

Monitoring Salmon in Coastal and Open Ocean Environments

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Wildlife Computers

BECI Workshop 3:
Technology and Tools for Monitoring and Synthesis
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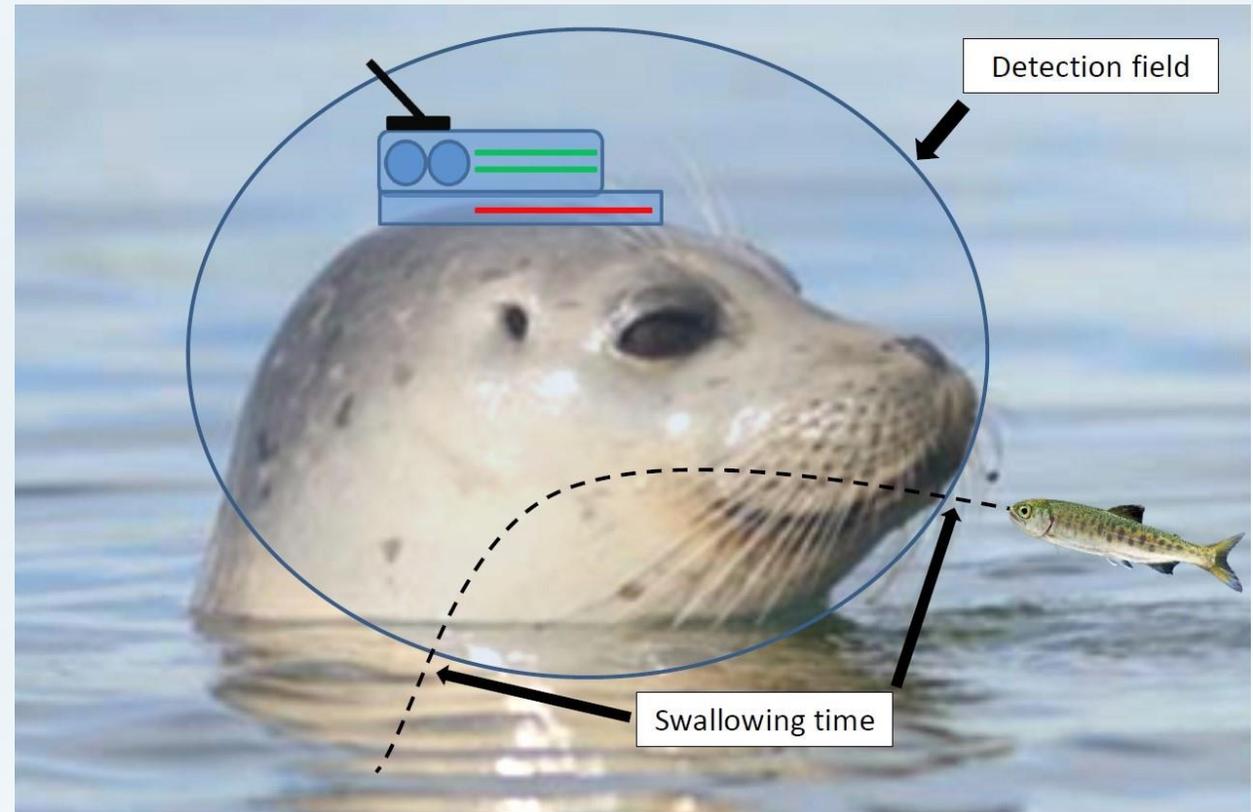
Studying salmon beyond their natal streams

- Historically, fishery catch sampling and mark-recapture tagging studies provided information on salmon at sea
- Most salmon tagging and tracking has been conducted in inland and coastal waterways with little known of salmon ocean ecology
- Tagging studies have evolved with technology
 - Conventional tags, coded wire, and visible implant tags
 - Radio tags
 - Acoustic tags
 - PIT tags
 - Archival tags
 - Satellite-linked archival tags



Combining technologies to track interspecies interactions

- Animal-borne PIT tag reader
 - Argos transmitter
 - Accelerometer
 - RFID Reader



Thomas et al. 2014. AFS 144th Annual Meeting

Recent developments in fish tracking

- Miniaturization of popup satellite tags
- Improving accuracy of light-based geolocation
- New telemetry technologies
 - Evolving low-power satellite constellations
 - Land-based gateways
- ROAM (RAFOS Ocean Acoustic Monitoring)

Miniaturization of popoff archival tags: microPAT



Leveraging off commercially-available low-power electronics

	Length	Max Dia	Air Weight	Water Weight
PAT5	175	42	78	-7
MiniPAT	124	39	61	-7
mrPAT	125	28	46	-6
microPAT	92	33	45	-4
X-Tag	117	33	46	-1.4



microPAT Features

P
R
I
O
R
I
T
Y

Minimize harm or behavioral change due to tag

Release when required (and not before)

Transmit after release, whether floating or on land

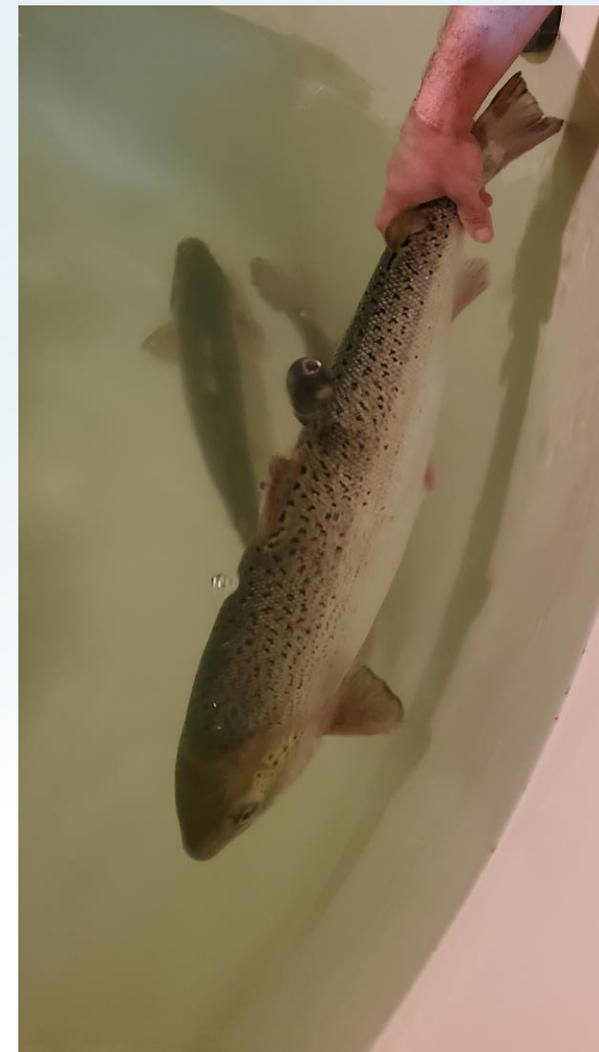
Provide release location and reason

Horizontal track while attached

Information about behavior

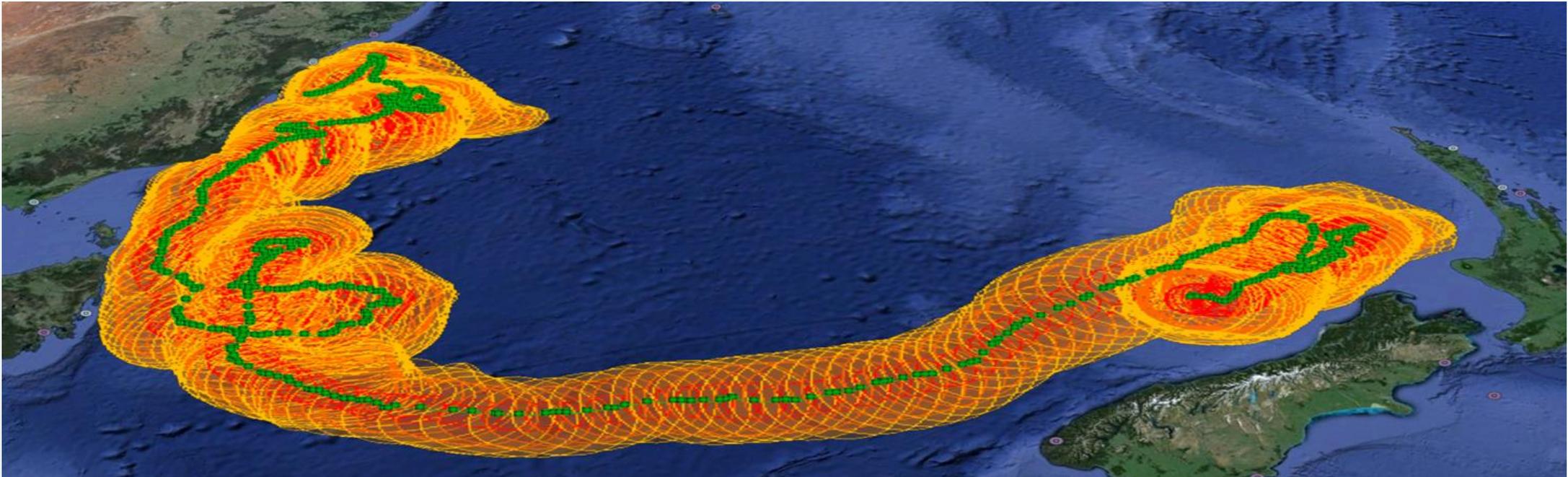
Information about the environment

Saddle attachment of a microPAT to a trout



Likelihood Position estimates using HMMs and complementary known data

- Observational data: depth, temperature, magnetism
- Locations with little error: Fastloc® GPS, Argos, acoustic detections, visual observations



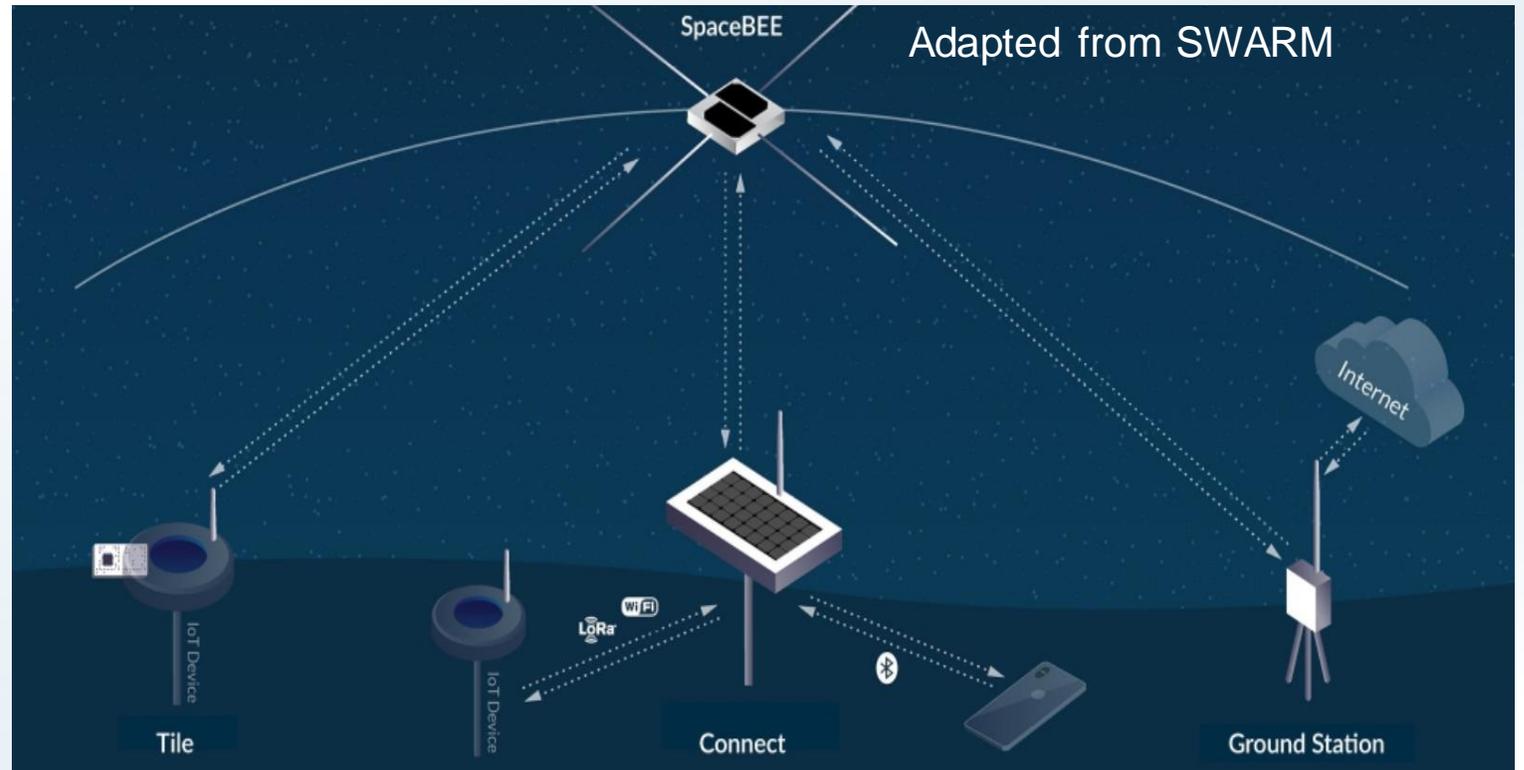
Satellites and more satellites



Argos historically has been the primary satellite system for marine animal studies

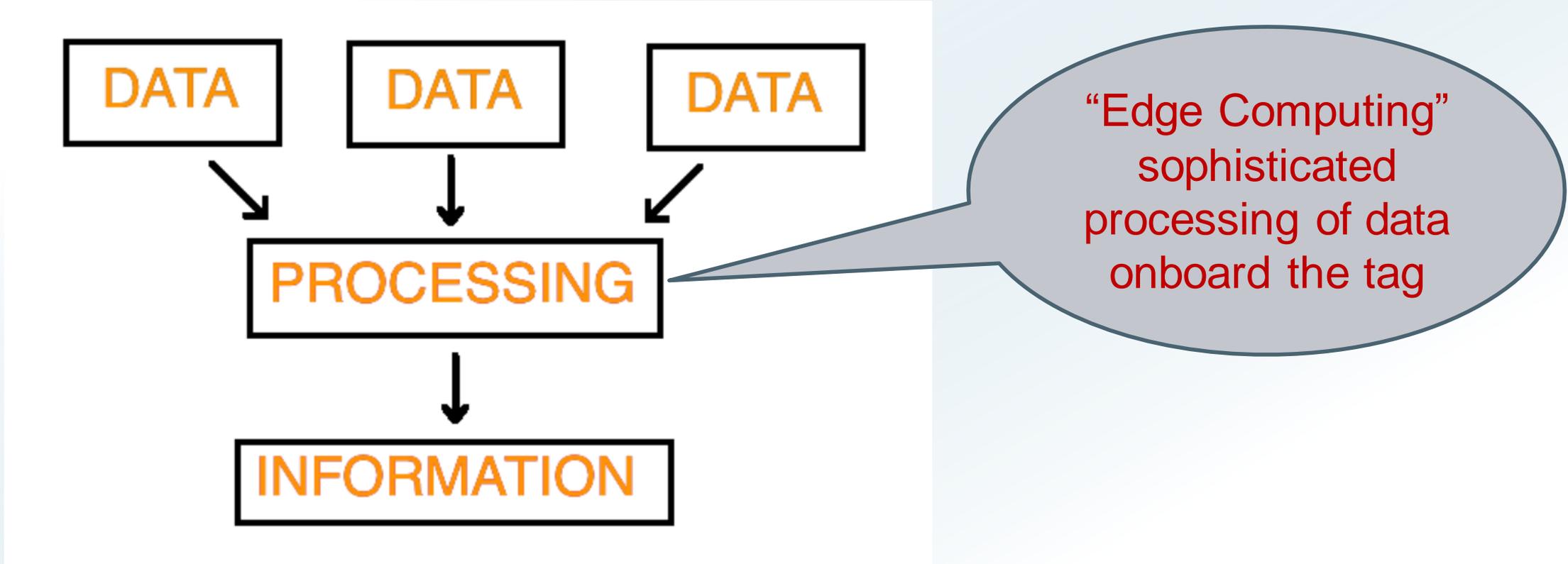
- Global coverage – especially over the oceans
- Supports low-power transmitters
 - Size and weight of the package must be as small as possible to limit impact on animal behavior
- Does not require lengthy handshakes – marine animals surface time may be 1 second or less
- However, data throughput is limited to a maximum of 31 bytes per transmission, and satellite coverage is dependent upon latitude

IoT – Internet of Things



- Explosion of new communication technologies with the potential for animal tracking applications
- Together, IoT and Edge Computing are a powerful way to rapidly analyze data in real-time.
- Cloud data storage and delivery to personal computers worldwide

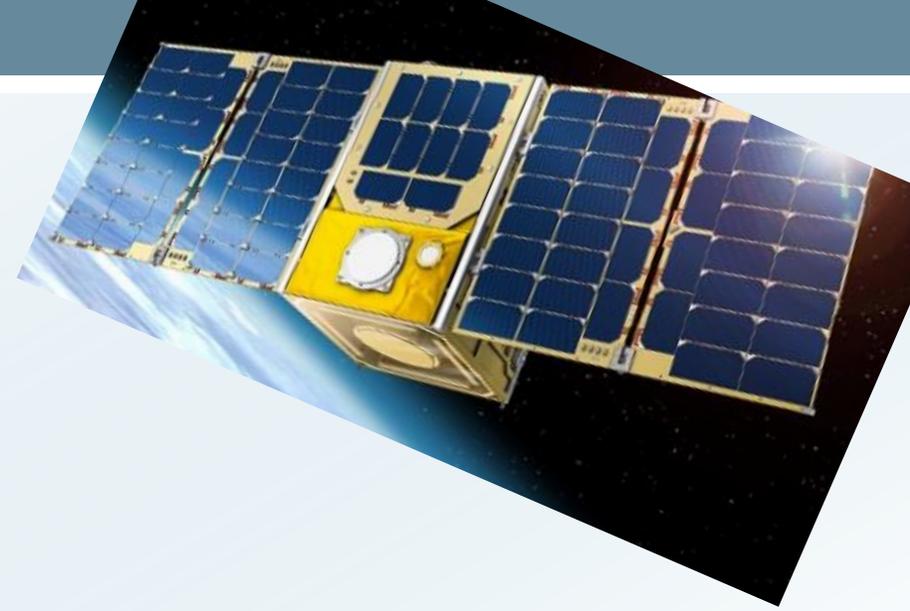
Tags have been doing Edge Computing for decades



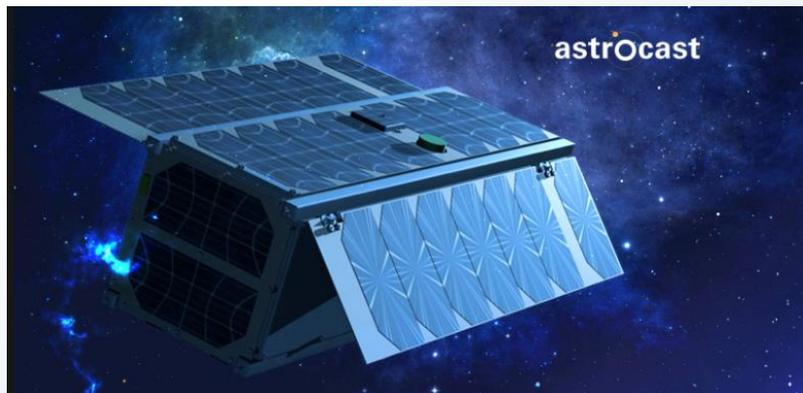
Leverage emerging technology for more powerful onboard deterministic and AI/ML algorithms

Smallsat Constellations

- Small size ~ as small as 10x10x10 cm
- Low cost ~ \$100K to build and launch
- Large number of development initiatives: Astrocast, Lacuna Space, ELO, Fleet Space, Hiber, ICARUS,, Myriota, Sky and Space, Swarm
- Many with small, low power, open source chips
- Kinéis/CLS – Argos-compatible



Astrocast and Lacuna Space are nearing operational status



Argos is evolving

WE'RE LAUNCHING KINÉIS'
ENTIRE CONSTELLATION

5
LAUNCHES

25
SATELLITES



008 x 544

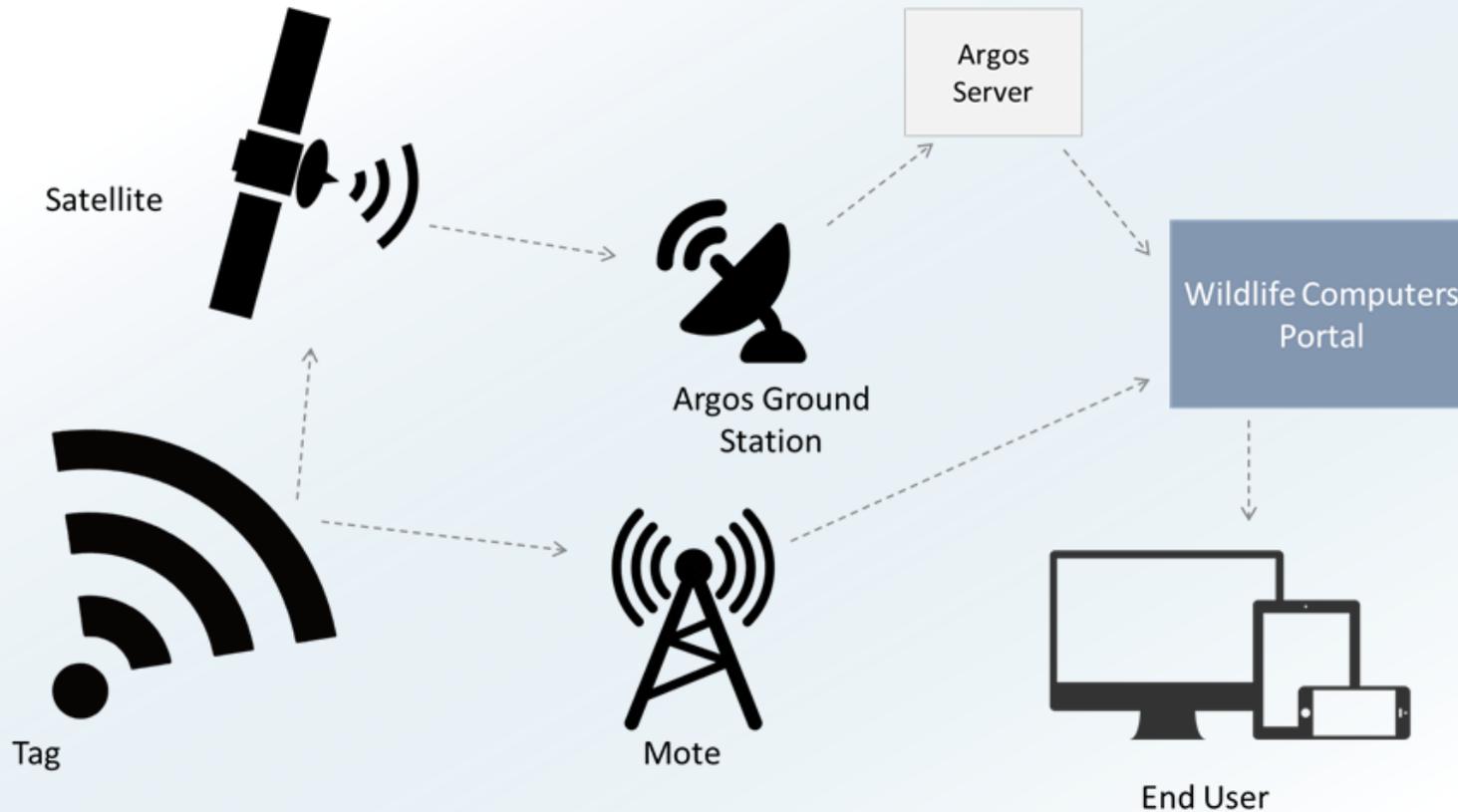
LAUNCHING 2023

Constellation Argos/Kineis

Actuellement... 8 satellites opérationnels



Augment satellite-received messages with Wildlife Computers Motes

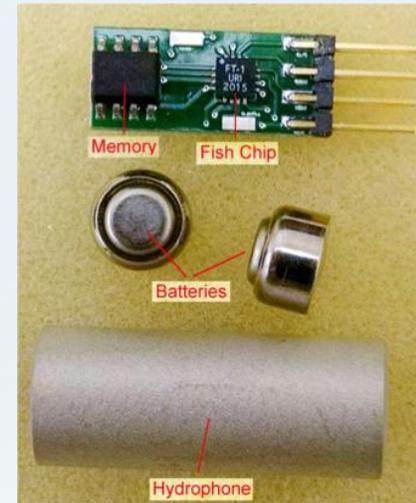


ROAM (RAFOS Ocean Acoustic Monitoring)

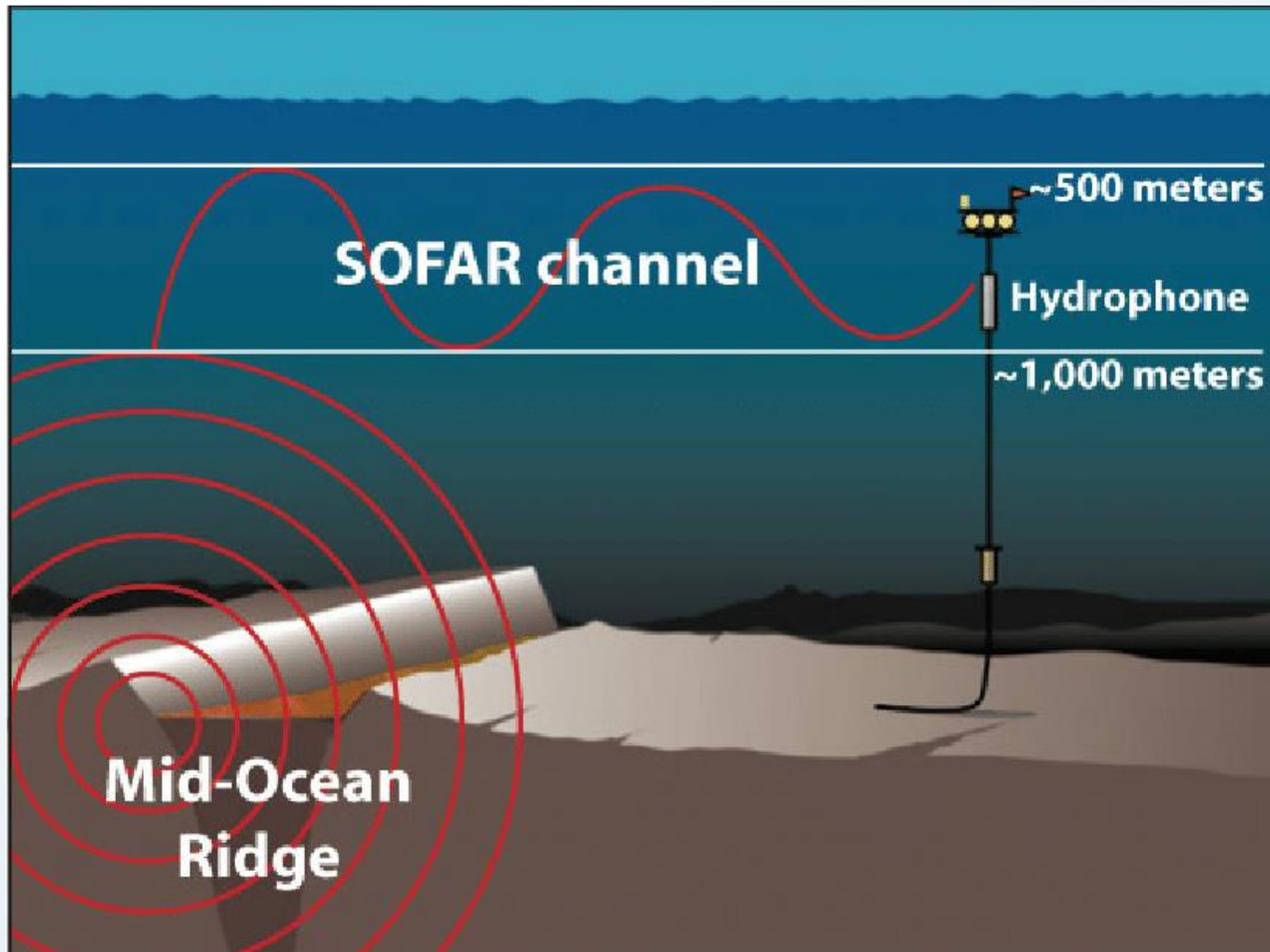


ROAM (RAFOS Ocean Acoustic Monitoring)

- Moored sound sources in ocean (~ 10 yr life)
- Hydrophone incorporated into fish tag
- Acoustic “chirp” detectable at distances up to 1,000 km
- Accurate geolocation via triangulation (<5 km), even at depth
- Concurrent measurements of temperature and depth



New **RAFOS** Ocean Acoustic Monitoring (ROAM) tags have recently been designed to allow tracking of pelagic fishes over large areas

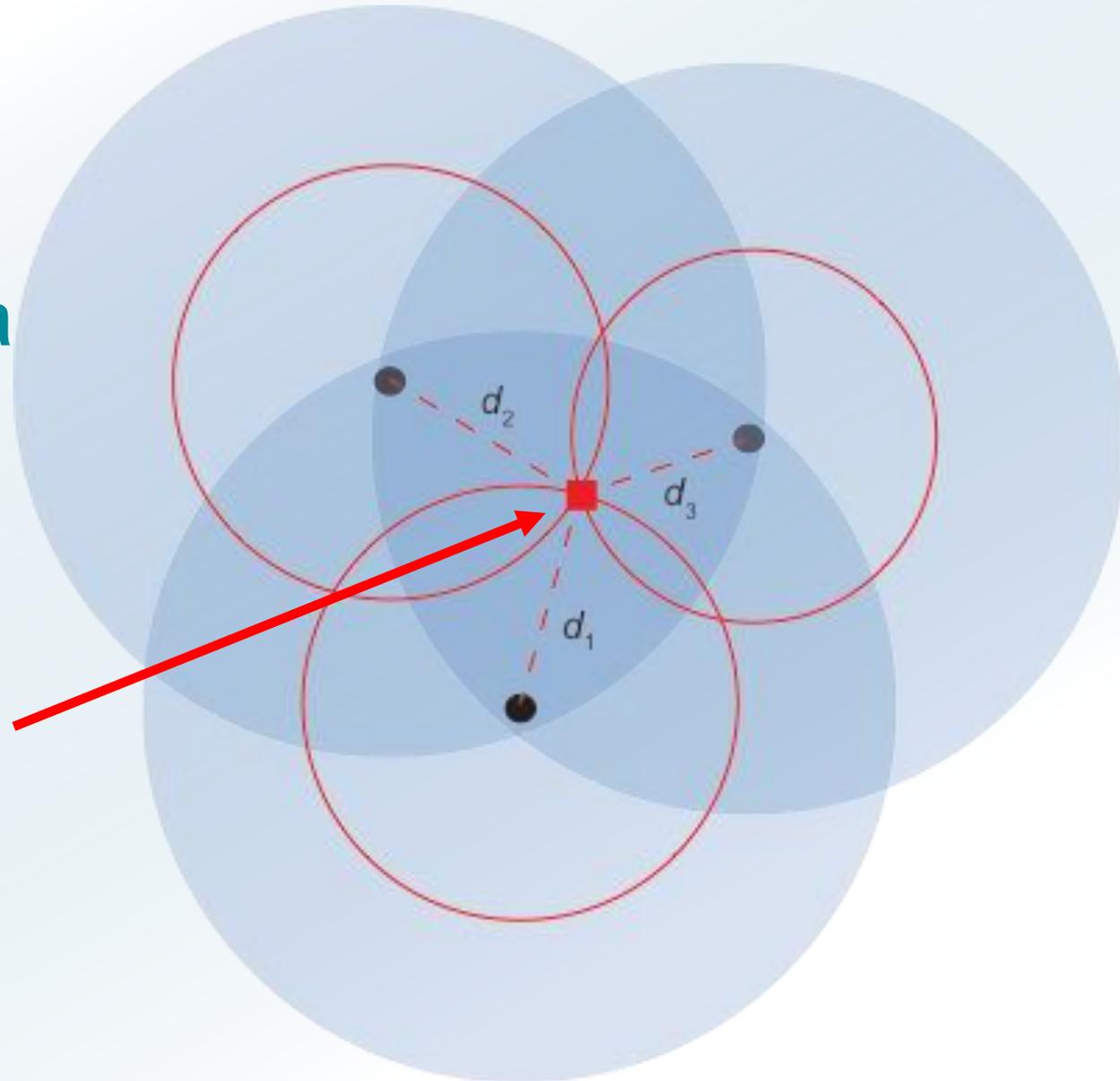


- Moored sound sources in ocean (~ 10 yr life)
- Hydrophone incorporated into fish tag
- Acoustic “chirp” detectable at distances up to 1,000 km
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Three sound sources
can triangulate

Accurate geolocation via
triangulation (<5 km),
even at depth

1 position

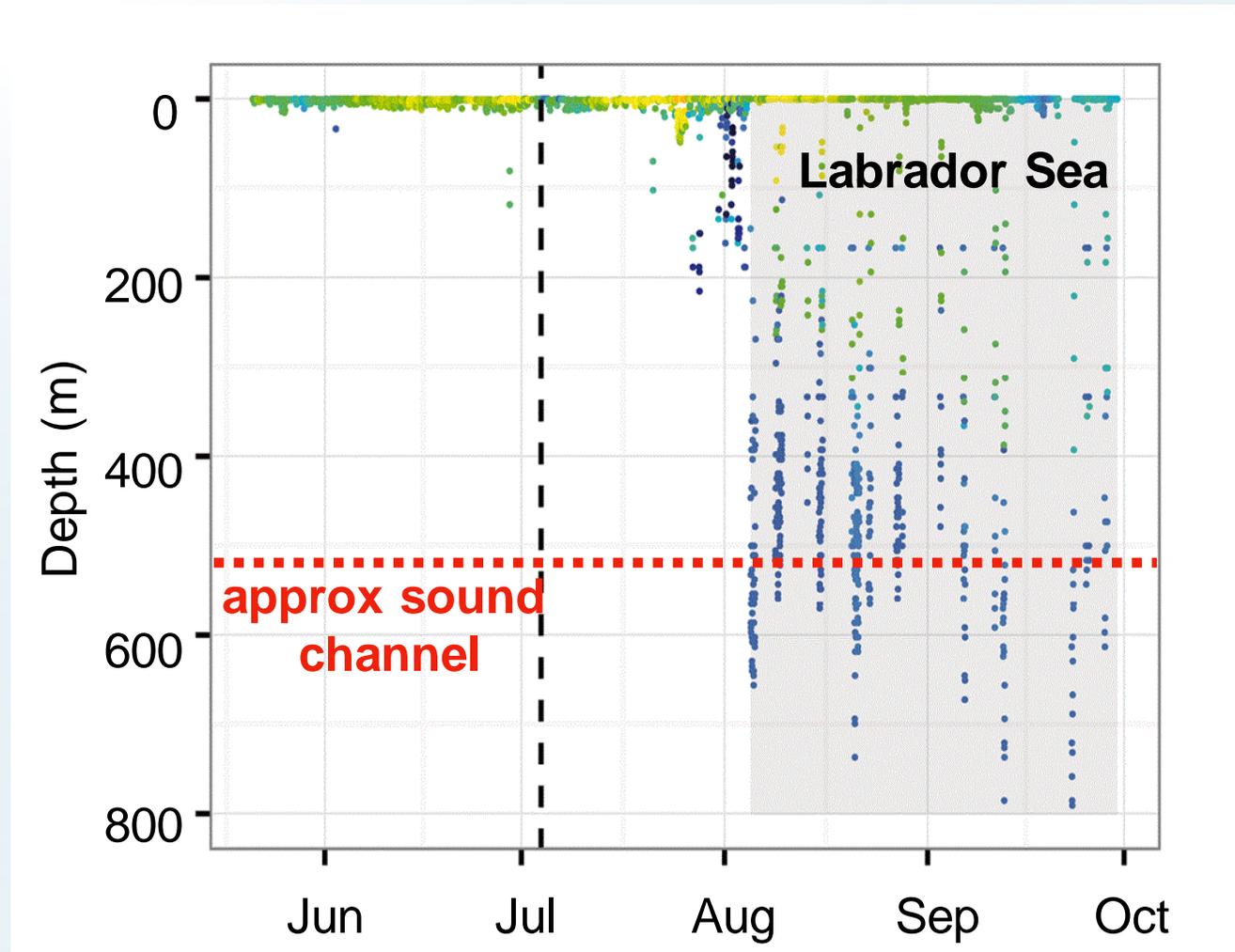


Potential technology for tracking fish



- Trials were done attaching a “tag” to a wave glider
- WHOI team was able to localize the wave glider to within 2 km.
- Sound was received up to 500 km from a source.
- About 2/3 of the eastern seaboard now has sound sources.
- Trials with tags on tunas, swordfish, and/or porbeagle sharks are planned for this summer.
- A proposal has been submitted to install sound sources in the Labrador Sea.

Many tagged salmon dive into the sound channel



Strøm et al. 2017. *ICES J Mar Sci* 74(5):1356-1370.

Acknowledgments

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THANK YOU!

