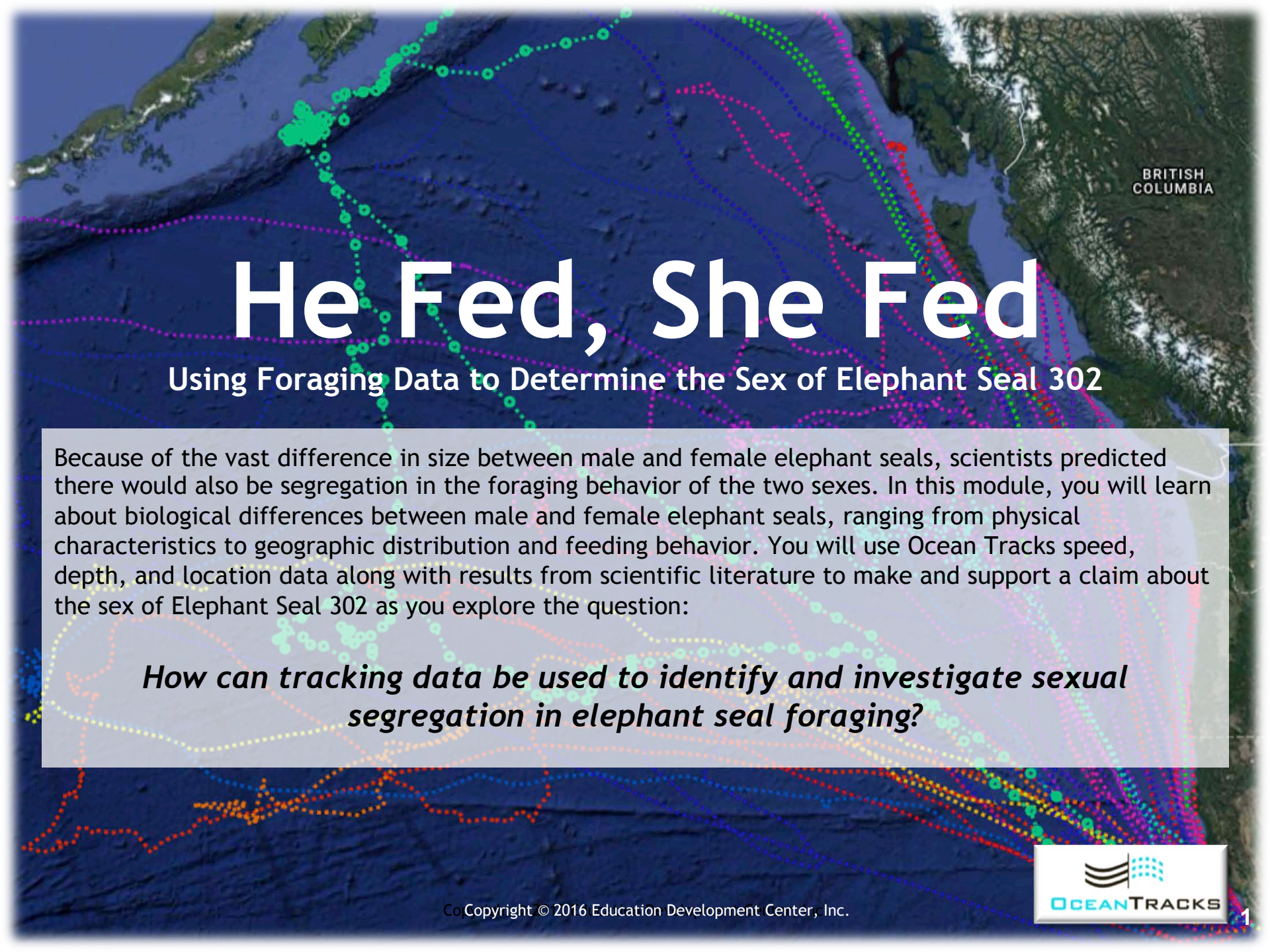


He Fed, She Fed

Using Foraging Data to Determine the Sex of Elephant Seal 302

Because of the vast difference in size between male and female elephant seals, scientists predicted there would also be segregation in the foraging behavior of the two sexes. In this module, you will learn about biological differences between male and female elephant seals, ranging from physical characteristics to geographic distribution and feeding behavior. You will use Ocean Tracks speed, depth, and location data along with results from scientific literature to make and support a claim about the sex of Elephant Seal 302 as you explore the question:

How can tracking data be used to identify and investigate sexual segregation in elephant seal foraging?

OCEANTRACKS

Engage

Satellite telemetry data has drastically changed what we know about the northern elephant seal. Figure 1 below illustrates one of the major discoveries about their range and behavior. The image on the left (A) shows the extent of what scientists believed was the full range of northern elephant seals based on data collected through boat and plane survey research conducted in the 1990s. More recently, satellite tags have been used to track seal migrations. The results of that research, shown in the image on the right (B), came as quite a surprise to researchers.

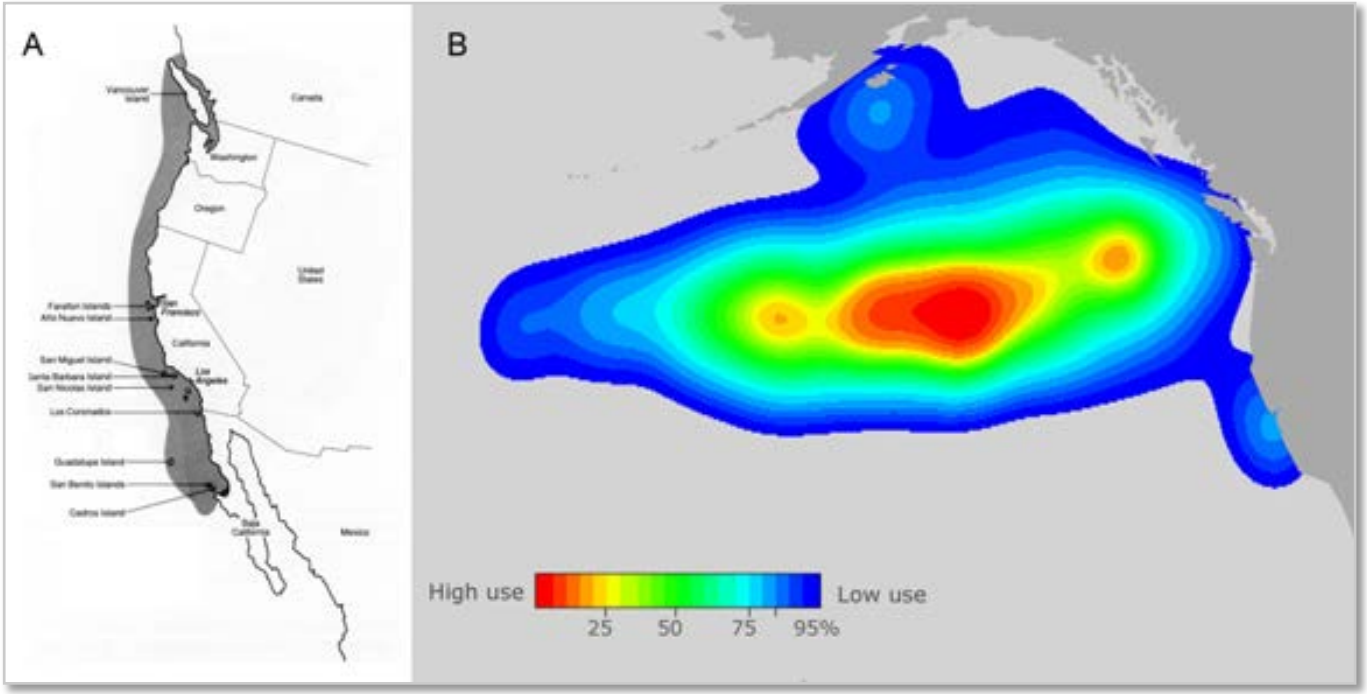


Figure 1. (A) Elephant seal distribution data from plane and boat surveys. (B) Elephant seal distribution data from satellite telemetry.

Engage

In addition to being the some of the fastest, deepest-diving, and farthest-traveling animals in the ocean, elephant seals show some of the most obvious traits of sexual dimorphism in class mammalia. Physically, male and female elephant seals appear very different. Most notably, males are significantly larger and have a pronounced proboscis (nose).

Species that demonstrate sexual dimorphism also tend to exhibit differences in energetic needs between the sexes. These differences can cause males and females to utilize different feeding strategies, including searching out different types of prey and/or visiting different foraging locations.

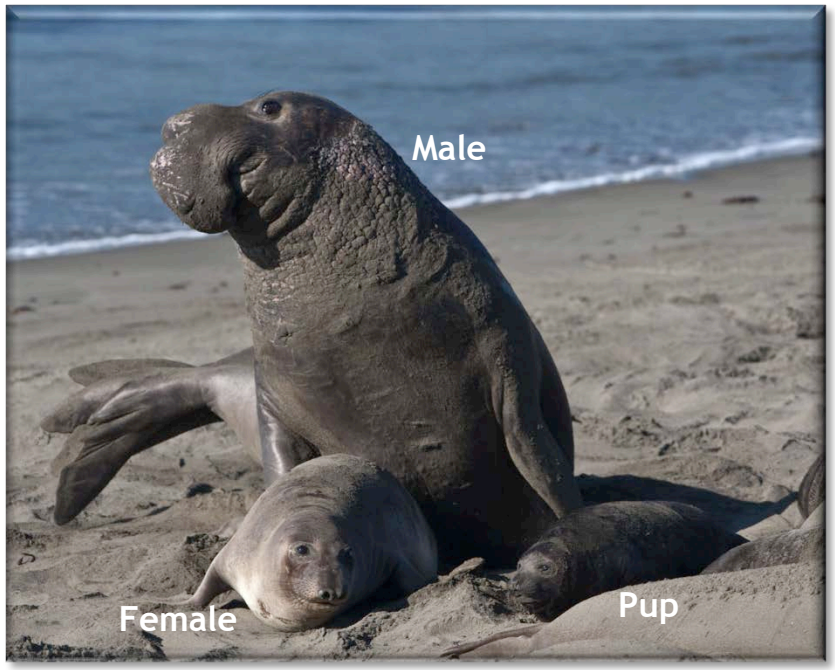


Photo by "Mike" Michael L. Baird, CC BY 2.0
https://commons.wikimedia.org/w/index.php?curid=9556818

CLASS DISCUSSION

As a class, discuss your answers to the following questions.

1. What did electronic tagging reveal about the migration and habitat ranges of elephant seals? (See Figure 1 on Slide 2.)

2. What data might help us investigate sexual segregation in elephant seal foraging? What can we look at in the data to identify differences in feeding behaviors?

OCEANTRACKS

Explore

PART 1: ELEPHANT SEAL #302

In order to determine differences between male and female foraging locations, it would be helpful to know which tracks belong to male elephant seals and which belong to females. Since we don't have access to that data in Ocean Tracks, you'll have to take clues from the data that *are* available to you, supplemented by other scientific research results to help you figure it out. In this section, you will start by looking at elephant seal track #302 in Ocean Tracks.

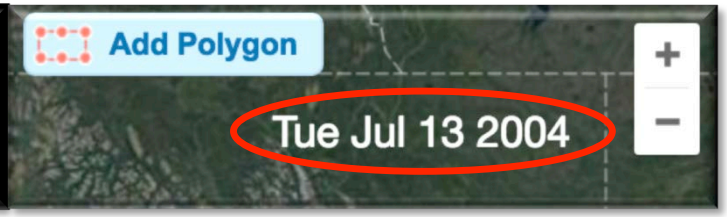
Learning Objectives

- Create a robust scientific explanation supported with a variety of evidence.
- Defend your claim against opposing viewpoints.

- Go to http://oceantracks.org/map. Elephant seal track #302 is displayed by default.
- Open the **Data & Tools** tab.
- Click **+** to expand **Tools** and adjust the time sliders to include the entire date range of elephant seal track #302.
- Click the **Show Animal Movement** button to animate the track on the map.

- Watch carefully as the seal makes its migratory journey, looking for where it goes, how fast (or slow) it travels, and how straight or curvy its path is along the track.

TIP: *Look for the date stamp in the top right corner of the screen. Each movement of the large dot on the animated track = 1 day.*



Explore

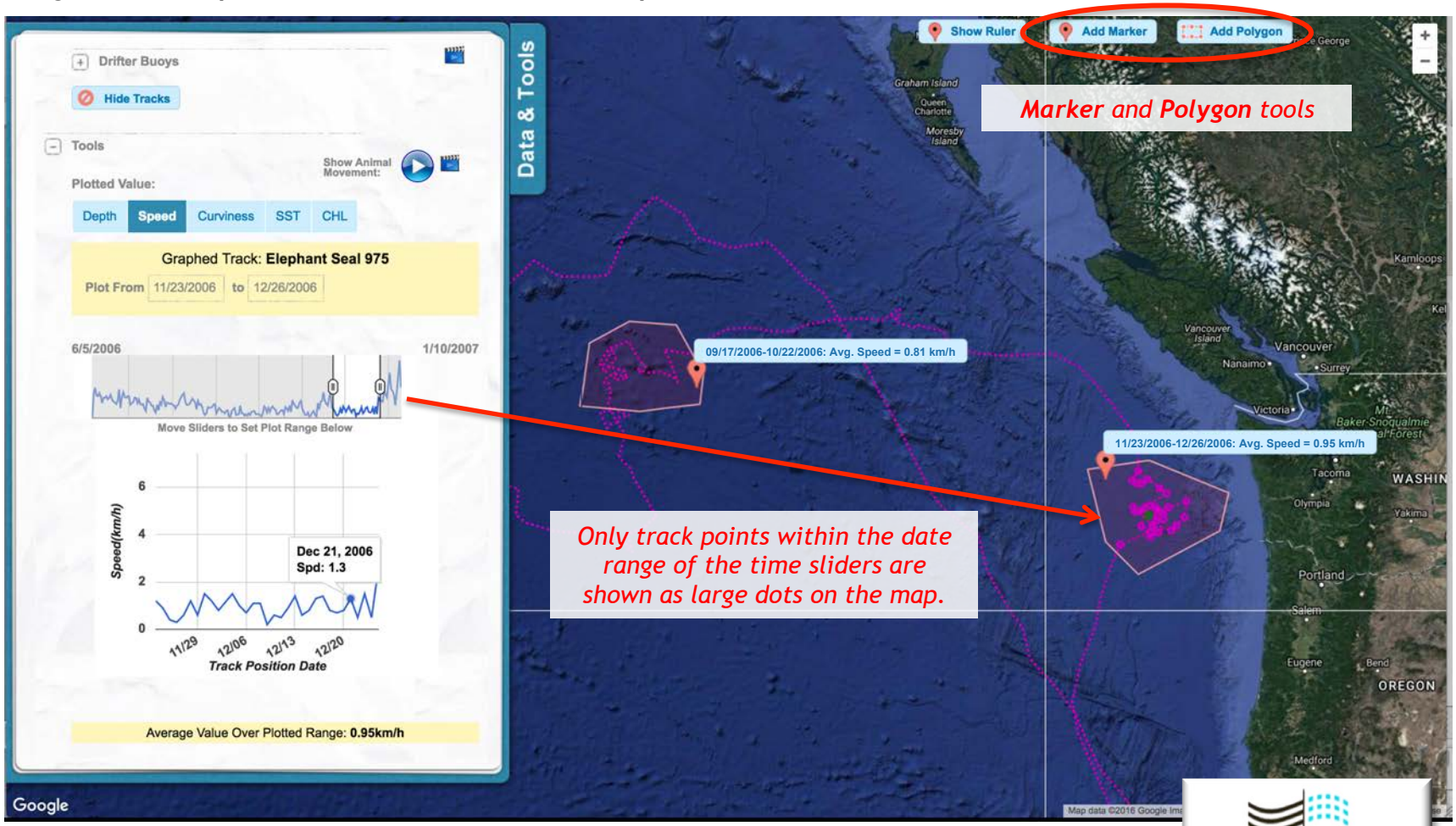
- Adjust the zoom and positioning of the map so that you can easily see both the map and the contents of the **Data & Tools** tab.
- Under **Tools**, look at the **Speed** and **Curviness** plots. (**TIP:** Learn more about the curviness tool in the Ocean Tracks **Library**: http://oceantracks.org/library/the-curviness-tool/)
- Hover your mouse over data points in the bottom graph to see the exact date and speed (or curviness) for those points. As you hover, the corresponding track point will also be highlighted on the map.
- Based on your observations of the track in motion and the speed and curviness data, identify one or more sections of the track in which you think the elephant seal is likely foraging for food.
- Use the **Add Polygon** tool to draw a shape around the potential foraging area(s):

  - Click on the **Add Polygon button** in the upper right portion of the screen. Then, click on the map where you want to place the first point of your polygon. Continue clicking to drop points on the map, creating an outline of the shape you want to make. To finish the shape, click on the starting point of your polygon. Click and drag the polygon to reposition if needed.
- Use the time sliders to isolate the dates that correspond to only the track points within one of your polygons.
- Use the **Add Marker** tool to label your polygon with the date range and average speed for those sections of the track. Repeat for additional polygons.
- Save a screenshot of your annotated map. (See Slide 6 for an example and tips.)

OCEANTRACKS

Explore

Figure 2. Example Annotated Screenshot for Elephant Seal 975



Explore

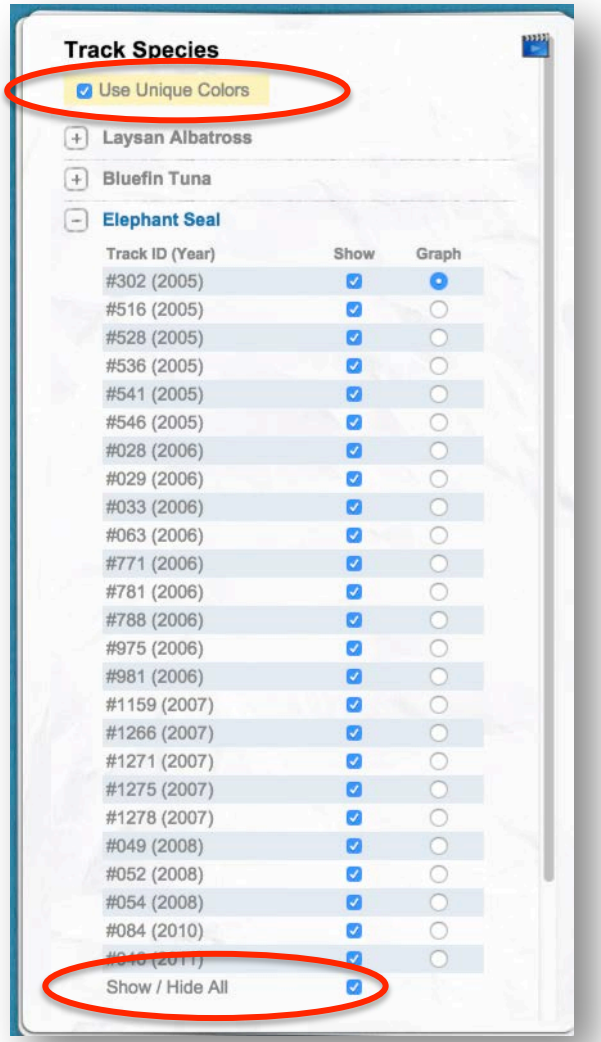
EXPLORE PART 1 QUESTIONS

1. *Where does elephant seal track #302 go?*
2. *What track features led you to choose the potential foraging area(s) you selected for Elephant Seal #302?*
3. *How do the speed and curviness data inside your polygon(s) support or not support your foraging location choice(s)? Use specific data values and/or averages in your explanation.*
4. *What other data would help you identify the seal's foraging locations and whether this animal is male or female?*

Explore

PART 2: COMPARE TRACK #302 TO OTHER TRACKS

Now, let's look at the other elephant seal tracks available in Ocean Tracks to see what patterns we can find that might help us determine the sex of Elephant Seal #302.



- Clear the markers and polygons off the map. To do this:
  - Click on each marker. Click **Delete** and then **OK**.
  - Right click on each polygon and click **Remove Polygon**.
- In the **Data & Tools** tab, click **+** to expand **Tracks** and then again to expand the list of **Elephant Seal** tracks.
- At the bottom of the list, check the box to **Show All** tracks.
- Check the **Use Unique Colors** box to make the different tracks easier to distinguish from one another.
- Under **Tools**, click the **Show Animal Movement** button to animate all the tracks at once. Look for and take note of similarities and differences among the tracks.
- Make (or print) a table like Table 1 on Slide 9 and fill in the missing data for Elephant Seal track 302. **TIP:** You might want to hide all tracks other than #302 before gathering these data. Make sure both **Show** and **Graph** are selected for track #302.

Explore

Table 1.

Track ID	Departed from shore	Returned to shore	Number of days at sea	Total distance traveled	Location of foraging area	Avg. speed (entire track)	Avg. depth (entire track)
302							
528	5/30/05	1/17/06	222	10816.89 km	NPTZ	3.2 km/hr	-559.11 m
771	2/17/06	5/17/06	88	5713.97 km	NPTZ	3.3 km/hr	-475.54 m
975	6/5/07	1/10/07	219	7877.28 km	Off coast of Washington/ B.C.	2.25 km/hr	-529.86 m
1271	6/9/07	1/31//08	236	9217.54 km	Gulf of Alaska	2.78 km/hr	-516 m
084	9/5/08	1/7/08	124	9544.72 km	Aleutian Islands	2.22 km/hr	-585.83 m
046	3/17/11	7/13/11	118	6793.41 km	Gulf of Alaska	1.67 km/hr	-544.59 m

Explore

Now that you have had a chance to examine all of the elephant seal tracks available on Ocean Tracks, let's see what another research study has discovered about elephant seal migration patterns.

- Read the abstract for the paper "*Foraging Ecology of Northern Elephant Seals*" on Slide 10. Then answer the explore questions below. If interested, read the full text of the paper:

  Le Boeuf, B. J., et al. "Foraging ecology of northern elephant seals." Ecological monographs 70.3 (2000): 353-382. http://tinyurl.com/leboeuf2000

EXPLORE PART 2 QUESTIONS

1. *Describe how the elephant seal tracks in Ocean Tracks compare to one another with respect to the paths the animals follow and the locations they visit. How are they similar? How are they different? Use your notes, data from Ocean Tracks, and Table 1 to support your answers.*
2. *Compare the times of year the seals in Ocean Tracks travel and describe how they are similar and/or different.*
3. *What was the hypothesis of the scientists involved in the study documented in the Le Boeuf et. al paper?*
4. *What data did the scientists collect? How was it similar or different to the data available in Ocean Tracks? What conclusions did the authors come to? Were they able to support their initial hypothesis?*

Explore

Ecological Monographs, 70(3), 2000, pp. 353–382

FORAGING ECOLOGY OF NORTHERN ELEPHANT SEALS

B. J. LE BOEUF, D. E. CROCKER, D. P. COSTA, S. B. BLACKWELL, P. M. WEBB, AND D. S. HOUSER

Department of Biology and Institute of Marine Sciences, University of California, Santa Cruz, California 95064 USA

Abstract. Sexual segregation in foraging is predicted from the great size disparity of male and female northern elephant seals, Mirounga angustirostris. Our aim was to test this prediction by measuring diving and foraging behavior, foraging locations, and distribution of the sexes during biannual migrations in the northeastern Pacific Ocean. Daily movements of 27 adult males and 20 adult females, during 56 migrations from Año Nuevo, California, USA, were determined by Argos satellite telemetry via head-mounted platform transmitter terminals. Diving records were obtained with archival time–depth–speed recorders attached to the backs of seals that were recovered when the seals returned to the rookery. Pronounced sex differences were found in foraging location and foraging pattern, as reflected by horizontal transit speed and diving behavior. Males moved directly north or northwest at a mean speed of 90 ± 27 km/d to focal foraging areas along the continental margin ranging from coastal Oregon (534 km away) to the western Aleutian Islands (4775 km away). Males remained in these areas (mean size = 7892 km^2) for 21–84% of their 4-mo stays at sea. The predominance of flat-bottom dives in these areas suggests concentrated feeding on benthic prey. Migration distance and estimated mass gain were positively correlated with male size, and individual males returned to the same area to forage on subsequent migrations. In contrast, females ranged across a wider area of the northeastern Pacific, from 38° to 60° N and from the coast to 172.5° E. Focal foraging areas, indicated by a reduction in swim speed to 0.4 m/s, were distributed over deep water along the migratory path, with females remaining on them a mean of 3.5 d before moving to another one. Jagged-bottom dives that tracked the deep scattering layer prevailed in these areas, suggesting that females were feeding on pelagic prey in the water column. Females took roughly similar initial paths in subsequent migrations, but large deviations from the previous route were observed. We conclude that there is habitat segregation between the sexes. Females range widely over deep water, apparently foraging on patchily distributed, vertically migrating, pelagic prey, whereas males forage along the continental margin at the distal end of their migration in a manner consistent with feeding on benthic prey.

Explore

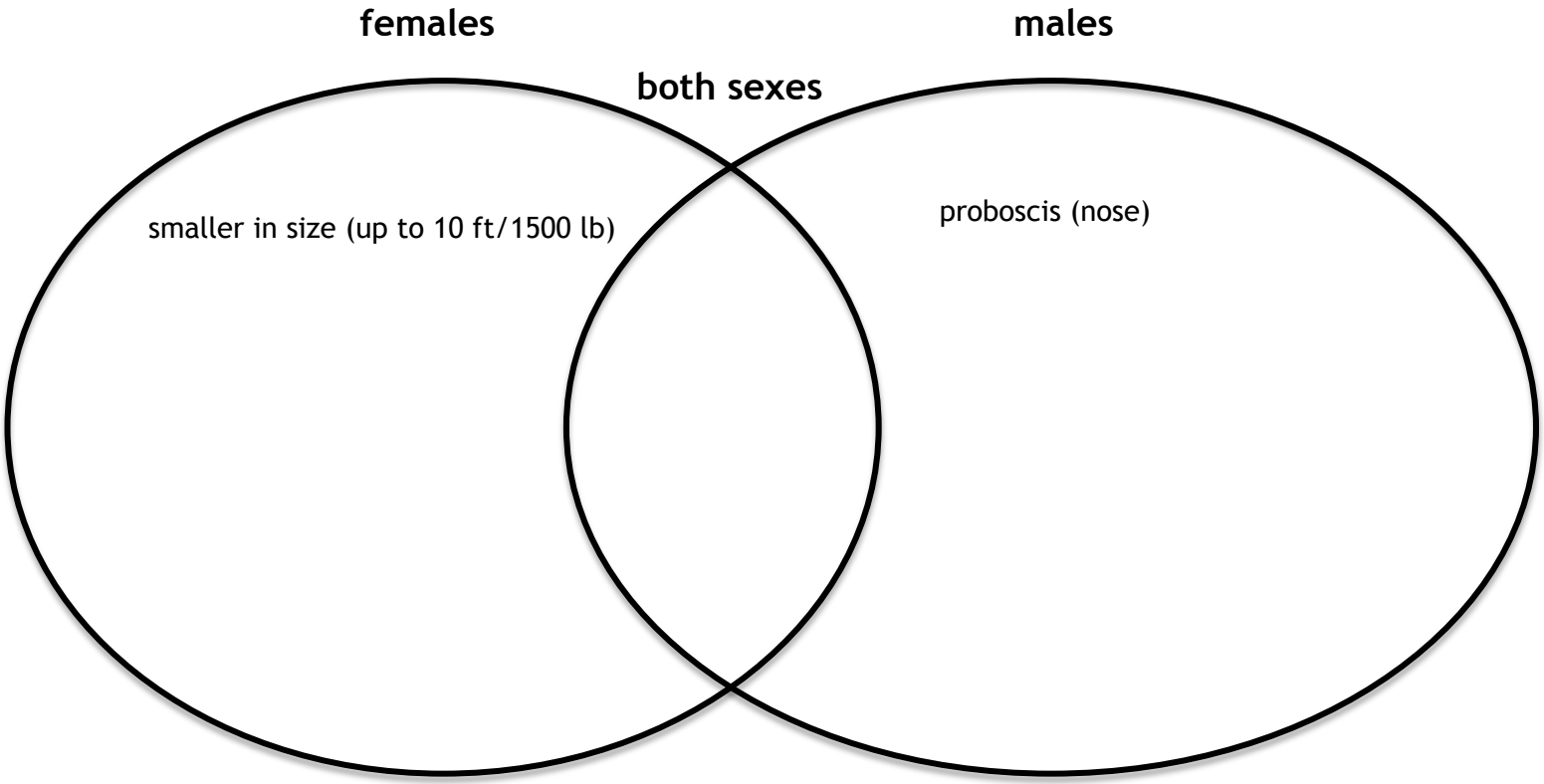
PART 3: COMPARE BEHAVIORS OF MALE & FEMALE ELEPHANT SEALS

Using the Ocean Tracks library and other resources, you are going to learn more about the differences between male and female elephant seals to help reveal additional useful clues for determining the sex of a seal from its track.

- Create a Venn diagram like the one started on Slide 13. Add in what you have learned about differences in male and female behaviors in the Le Boeuf et. al paper abstract.
- Use the information from the following sources to learn even more about similarities and differences between male and female elephant seals and add them to your Venn diagram:
  - the Ocean Tracks **Library**
    http://oceantracks.org/library/
  - Earthguide: Elephant Seals Lifestyle
    http://earthguide.ucsd.edu/elephantseals/lifestyle/index.html
  - The timeline in Figure 3 on Slide 14.

Explore

VENN DIAGRAM



Explore

Figure 3. Elephant Seal Annual Schedule

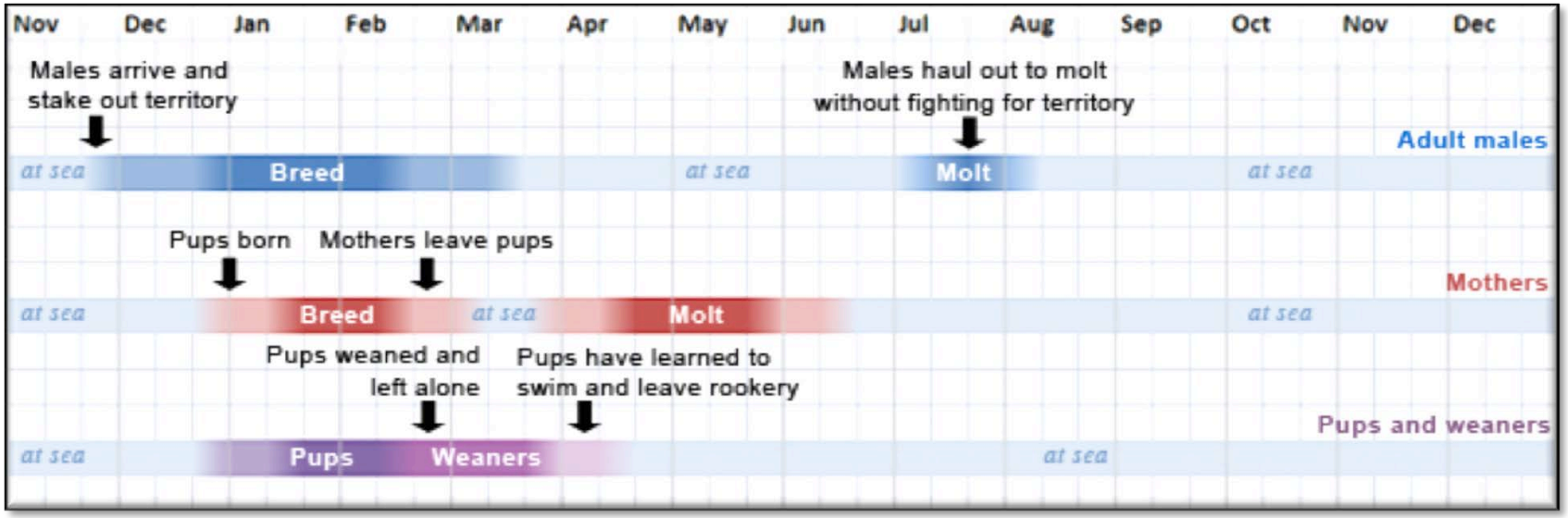


Image source: [Earthguide]

Synthesize

FINAL REPORT

Is Elephant Seal #302 male or female? Create a report or PowerPoint presentation to make and share your claim and supporting evidence. Your report should include the following:

1. **State your claim**: Based on your research, what conclusion have you come to? Is Elephant Seal #302 male or female?

2. **Present and support your argument**: Explain how you arrived at your conclusion. (See Slide 17 for an example.)
   - How strongly does your evidence support your claim? Include a variety of different types of evidence that most strongly support your claim. This can include notes from your research, tables, graphs, screenshots, etc.
   - Explain why you selected each piece of evidence and how it helps support your claim.

3. **Support and rebut the counterclaim**: A counterclaim is a statement that is in opposition to a claim. A rebuttal is a response that refutes the counterclaim.
   - What evidence did you find that would support the counterclaim to your conclusion?
   - How would you rebut this counterclaim? Explain why your original claim is stronger than the counterclaim.

Continued…

Synthesize

4. **Answer the challenge question:**

How can tracking data be used to investigate sexual segregation in elephant seal foraging?

Explain, in paragraph form, what you have learned about the challenge question you have been exploring in this module. Include the following in your explanation.

- What examples of sexual segregation, if any, were you able to see in the foraging behavior of elephant seals in Ocean Tracks? What were some of the patterns you observed?
- Did you observe any exceptions to the patterns you expected to see? Why might those exceptions exist?

Synthesize

The example below is to provide some guidance on how to present evidence to support your claim. This example is for one piece of evidence; you should incorporate as many pieces of evidence as you can into your report. Please note this example is for Elephant Seal #046 (not Elephant Seal #302).

Claim: Elephant Seal #046 is male.

Evidence that supports the claim:	**Explanation:**
Example #1 **Figure 1:** Tracks Summary Statistics showing that track 46 began on March 17 and ended on July 13.  	Figure 1 shows the elephant seal leaving the shore in March, traveling out at sea for 4 months and then returning to shore in July. If we compare these dates to the Elephant Seal Annual Schedule, we can see that they coincide with when male elephant seals typically head out to sea after mating and return to shore in the summer for molting.