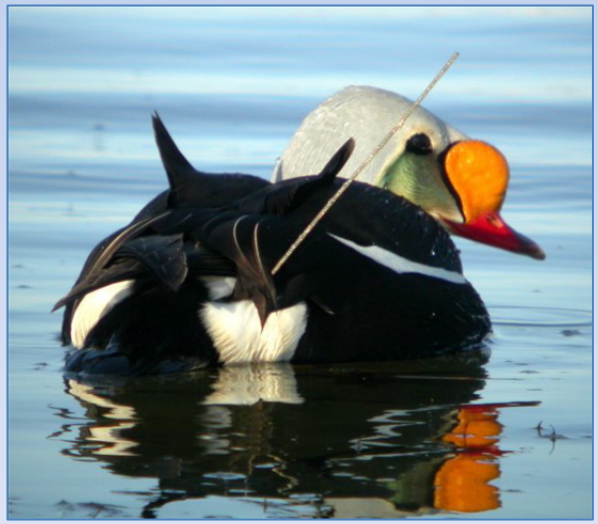
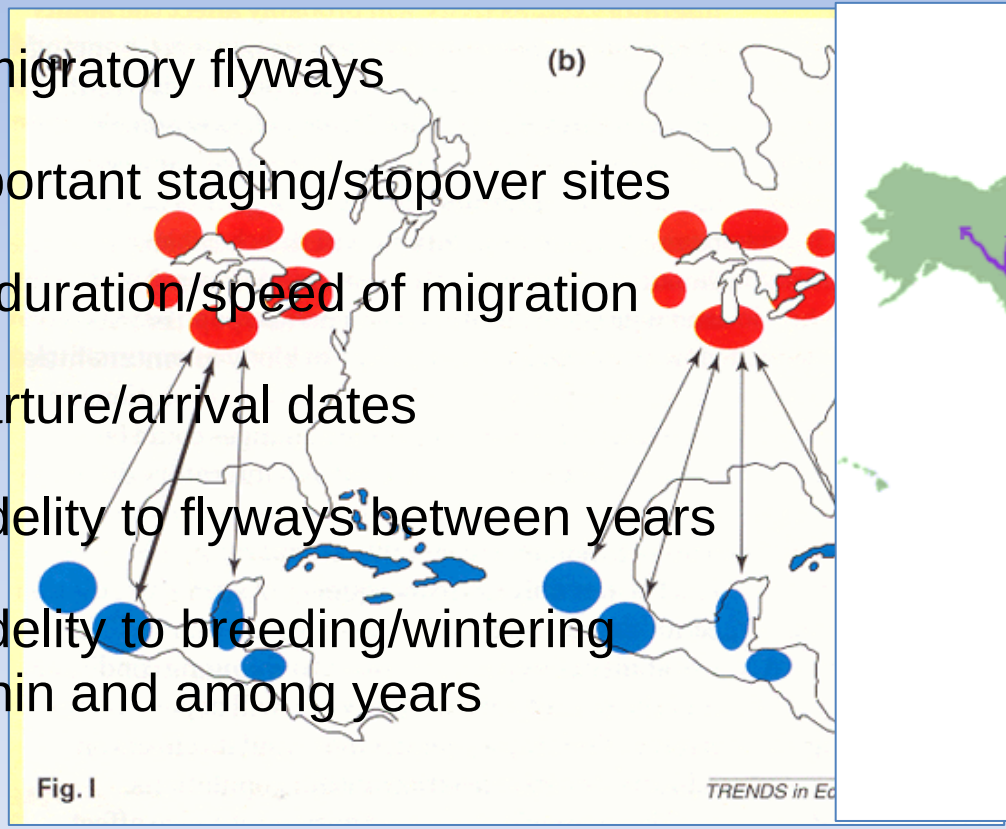
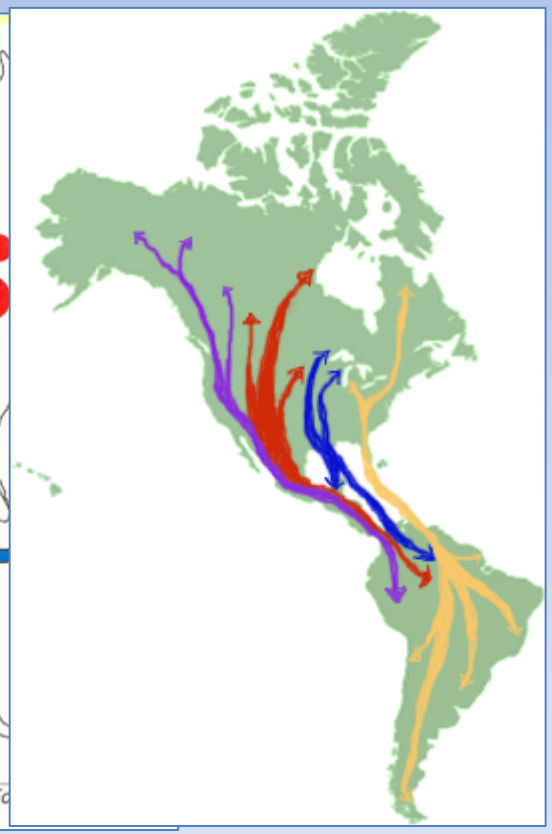
Tracking Avian Movements:
Satellite Transmitters, GPS and Geolocators



Connectivity

- Delineate migratory flyways
- Identify important staging/stopover sites
- Determine duration/speed of migration
- Learn departure/arrival dates
- Examine fidelity to flyways between years
- Examine fidelity to breeding/wintering locations within and among years





To be covered...

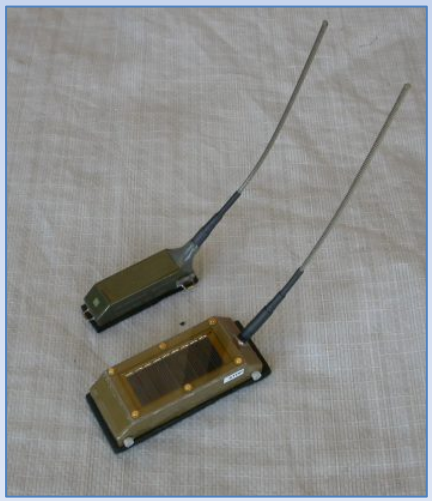
- What are the different tracking methods?
- How do they work?
- What are the costs?
- Pros and Cons of each method
- Compare and Contrast methods
- Which method is best for your question(s)?

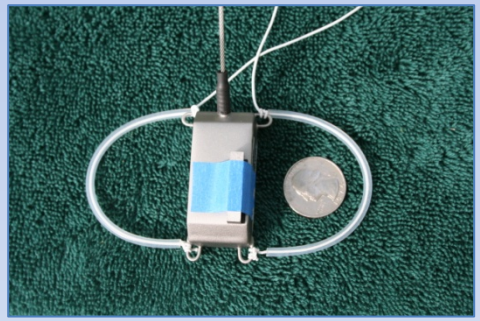
Tracking Avian Movements

- Satellite Transmitters
  - Platform Transmitting Terminals (PTTs)
- GPS Tracking
- Geolocators—Global Location Sensor Systems

Platform Transmitting Terminals (PTTs)

- Radio transmitter system that uses orbiting satellites as receivers
  - Signal: 401.650 MHz ± 30 kHz (with unique id number)





PTT Manufacturers

NORTH STAR
Science and Technology

TELONICS

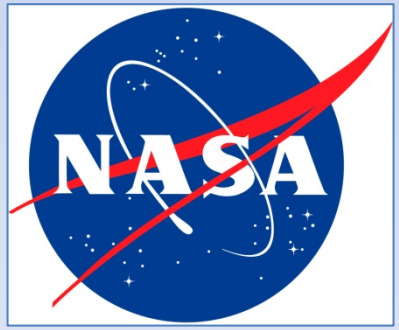
SIRTRACK
WILDLIFE TRACKING SOLUTIONS

Wildlife Computers
Innovative Tags for Innovative Research

LOTEK
WIRELESS
FISH & WILDLIFE MONITORING

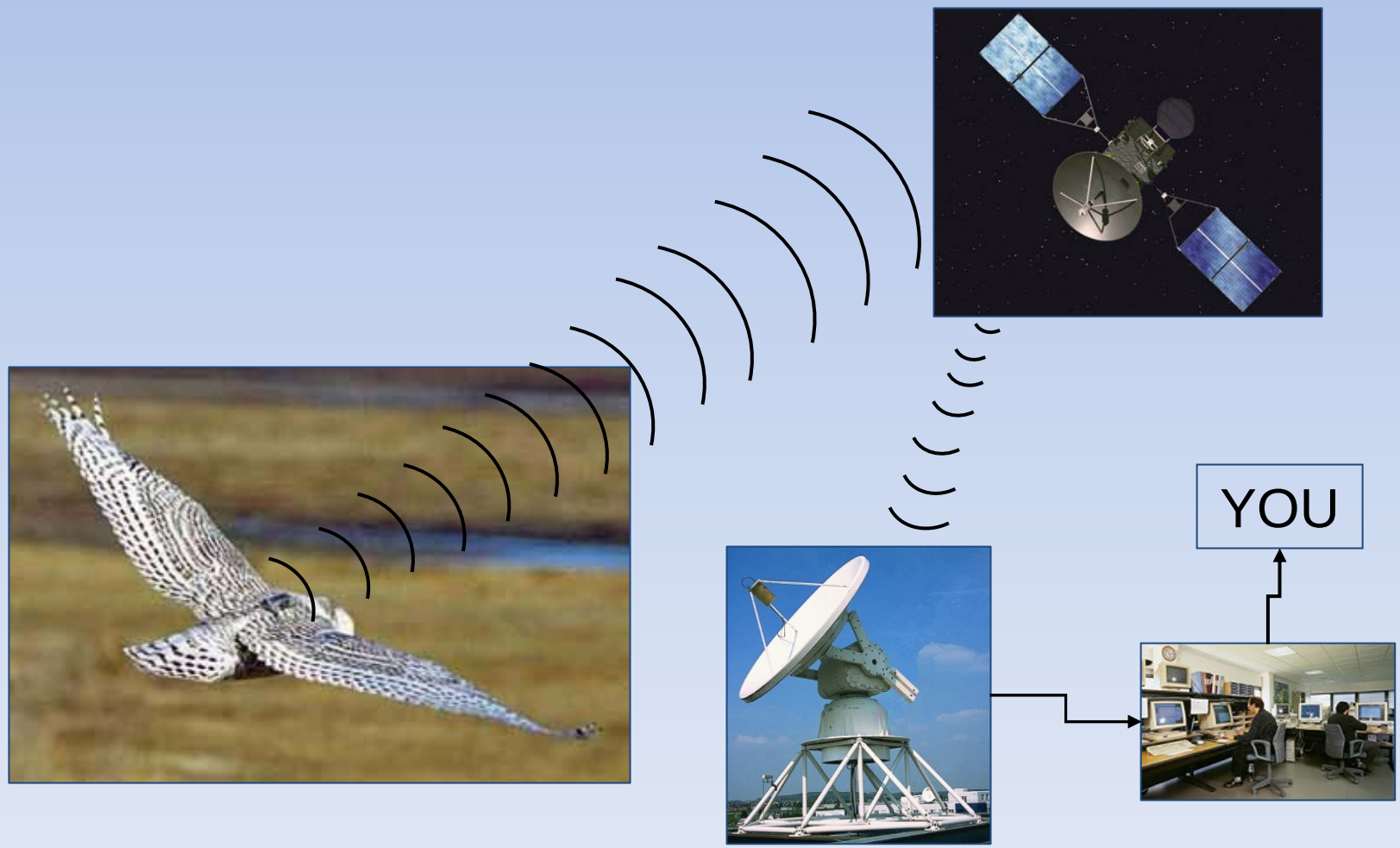
The Argos System

- Advanced Research and Global Observation Satellite
- Global, satellite-based location and data collection system
- Created in 1978, commercialized in 1986
- French-American cooperative
- http://www.argos-system.org/

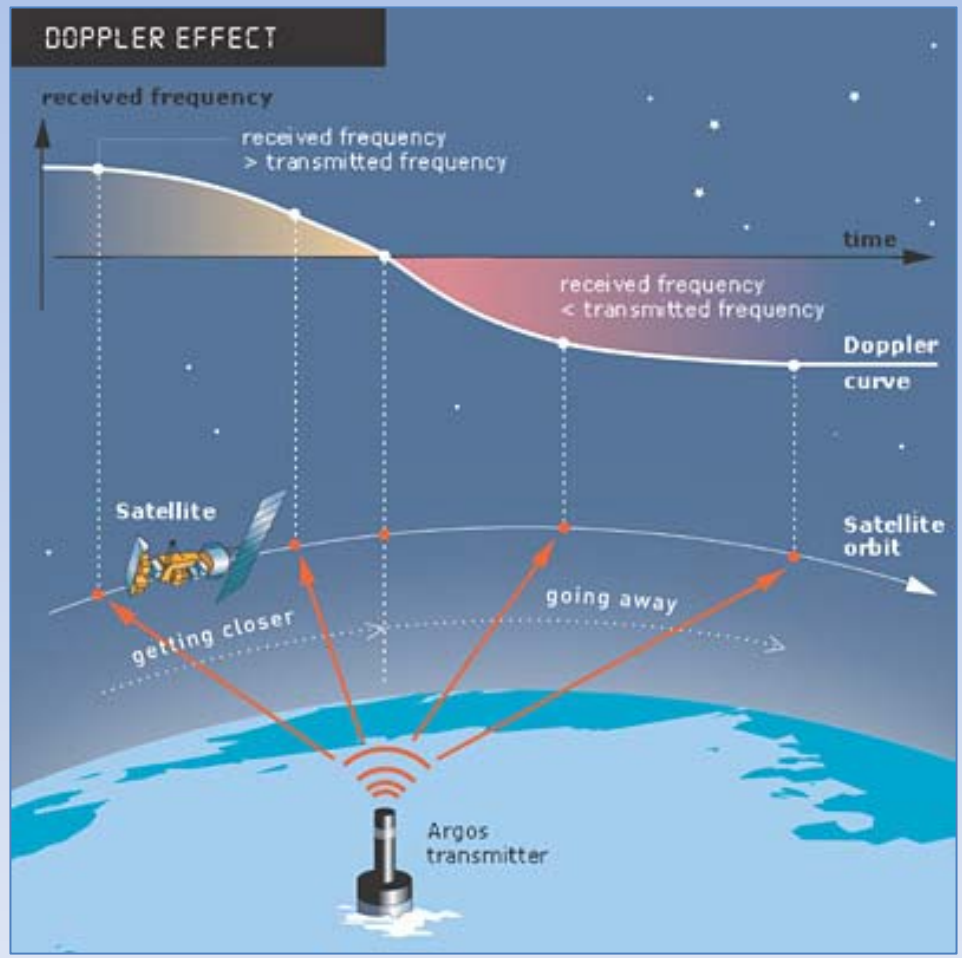


PTTs

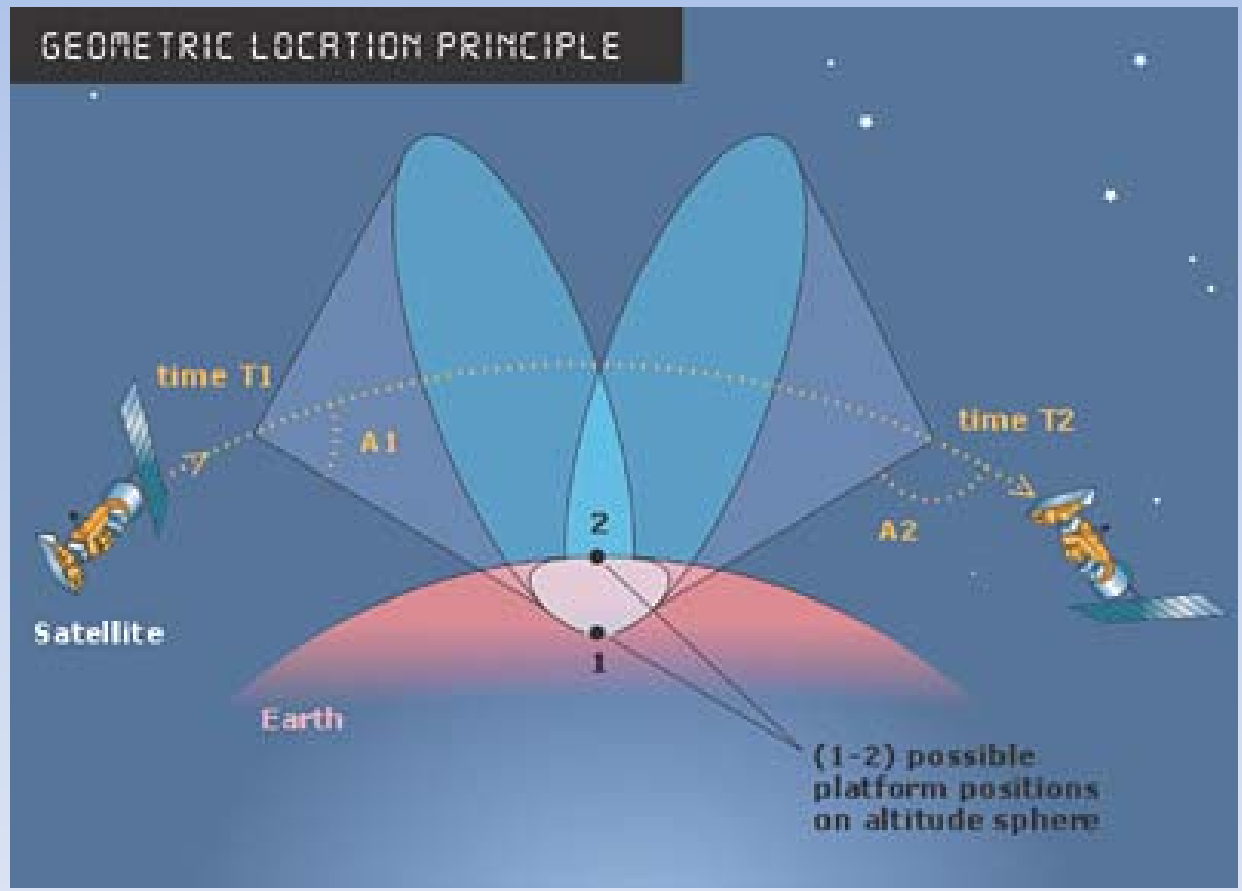
PTTs: How do they work?



PTTs and the Doppler Effect



Location Principle

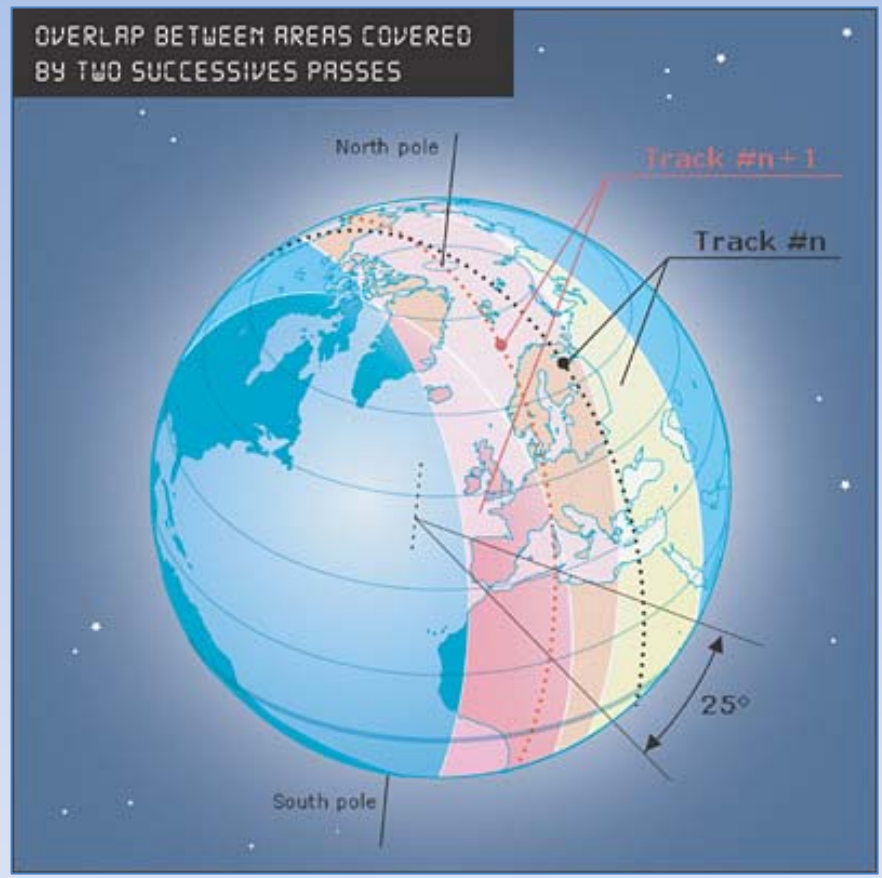


Argos Satellites

- Altitude: 850km
- 5000km diameter footprint
- 10 min per pass

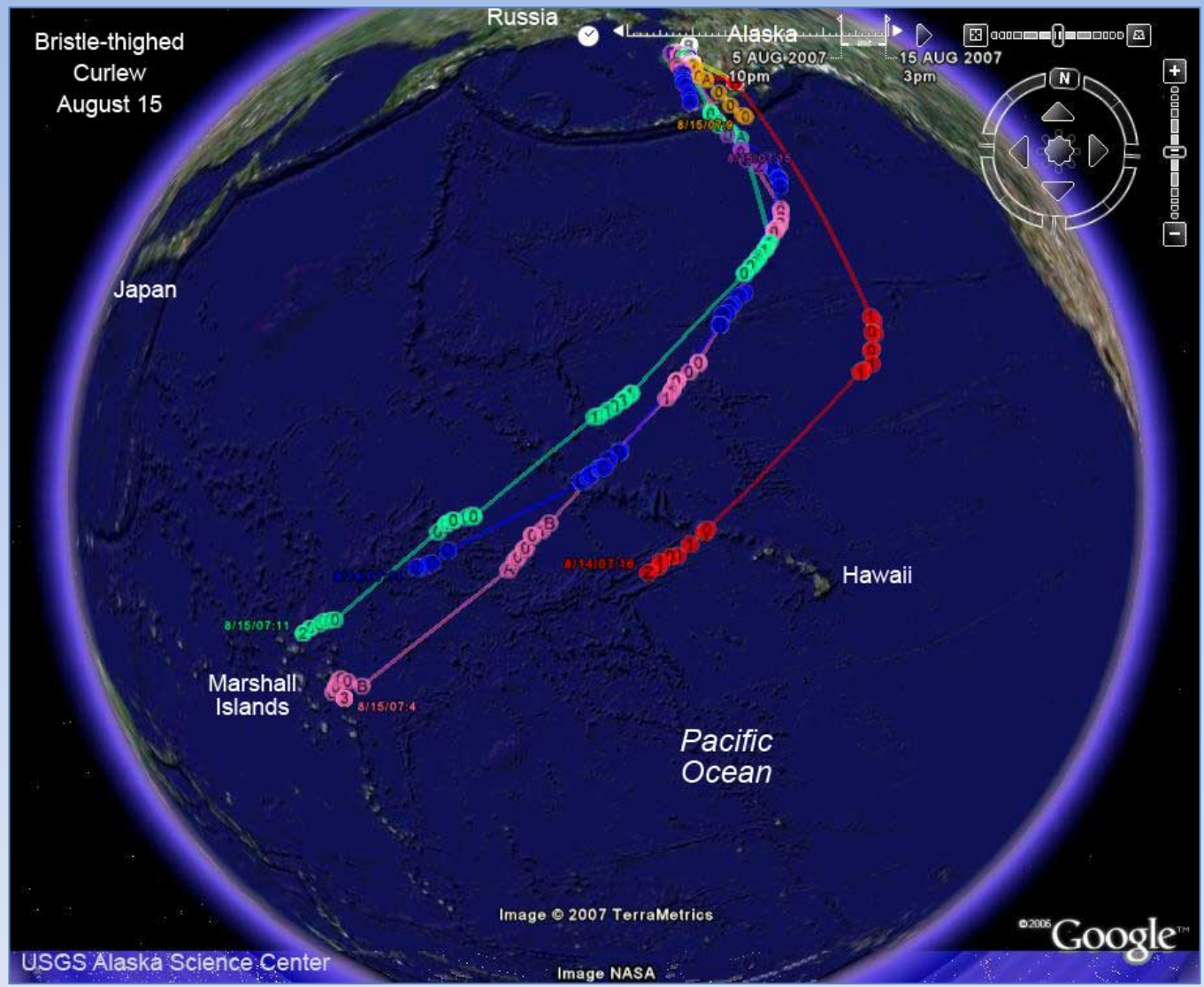
Argos Satellites

- Altitude: 850km
- 5000km diameter footprint
- 10 min per pass
- Polar orbit
- 1 revolution: 100 min
- Coverage increases with latitude
- Increase transmission time near equator



Duty Cycles

- Transmission schedule
  - How many hours/day the PTT sends signals to satellites
- Important for two reasons
  1) How often data are captured
  2) Preservation of battery life/recharging
- Combination of on/off cycles
  - Eg. 10h on /24h off
    8h on/18h off
    8h on/120h off


Bristle-thighed
Curlew
August 15
Russia
Alaska
5 AUG 2007
10pm
15 AUG 2007
3pm
Japan
Hawaii
Marshall
Islands
Pacific
Ocean
8/15/07:11
8/14/07:16
8/15/07:4
Image © 2007 TerraMetrics
USGS Alaska Science Center
Image NASA
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PTT Costs

- PTT: $2500 – $3500 USD per unit
- Tracking costs: $85 – $130 USD per unit per month

- 6 PTTs for 12 months = $21,120 – $30,360 USD

PTT Attachment

- External
  - Leg-loop harness
  - Backpack
  - Neck collar
  - Leg band
  - Patagial tag
- Internal

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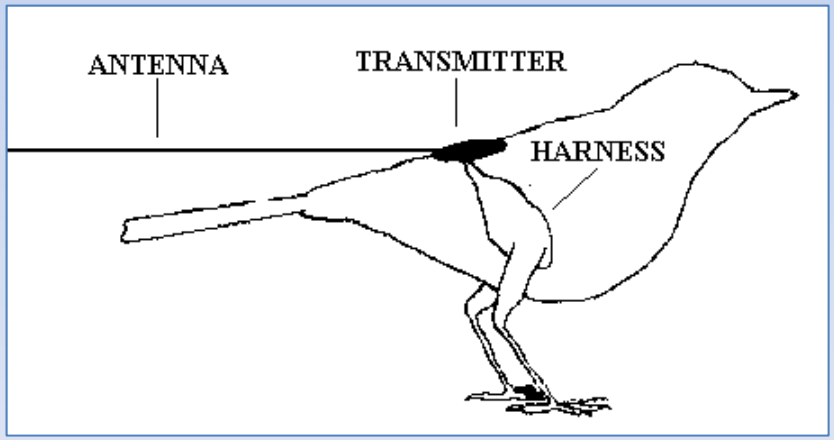

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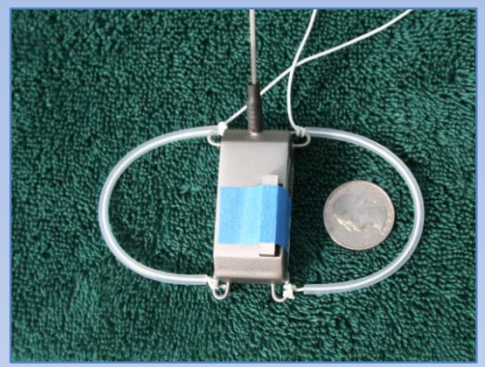
Solar vs. Battery



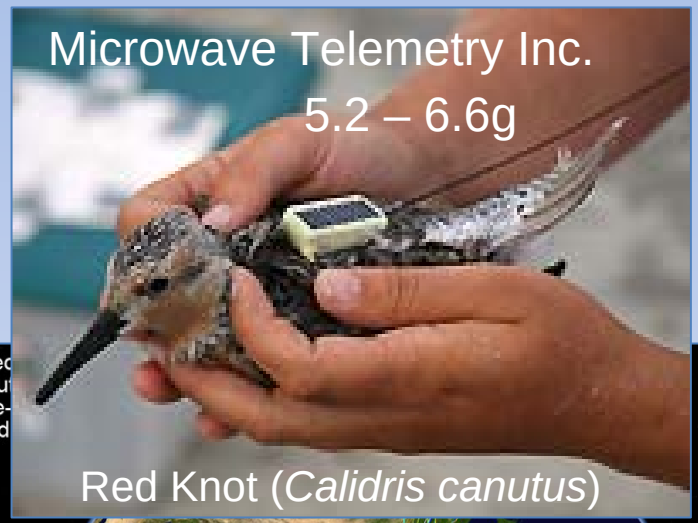
- Attachment:
  - Internal (battery) or external (battery or solar)
- How long do you intend to track individuals?
- Habitat/behavior limiting solar recharging
- Weight: Solar < Battery
  - Eg. Microwave Telemetry
    - Lightest battery powered PTT: 20g
    - Lightest solar powered PTT: 9.5g

Checklist

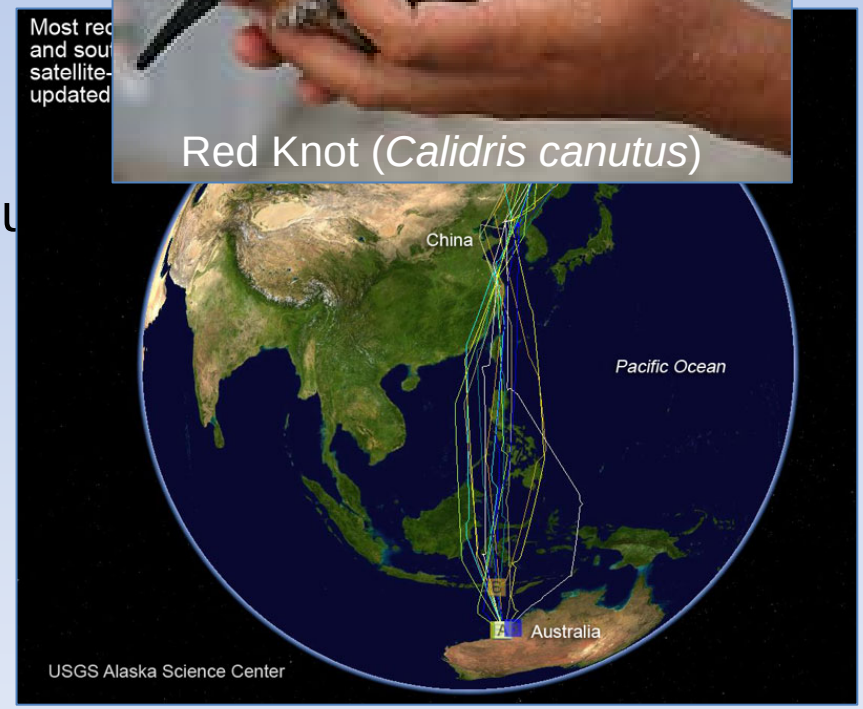
- Allow significant lead time
- Obtain an Argos use agreement
- Request platform ID numbers
- Fill out a service contract with Argos
  - Choose services (data distribution, etc.)
  - Manage payments
- Purchase PTTs from manufacturer
  - Provide them with the Argos platform ID numbers
  - Program Duty Cycles
- Test PTTs
- Deploy PTTs

PTT Summary

- Gross movements
  - Dispersal, migration paths
  - Breeding/nonbreeding ranges
- Moderate error
  - 0.25 – 1.5 km
  - Can make fine scale habitat u
- Few transmissions per day
- Expensive ($2500-$3500 USD)
- Heavy transmitters



Red Knot (*Calidris canutus*)



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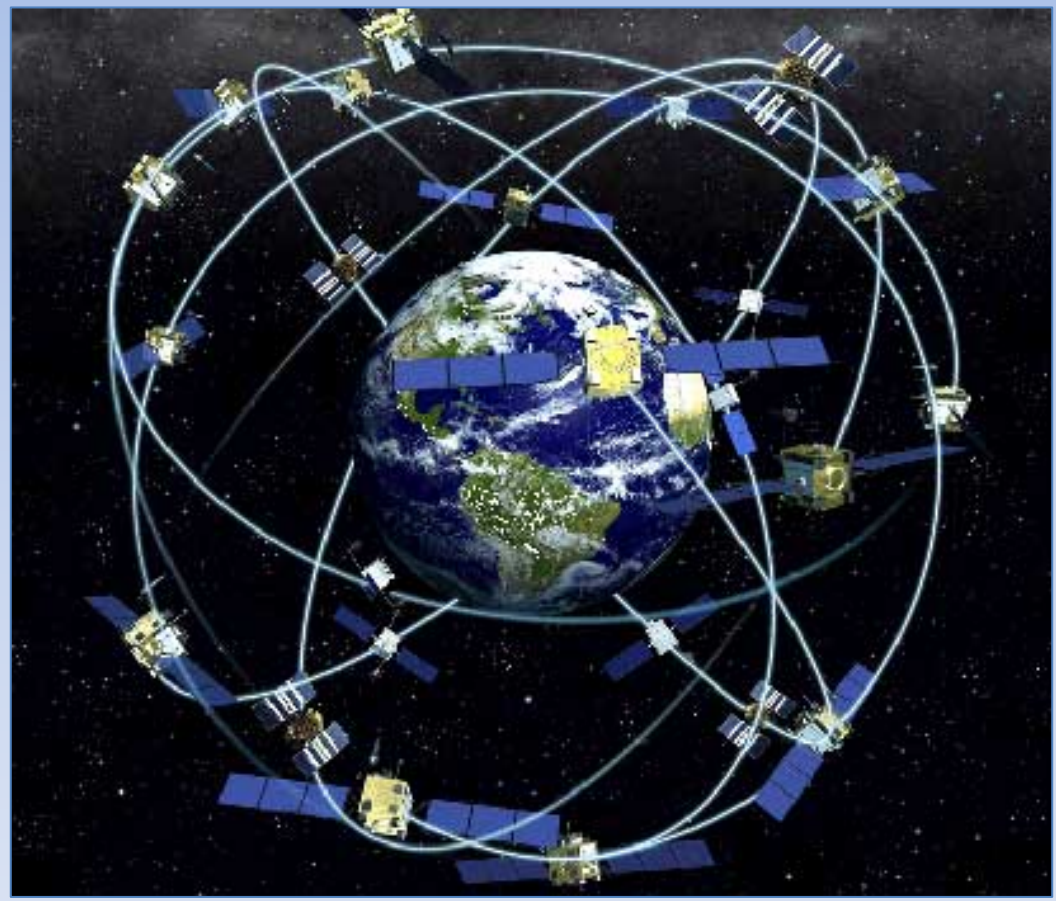
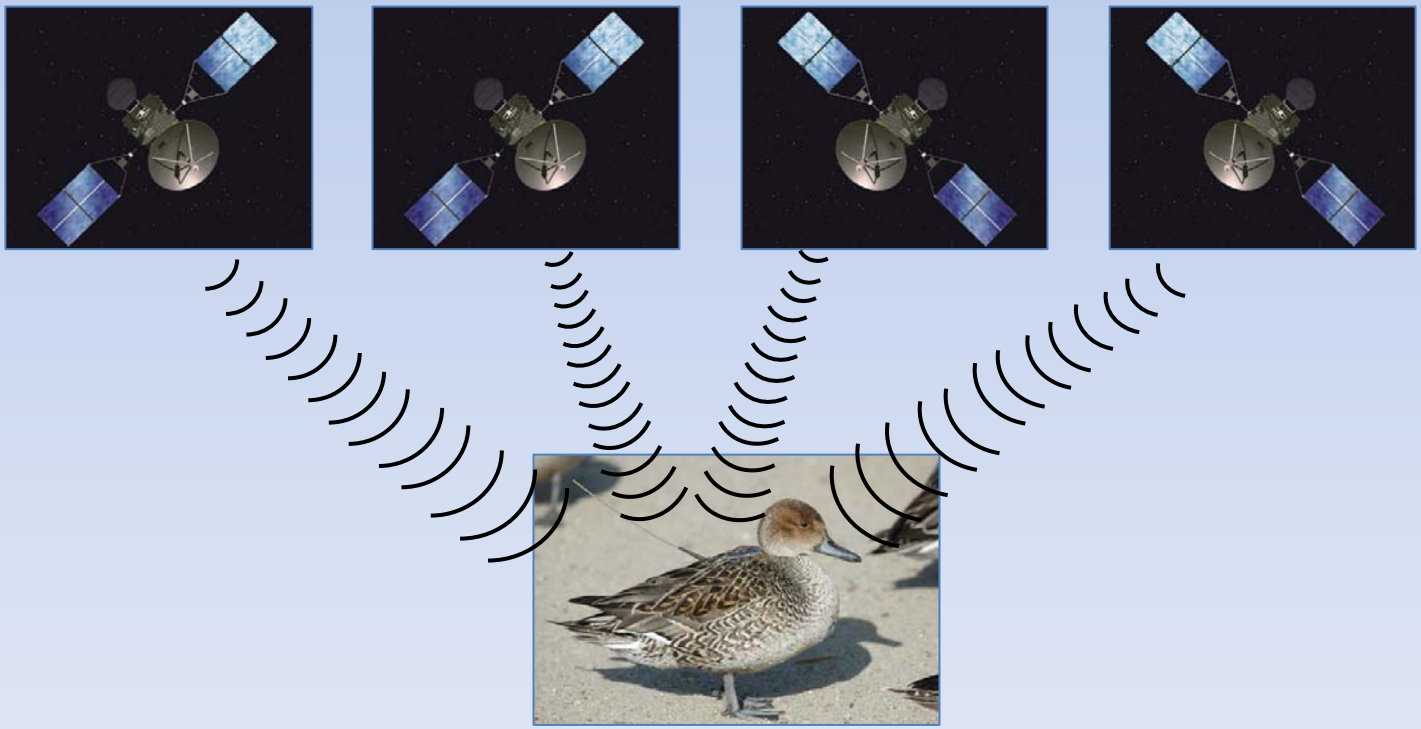
GPS

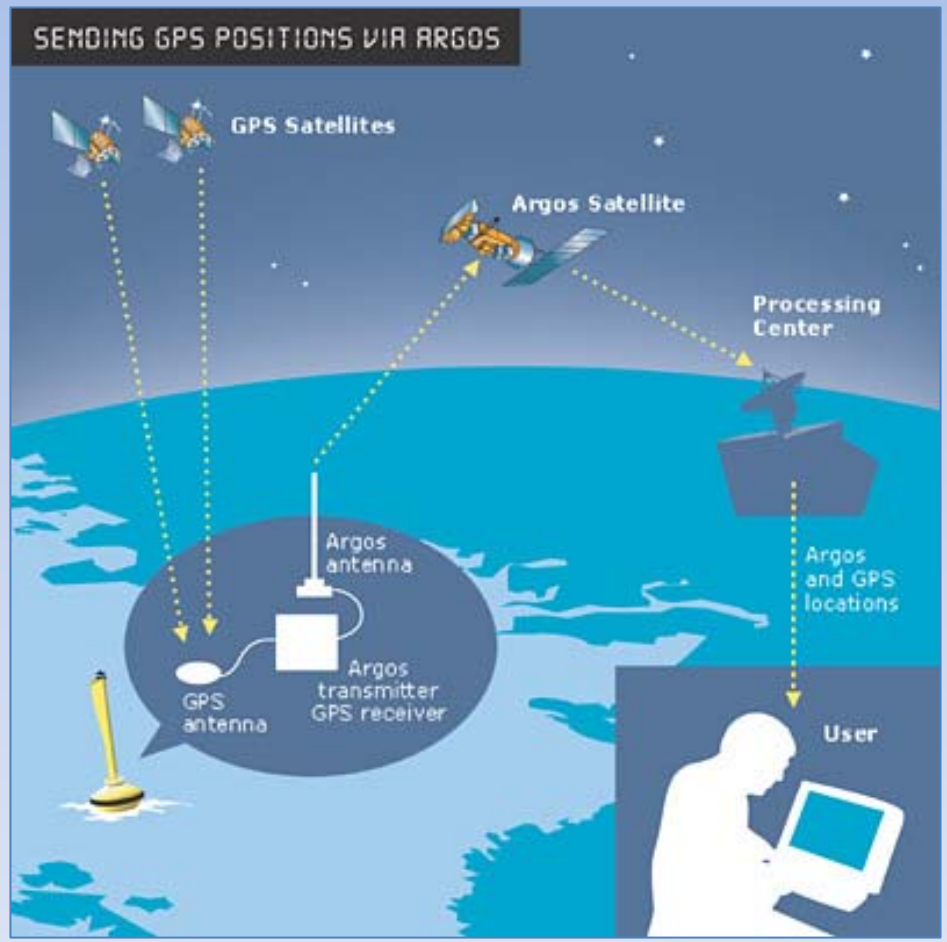


GPS: How does it work?

- GPS units passively receive signals from orbiting satellites
- When GPS unit receives signals from multiple satellites its position can be determined



GPS + PTT


SENDING GPS POSITIONS VIA ARGOS
GPS Satellites
Argos Satellite
Processing Center
Argos antenna
Argos and GPS locations
Argos transmitter GPS receiver
GPS antenna
User

GPS: Summary

Advantages

- More accurate location data (error < 100m)
- More frequent data capture
- GPS alone: no tracking costs
- Long lasting (2 – 3 years)

Disadvantages

- Heavy (20+ g)
- Costly: GPS alone ($1000 – $2000), with PTT ($3000 – $4000)
- GPS alone: recapture necessary
- GPS + PTT: greater tracking costs

Tracking Avian Movements

- Satellite Transmitters
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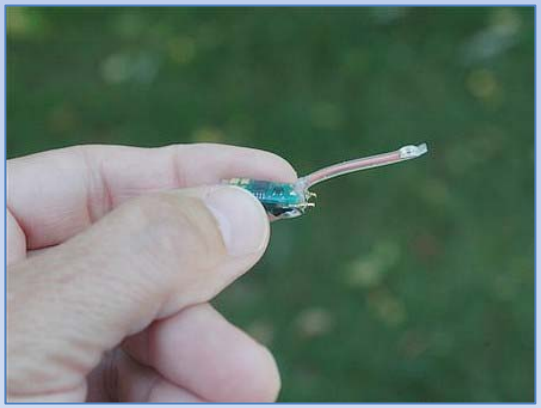
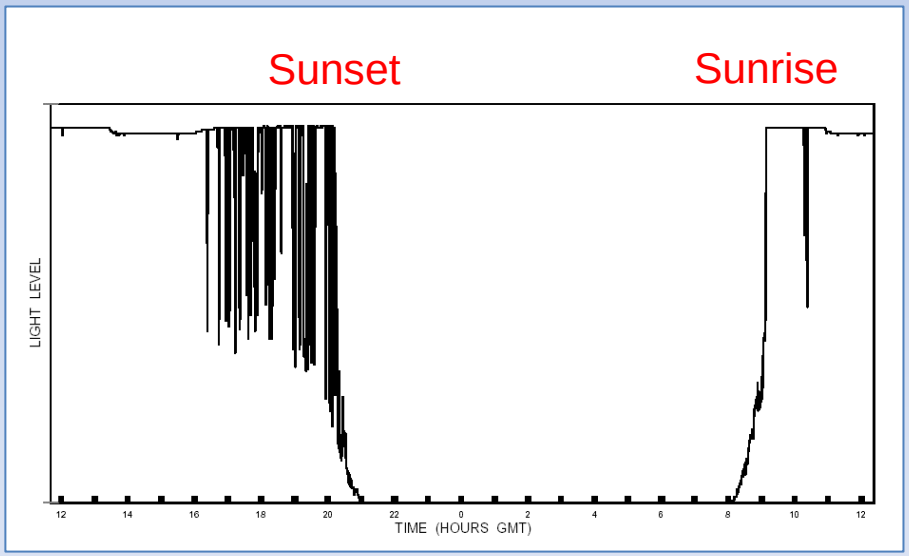
Geolocators

- Developed by the British Antarctic Survey
- Small data loggers that record light intensity



Geolocators: How do they work?

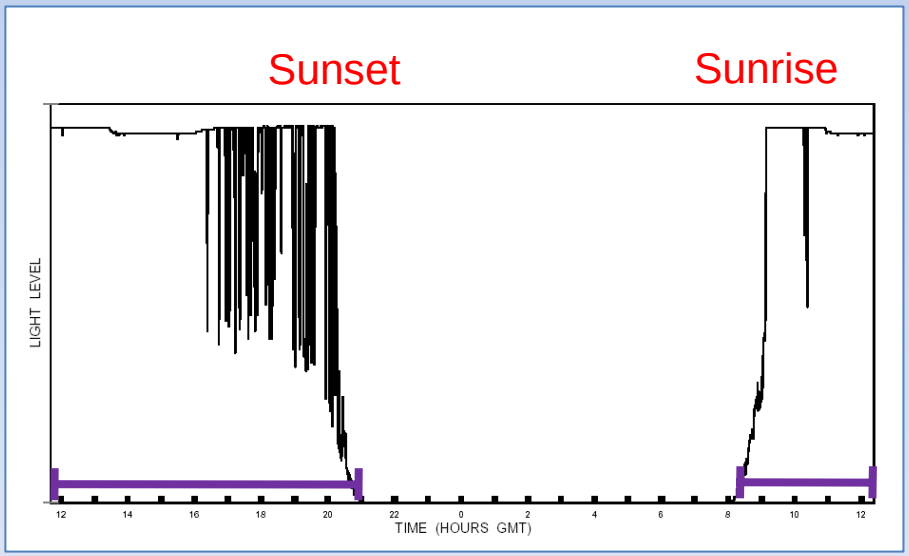
- Local sunrise and sunset recorded each day
- Sunrise and sunset times used to calculate longitude



6:27 am

Geolocators: How do they work?

- Local sunrise and sunset recorded each day
- Sunrise and sunset times used to calculate longitude
- Overall day length used to calculate latitude



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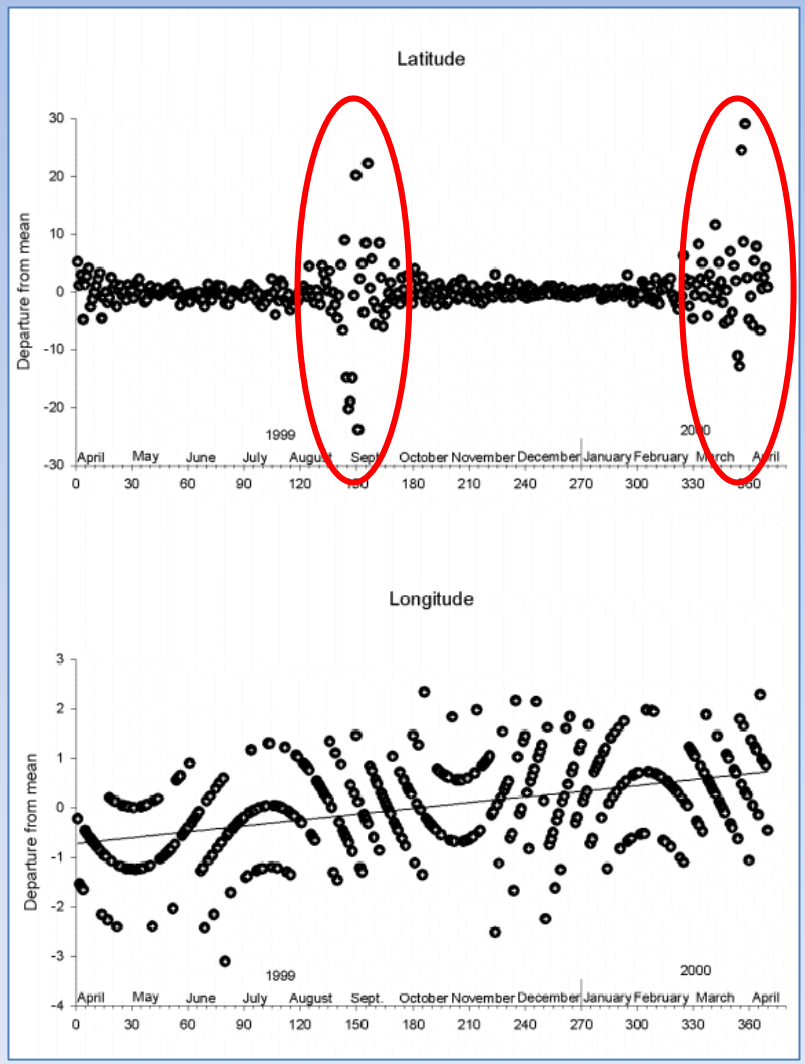

Geolocator Summary

Advantages

- Small and light weight (as little as 1.0g)
- Inexpensive
  - $200 USD
  - No tracking costs
- Long lasting (2 years)

Disadvantages

- Large error (± 150 – 200km)
- Must recapture the bird

Purple Martin (*Progne subis*)
50g
Stutchbury et al. 2009

Compare & Contrast

VHF				
PTT				
GPS				
GPS + PTT				
Geolocator				

Compare & Contrast

	Cost USD
VHF	$100 – $200*
PTT	$2500 – $3500*
GPS	$1000 – $2000
GPS + PTT	$3000 – $4000*
Geolocator	$200

*Not including tracking costs

Compare & Contrast

	Cost USD	Accuracy
VHF	$100 – $200*	5 – 1000 m
PTT	$2500 – $3500*	0.25 – 1.5 km
GPS	$1000 – $2000	10 – 100 m
GPS + PTT	$3000 – $4000*	10 – 100 m
Geolocator	$200	± 200 km

*Not including tracking costs

Compare & Contrast

	Cost USD	Accuracy	Min. Weight		
VHF	$100 – $200*	5 – 1000 m	0.35 g		
PTT	$2500 – $3500*	0.25 – 1.5 km	9.5 g		
GPS	$1000 – $2000	10 – 100 m	20 g		
GPS + PTT	$3000 – $4000*	10 – 100 m	22 g		
Geolocator	$200	± 200 km	1.0 g		

*Not including tracking costs

Compare & Contrast

	Cost USD	Accuracy	Min. Weight	Longevity	
VHF	$100 – $200*	5 – 1000 m	0.35 g	Days – Months	
PTT	$2500 – $3500*	0.25 – 1.5 km	9.5 g	Months – Years	
GPS	$1000 – $2000	10 – 100 m	20 g	Months – Years	
GPS + PTT	$3000 – $4000*	10 – 100 m	22 g	Months – Years	
Geolocator	$200	± 200 km	1.0 g	1 – 2 years	

*Not including tracking costs

Compare & Contrast

	Cost USD	Accuracy	Min. Weight	Longevity	Recapture?
VHF	$100 – $200*	5 – 1000 m	0.35 g	Days – Months	No
PTT	$2500 – $3500*	0.25 – 1.5 km	9.5 g	Months – Years	No
GPS	$1000 – $2000	10 – 100 m	20 g	Months – Years	Yes
GPS + PTT	$3000 – $4000*	10 – 100 m	22 g	Months – Years	No
Geolocator	$200	± 200 km	1.0 g	1 – 2 years	Yes

*Not including tracking costs

- What are my questions?
- What data are necessary to answer my questions?
- What method can provide these data?
- Which system will work best? What is my budget?