Advances in marine animal telemetry, sensors and analyses

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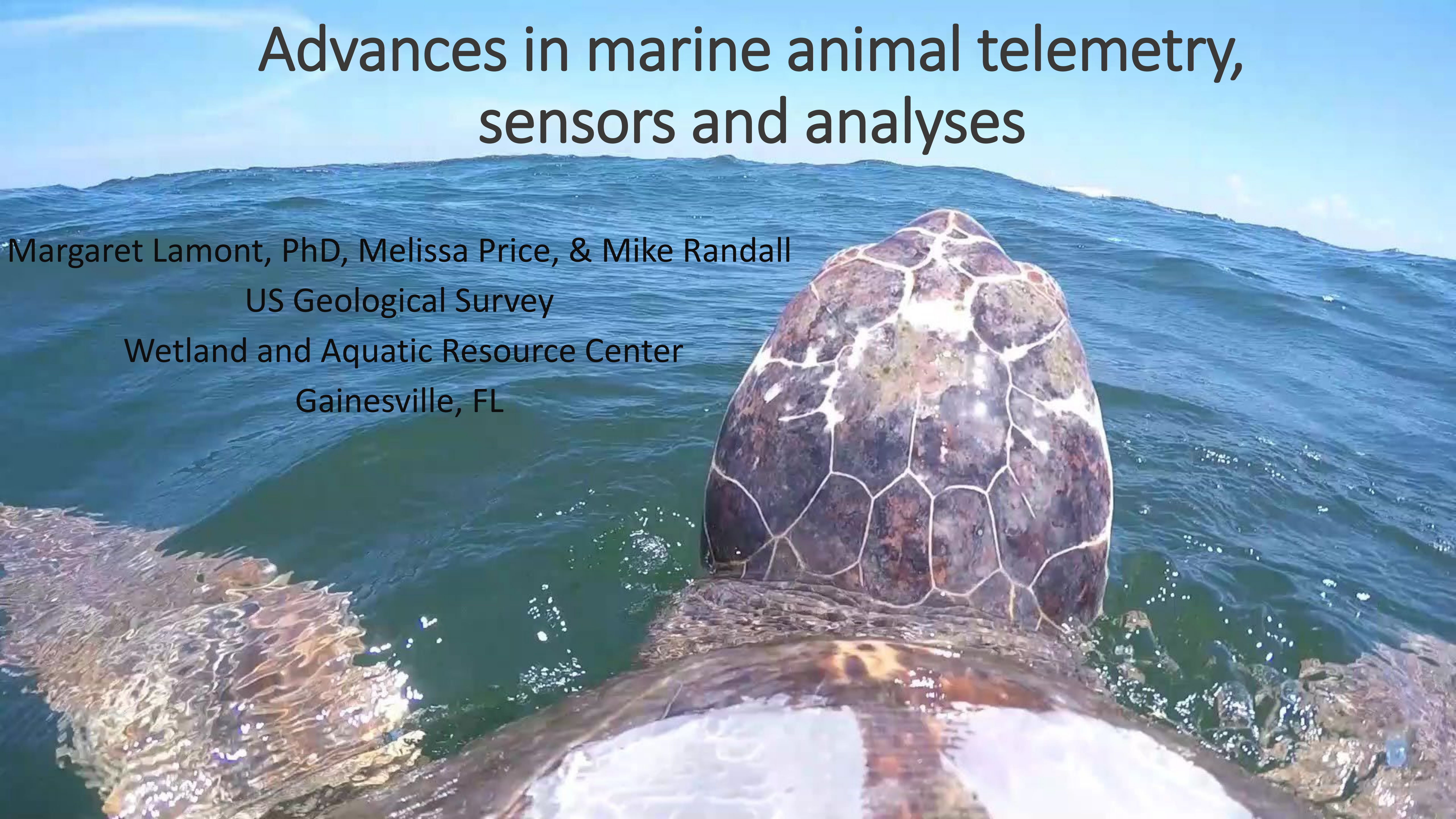
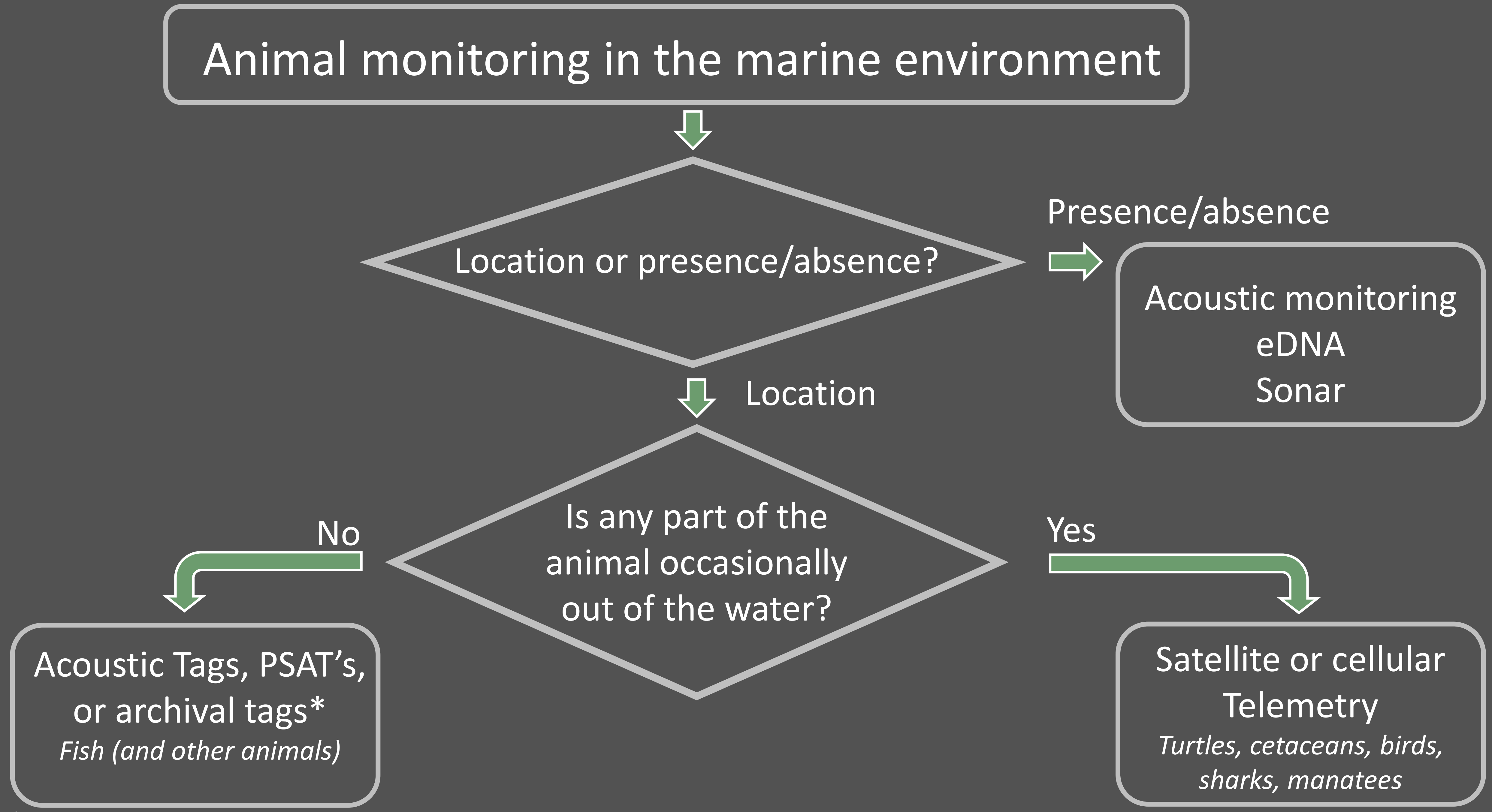
US Geological Survey

Wetland and Aquatic Resource Center

Gainesville, FL





* Archive tags rely on recaptures & reporting. Very low odds of success unless deployed into an intensive fishery

Photo: Sonotronics

In the Past…

- Manual, single-point process
- Limited data collection
- Labor intensive (expensive)
- Daytime, fair-weather biology
- Low data intensity
- Big data gaps

Photo: Advanced Telemetry Systems

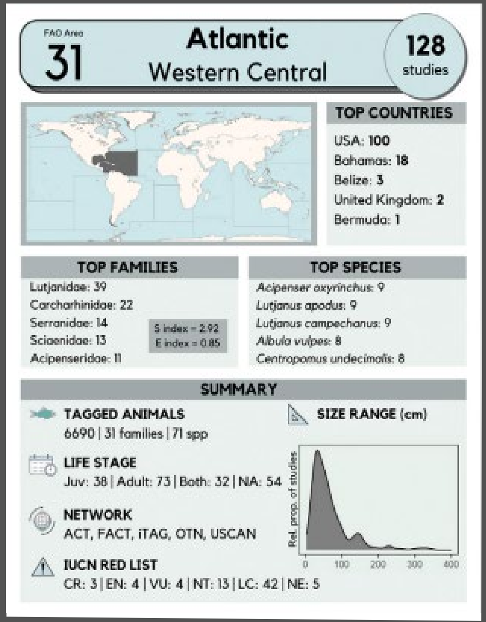
Now…

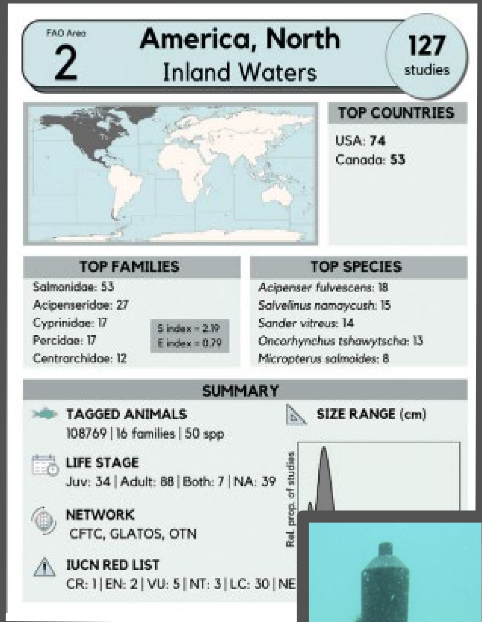
- Automation
- 24/7/365 detections
- Reduced effort
- High data intensity
- Less data gaps
- Smaller, cheaper*, faster

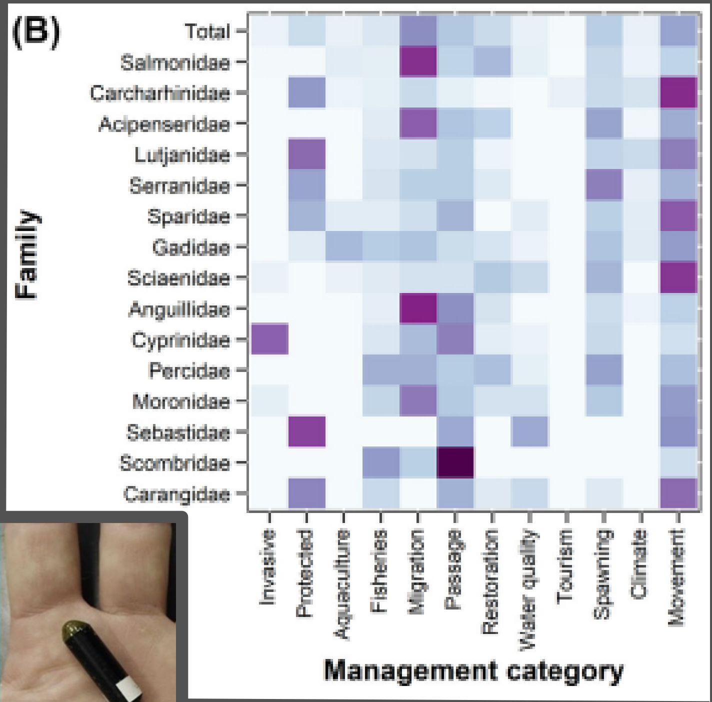
* At least in terms of cost per data point

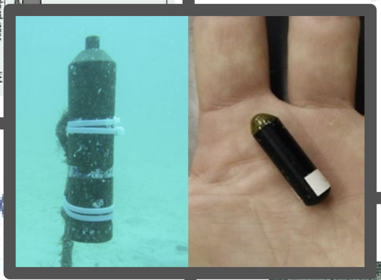
Acoustic Telemetry

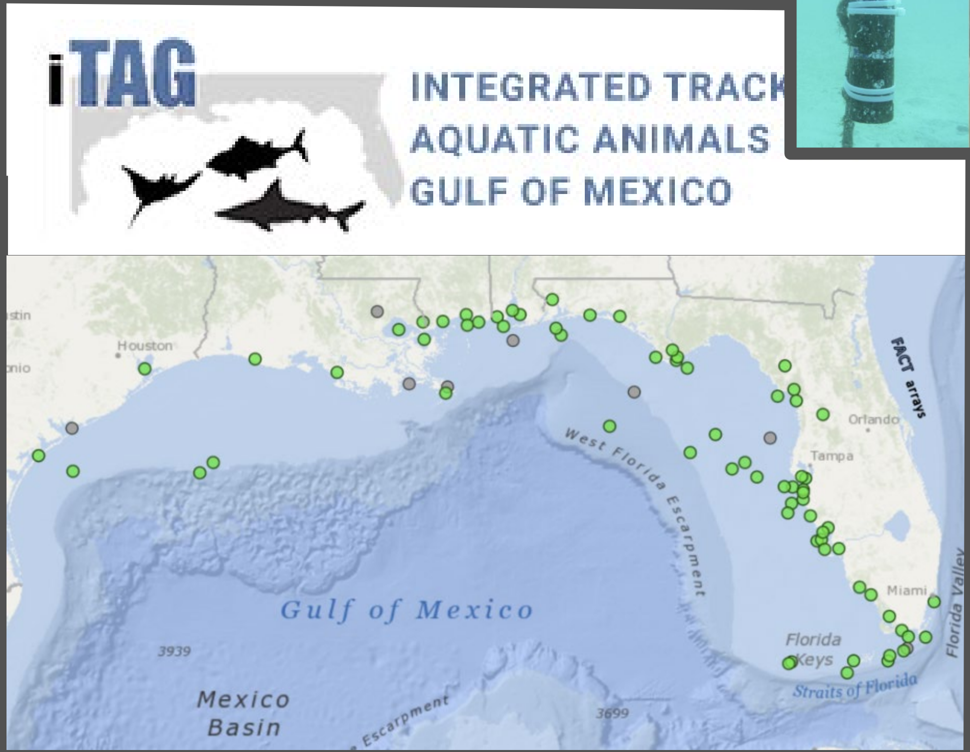
- Passive arrays increase spatial and temporal scale while reducing effort
- Further expansion by integrated networks at different scales
  - GLATOS, IMOS, iTag, OTN
- Fine-scale resolution (VPS)
- Several receiver upload methods
  - Manual
  - Acoustic modem
  - Cell or satellite
- Remote receiver uploads via drone
- Decreasing tag sizes
- Increasing sensor capabilities
- Trade-offs:
  - Spatially restricted
  - Location accuracy
  - Longer battery life

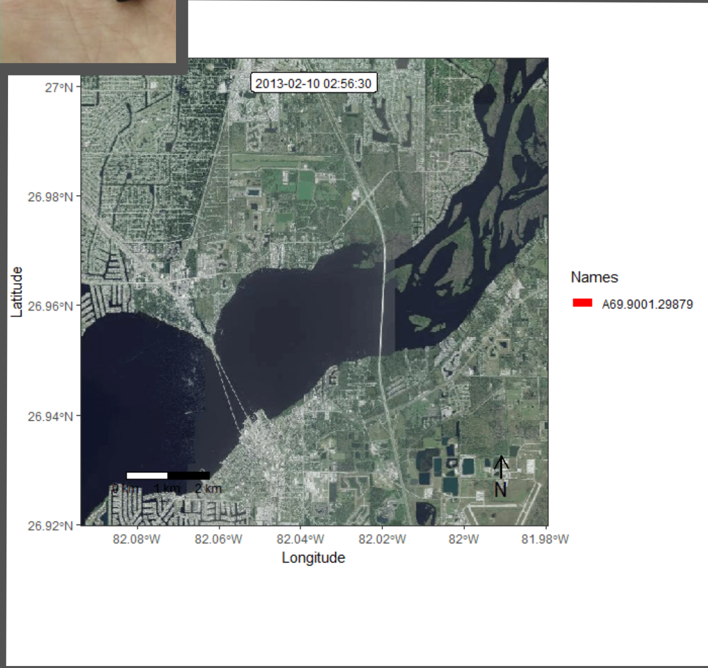






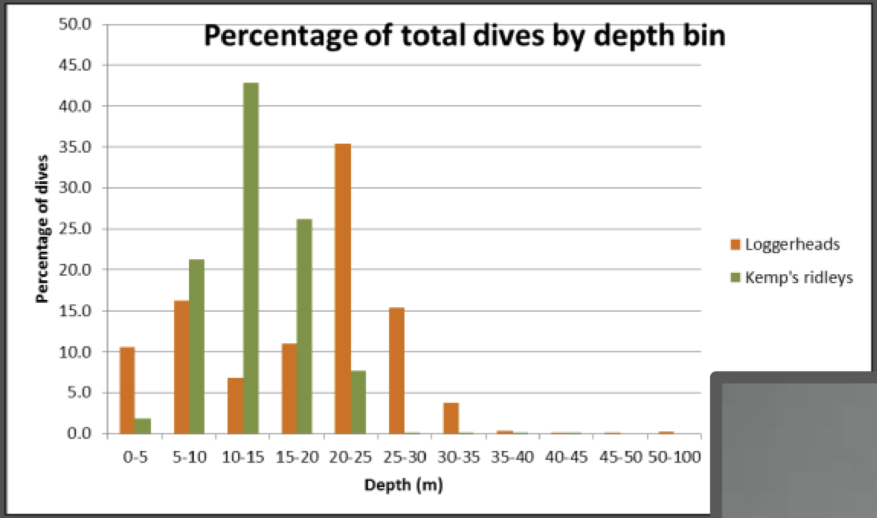


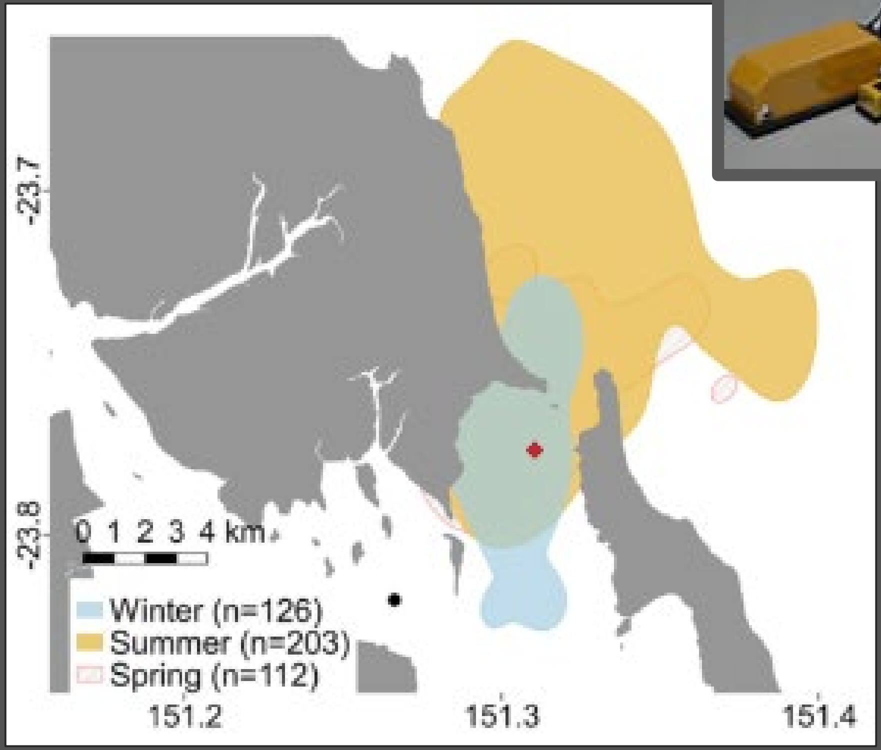


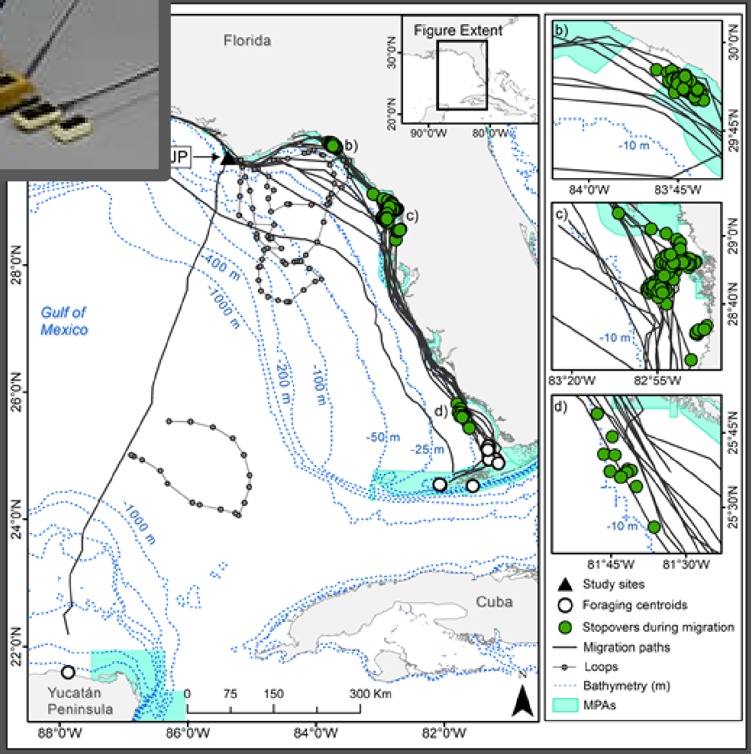


Satellite Telemetry

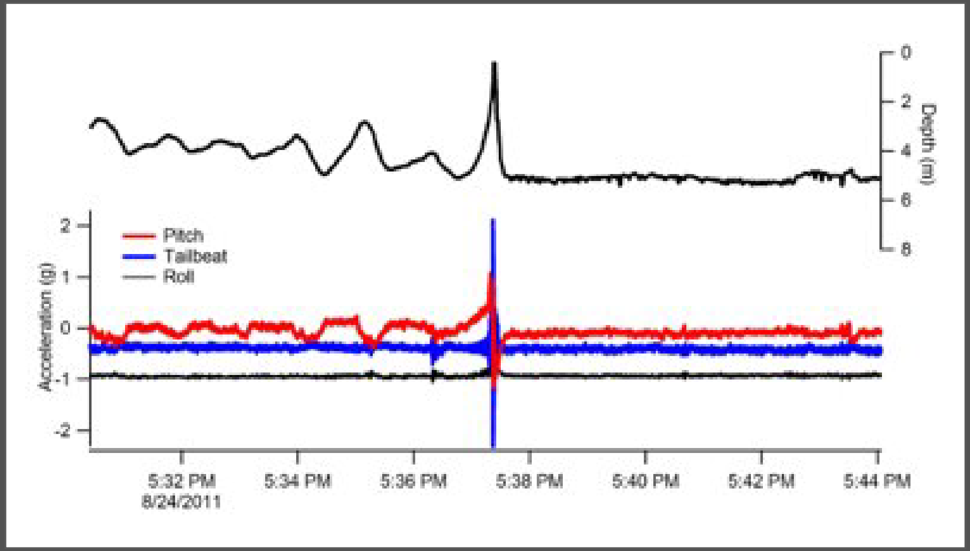
- Supplementing radio telemetry
- Smallest tag now 2 grams
- Multiple types with different constellations
  - Argos
  - Iridium
- Additional sensors
  - GPS fixes between satellite passes
  - Temperature
  - Depth
  - Light
- Trade-offs:
  - Requires surfacing
  - Location quality varies
  - Shorter battery life

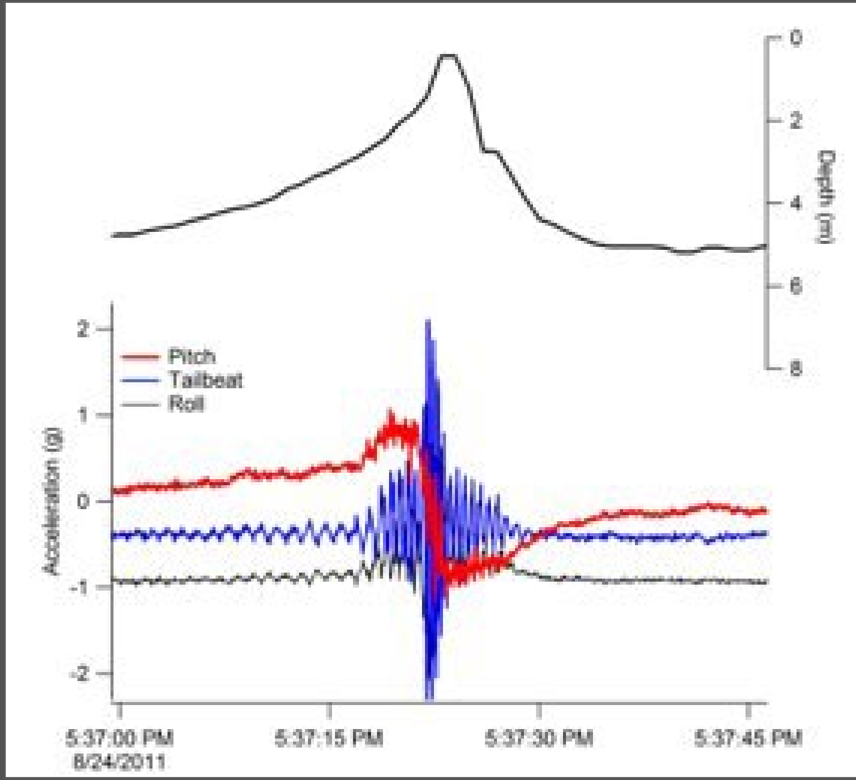




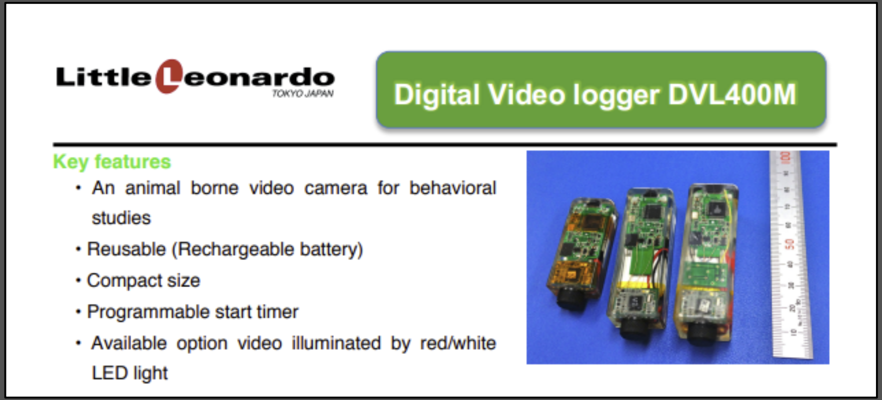


Logging Tags





- Environmental
  - Temp
  - Depth
  - Heading
  - Salinity
  - Velocity
- Positional
  - Heading
  - Velocity
  - Accelerometer (ADL)
- Nearby acoustic tags
  - CHAT tags detect other tags



Little Leonardo TOKYO JAPAN

Digital Video logger DVL400M

Key features

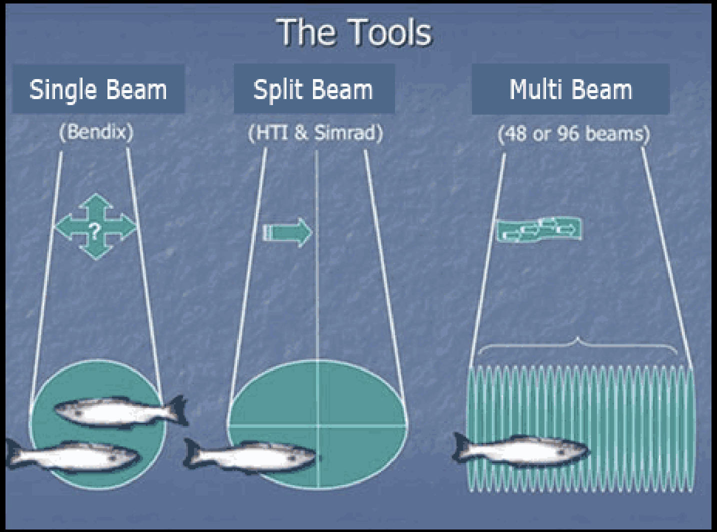
- An animal borne video camera for behavioral studies
- Reusable (Rechargeable battery)
- Compact size
- Programmable start timer
- Available option video illuminated by red/white LED light

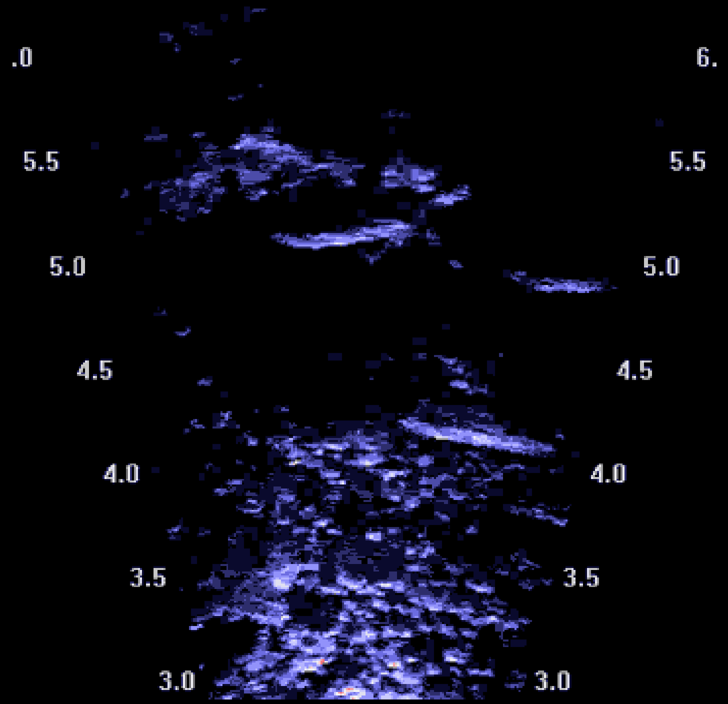
Cameras

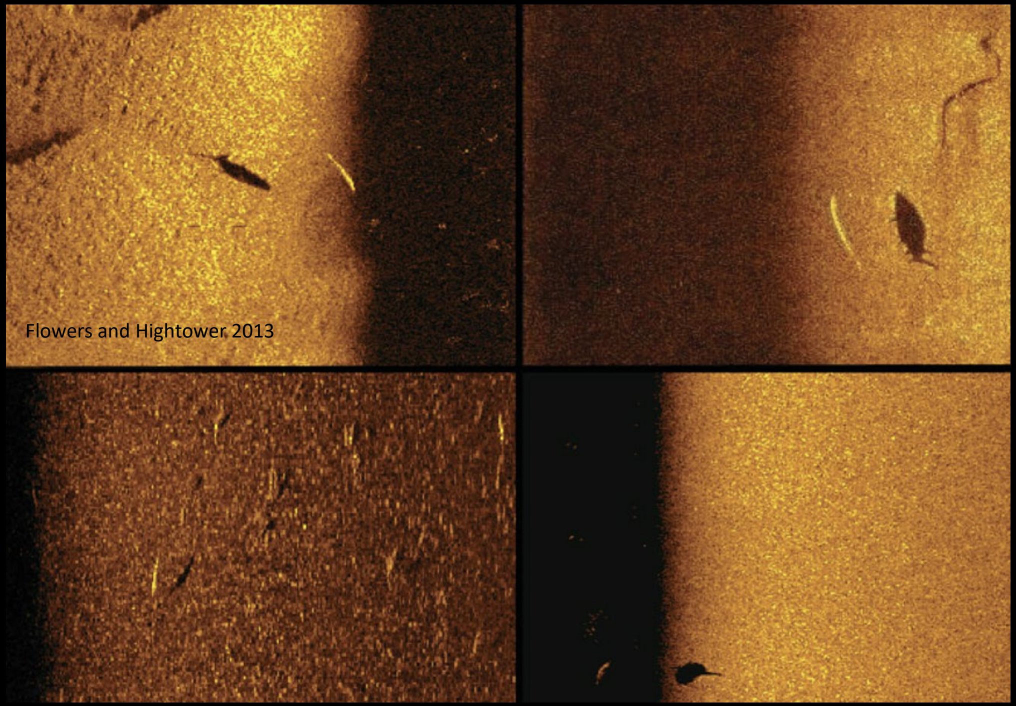
- Set Location (camera traps)
- Animal Mounted (critter cams)
- Short battery life
- Requires recovery

Sonar

- Single/split beam
- Multi-beam
- Acoustic cameras
  - ARIS
  - DIDSON
- Sidescan
- Used to detect animals
- Works in murky water and at night
- Larger swept area than video

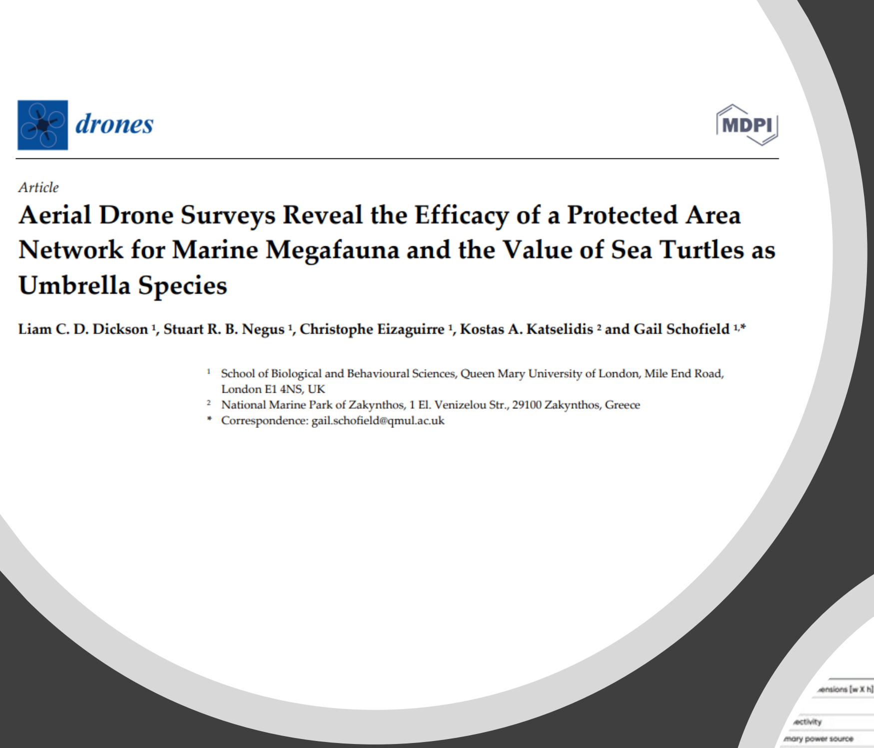





Flowers and Hightower 2013

Drones and Floats

- Surface
    - Waveglider
    - Saildrone
    - Spotter
- Submerged
    - Argo floats
    - Slocum gliders
    - AUV’s
- Can be roaming acoustic receivers or downloaders
- Fixed location, set course, or drifters


drones — MDPI

Article

Aerial Drone Surveys Reveal the Efficacy of a Protected Area Network for Marine Megafauna and the Value of Sea Turtles as Umbrella Species

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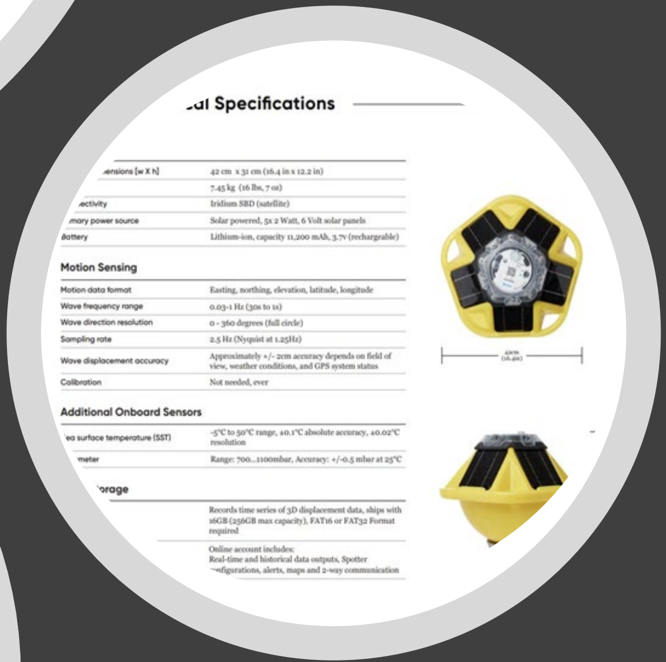

…al Specifications

…ensions [w X h]	42 cm x 31 cm (16.4 in x 12.2 in)
	7.45 kg (16 lbs, 7 oz)
…ectivity	Iridium SBD (satellite)
…mary power source	Solar powered, 5x 2 Watt, 6 Volt solar panels
Battery	Lithium-ion, capacity 11,200 mAh, 3.7v (rechargeable)

Motion Sensing

Motion data format	Easting, northing, elevation, latitude, longitude
Wave frequency range	0.03-1 Hz (30s to 1s)
Wave direction resolution	0 - 360 degrees (full circle)
Sampling rate	2.5 Hz (Nyquist at 1.25Hz)
Wave displacement accuracy	Approximately +/- 2cm accuracy depends on field of view, weather conditions, and GPS system status
Calibration	Not needed, ever

Additional Onboard Sensors

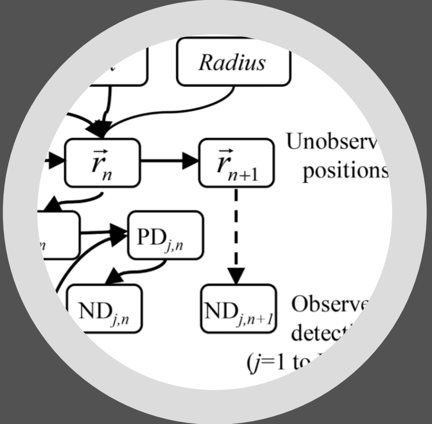
…ea surface temperature (SST)	-5°C to 50°C range, ±0.1°C absolute accuracy, ±0.02°C resolution
…meter	Range: 700...1100mbar, Accuracy: +/-0.5 mbar at 25°C

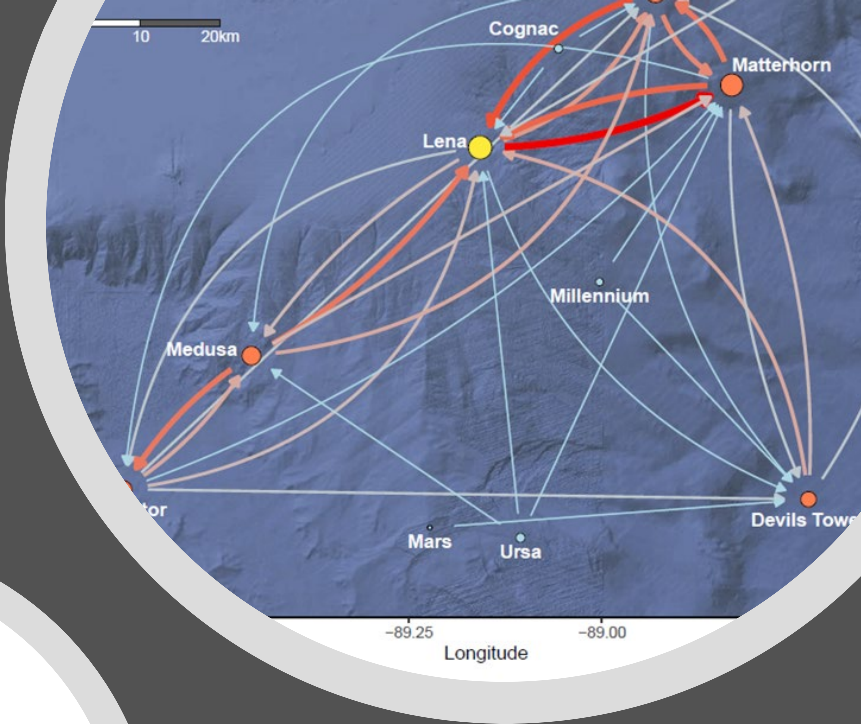
…orage

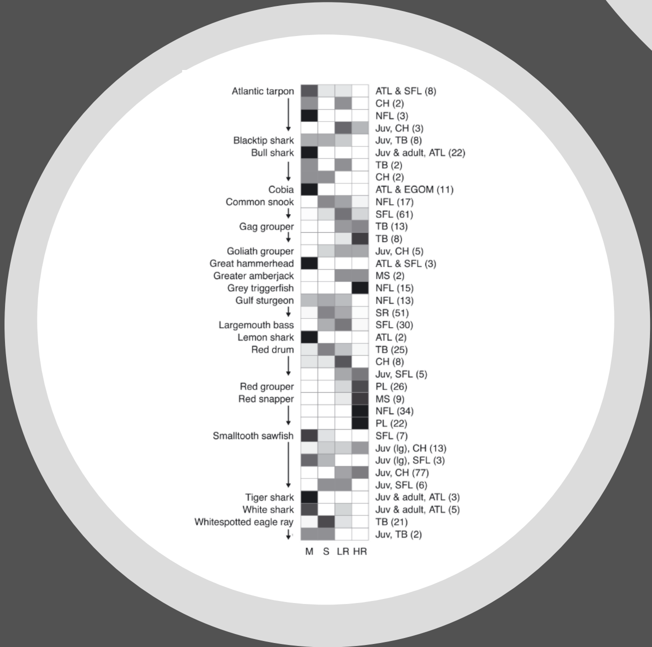
	Records time series of 3D displacement data, ships with 16GB (256GB max capacity), FAT16 or FAT32 Format required
	Online account includes: Real-time and historical data outputs, Spotter …nfigurations, alerts, maps and 2-way communication

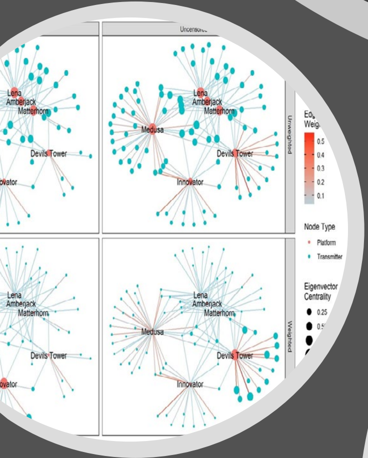
Improved Analyses

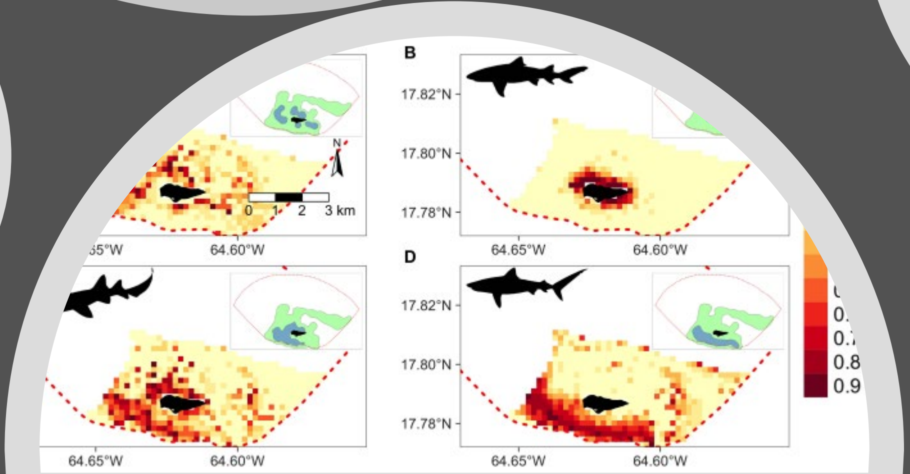
- Advances in technology lead to "big data"
- Easily process in new programs with improved computing ability
- Bayesian statistics
- Machine learning techniques
- Network analysis

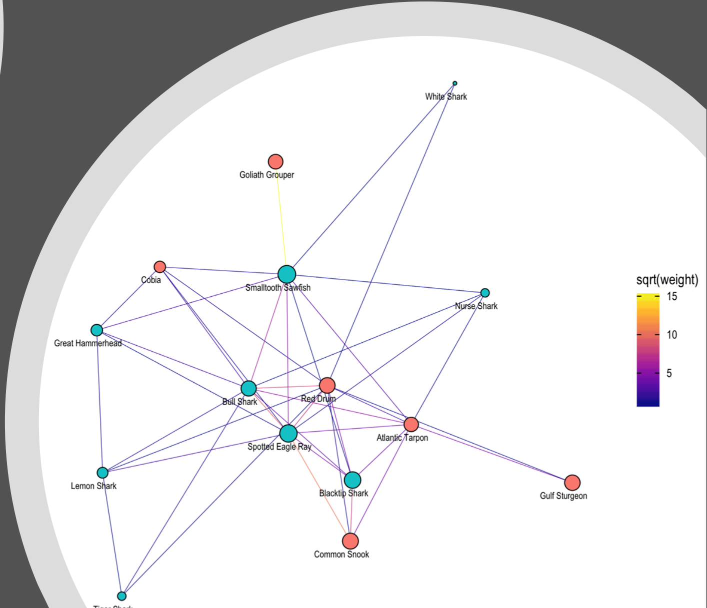






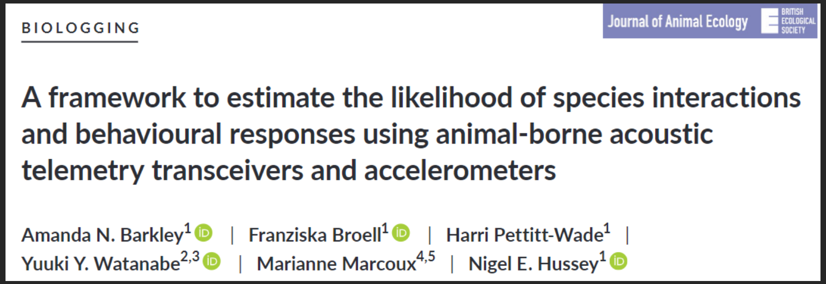






Futurecasting

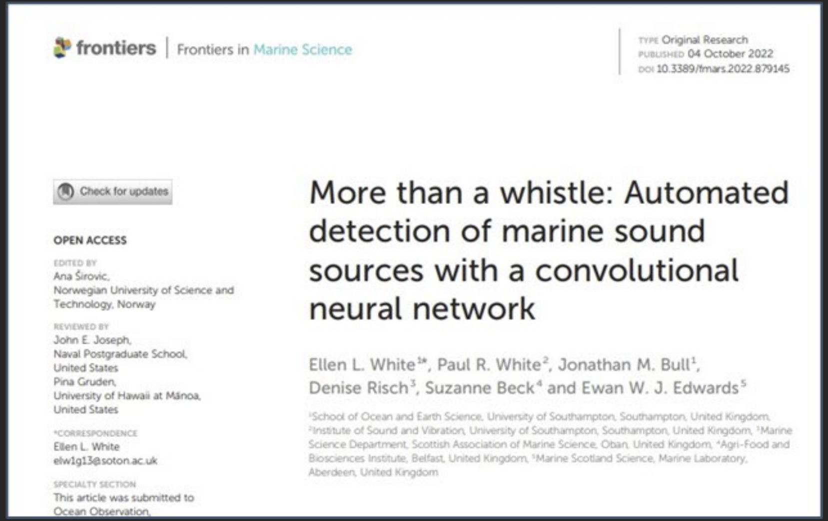
- Integration
  - multiple tag types combined: acoustic tag/sat tag, ADL/PSAT/acoustic tag, sonar/acoustic, etc
- Multi-sensor/modular
  - tags and lab-on-a-chip sensors (environmental DNA)
- Very large scale- lots of receivers/ sensors (small, cheap, fast).
- Swarms of autonomous mobile receivers/sensors in self-creating networks (underwater, surface, aerial). New satellite constellations used (Starlink)
- Reporter tags (animal:animal, animal:receiver)
- Automated with artificial intelligence (as in Birdnet)
- Fiber optic cables as detectors (Passive Acoustic location/ID)


BIOLOGGING

Journal of Animal Ecology | BRITISH ECOLOGICAL SOCIETY

A framework to estimate the likelihood of species interactions and behavioural responses using animal-borne acoustic telemetry transceivers and accelerometers

Amanda N. Barkley[1] | Franziska Broell[1] | Harri Pettitt-Wade[1] | Yuuki Y. Watanabe[2,3] | Marianne Marcoux[4,5] | Nigel E. Hussey[1]


frontiers | Frontiers in Marine Science

TYPE Original Research
PUBLISHED 04 October 2022
DOI 10.3389/fmars.2022.879145

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SPECIALTY SECTION
This article was submitted to Ocean Observation,

More than a whistle: Automated detection of marine sound sources with a convolutional neural network

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ORIGINAL RESEARCH article

Front. Mar. Sci., 05 July 2022
Sec. Ocean Observation
https://doi.org/10.3389/fmars.2022.901348

Eavesdropping at the Speed of Light: Distributed Acoustic Sensing of Baleen Whales in the Arctic

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Gulf of Mexico challenges

- No strong central actor (ex: GLATOS – Great Lakes)
- Acoustic telemetry weakly integrated through volunteer network (iTAG) facilitated by FWCC
- No similar structure for satellite tagging – Animal Telemetry Network (ATN)?
- Data storage for environmental data (GCOOS, SECOORA), but no easy linkage between animal data and environmental data – and limitations based on locations

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Questions?