time
 - Conventional Tags
 - Acoustic Tags
 - PSATs
 - SPOTs
 - Not a perfect system
 - Biofouling/ingestion
 - Recapture (if necessary)
 - Cost
 - Reliability of data

Questions Involved In Each System

- How does it work?
- What kind of data does it give you?
- What are its limitations?
- Which of the Questions does it answer?
 - Where do they go?
 - How do they get there?
 - How quickly do they get there?
 - Why do they go there instead of somewhere else?
 - Who (or what) else is there?

• How does it work?

- Simple identifier physically attached to study animal
- What kind of data does it give you?
 - Point to Point Data
 - Proof of presence
- What are its limitations?
 - Requires recapture
 - Often rely on industry recapture – taken into account for accuracy of recapture locations
 - No Movement Data Between Points

Conventional Tags



Acoustic Tags



- How does it work?
 - Uses high frequency sound for animal detection
 - Animal is outfitted with transmitter which relays specific ID code to static receivers, aka hydrophones
- What kind of data does it give you?
 - Proof of presence
 - Detailed area movements
 - Two different arrangements of hydrophones, array vs gate
- What are its limitations?
 - Require the animal to be near a hydrophone
 - Do not require recapture
 - Hydrophones require servicing
 - Biofouling/environmental interference can lower effective range



Domeier, M.L. 2005. Methods for the Deployment and Maintenance of an Acoustic Tag Tracking Array: An Example from California's Channel Islands, *Marine Technology Society Journal*, 39(1): 74-80.

Pop-Up Satellite Archival Tags (PSATs)

- How does it work?
 - Light-Level Geolocation
 - Dawn, Dusk, Noon calculation
 - Often paired with SST or magnetic field measurement to verify
 - Pop off after preset amount of time
 - Transmit data to satellite system
- What kind of data does it give you?
 - Movement data throughout time span
 - Can be outfitted with other sensors
 - Temperature
 - Depth
- What are its limitations?
 - Limited battery life
 - High cost
 - Questionable accuracy of location measurements
 - Inability to measure location in extreme latitudes
 - Biofouling can reduce ability to measure light levels





Smart Position or Temperature Transmitting Tags (SPOTs)



- How does it work?
 - ARGOS Doppler Effect measures geolocation
- What kind of data does it give you?
 - High quality location data
- What are its limitations?
 - Lots of power
 - Large battery
 - Salt water on/off switch
 - Requires surfacing limits animals it's useful on
 - Moderately high cost

Class	Туре	Estimated error*		Number of messages received per satellite pass		
		Least Squares	Kalman Filter	Least Squares	Kalman Filter	
G	GPS	< 100m		1 message or more		
3	Argos	< 250m		4 messages or more		
2	Argos	250m < < 500m		4 messages or more		
1	Argos	500m < < 1500m		4 messages or more		
0*	Argos	> 1500m		4 messages or more		
A	Argos	No accuracy estimation	Unbounded accuracy estimation	3 messages		
В	Argos	No accuracy estimation	Unbounded accuracy estimation	messages	1 or 2 messages	
Z	Argos	Invalid location (available o Plus/Auxiliary Location Pro	nly for Service cessing)	www.argos-system.org		

Accelerometers

- How does it work
 - Same as a FitBit
 - Piezoelectric accelerometer
- What kind of data does it give you?
 - Animal acceleration logged over time
 - Now being incorporated into acoustic tags and PSATs
- What are its limitations?
 - Archival tag requires recapture
 - Acoustic tags transmit remotely
 - Incorporated accelerometers don't require recapture



- Study Animal: Gray Sharks and Bull Sharks
- Study Area: Great Barrier Reefs
- Goal: Investigating Habitat Use and Marine Protected Area Use
- Goal Number of Study Animals: Undetermined
- Presence of Acoustic Network: Yes
- Time Limitation: 2 Years
- Which Tag Do You Use?

- Study Animal: Green Sea Turtle
- Study Area: Everglades, FL
- Goal: Monitoring Habitat Use of Juveniles
- Goal Number of Study Animals: <10
- Presence of Acoustic Network: No
- Time Limitation: 1 Year
- Which Tag Do You Use?

- Study Animal: White Sharks
- Study Area: Western South Africa
- Goal: Investigating Habitat Use and Population Linkages with Australian Population
- Goal Number of Study Animals: >30
- Presence of Acoustic Network: Yes
- Time Limitation: 2 Years
- Which Tag Do You Use?

- Study Animal: Nurse Sharks
- Study Area: Dry Tortugas group, FL
- Goal: Identifying Mating Behavior
- Goal Number of Study Animals: <10
- Presence of Acoustic Network: No
- Time Limitation: 7 Days
- Which Tag Do You Use?

- Study Animal: Whale Sharks
- Study Area: Mesoamerican Barrier Reef
- Goal: Defining Population Size
- Goal Number of Study Animals: >100
- Presence of Acoustic Network: No
- Time Limitation: 5 Years
- Which Tag Do You Use?

Do these tags affect the study animals?

- Natural stressors on the study animals
- Dangers of additional stressors
 - American Eel migration
- 2% bodymass rule
- Different ways to test
 - Swim Tunnel
 - Intermittent Flow Respirometry



Methling, C., Tudorache, C., Skov, P.V., Steffensen, J.F., 2011. Pop up satellite tags impair swimming performance and energetics of the European Eel (Anguilla anguilla). PLoS One 6, e20797.

