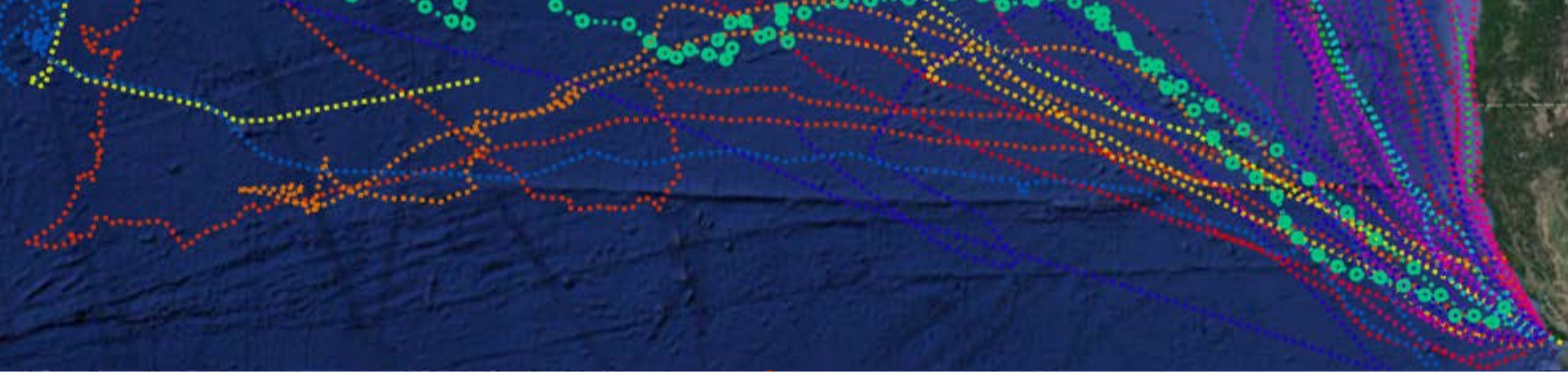


He Fed, She Fed

In this module, you will learn how migration patterns can provide key insights into the biology and ecology of ocean-going species by investigating the following question: Is Elephant Seal #302 male or female?

Learning Objectives

- Use data to link key characteristics of animal tracks to species biology
- Learn the physical, behavioral, and ecological characteristics that distinguish male from female elephant seals
- Create a robust scientific explanation supported with a variety of evidence
- Defend counter arguments with evidence

OCEANTRACKS

Engage

Satellite telemetry data has drastically changed our understanding of the movements of northern elephant seals. Figure 1 below illustrates one of the major discoveries about their range and behavior.

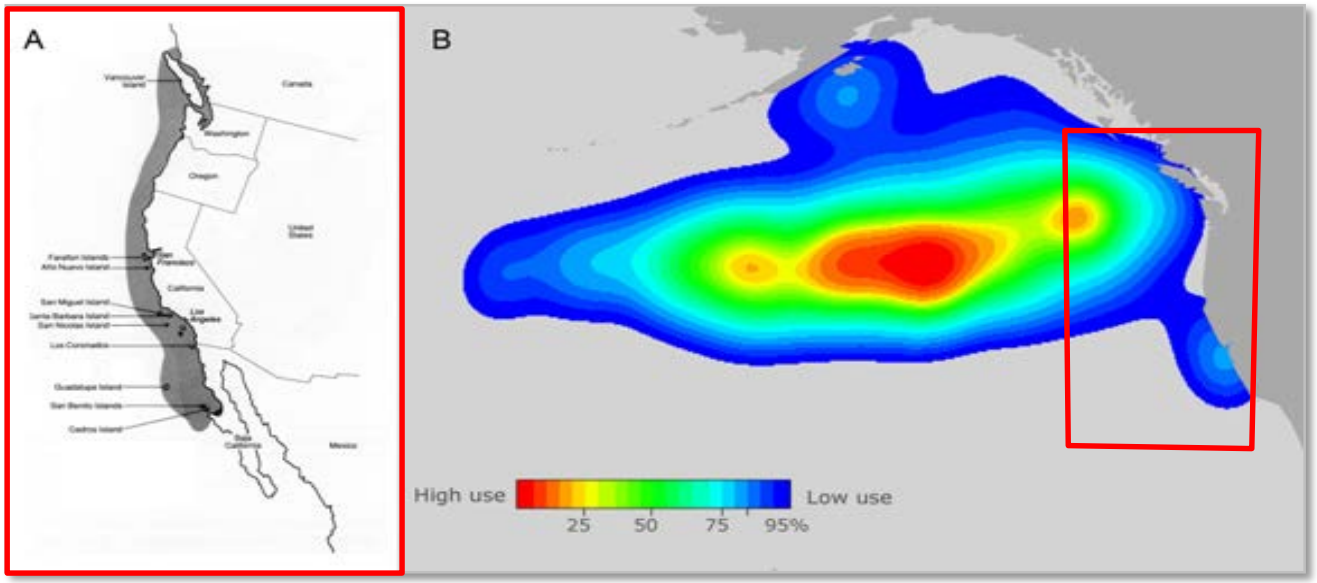


Figure 1. Image A shows the extent of what scientists believed was the full range of northern elephant seals based on data collected through boat and plane survey research conducted in the 1990s. More recently, satellite tags have been used to track seal migrations. The results of that research, shown in Image B, came as quite a surprise to researchers. Source: Riedman, M. (1990). The pinnipeds: Seals, sea lions, and walruses. Los Angeles, CA: University of California Press.

CLASS DISCUSSION

Inspect the images above, and discuss the following questions as a class.

1. *In what ways did electronic tagging change our understanding of the migration patterns of elephant seals?*
2. *How might this information be useful for conserving this species?*

Explore

In addition to being 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.

Some physical, biological, and ecological traits that distinguish male from female elephant seals include the following:

- Differences in **physical appearance**, with males being significantly larger and having a pronounced proboscis (nose)
- Differences in energetic needs, leading to differences in **foraging locations and behavior**
- Differences in reproductive roles, leading to variation in the **timing of migration** and **duration of time at sea**

Because there are such pronounced differences in the migratory behavior between male and female elephant seals, you can use tracking data to distinguish the sex of individuals. Try it out by seeing if you can determine the sex of Elephant Seal #302 by analyzing its track.

Figure 2. Male, female, and pup elephant seals
Source: "Mike" Michael L. Baird, CC BY 2.0
https://commons.wikimedia.org/w/index.php?curid=9556818

Explore

PART 1: ELEPHANT SEAL #302

First, you will do some initial explorations of the track of Elephant Seal #302 to begin thinking about how its data may give you clues about its sex.

- 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 #302's track. Notice when the animal leaves and returns to shore, and how many days the animal is at sea. Record this information in a table like Table 1 on Slide 5.
- Click the Show Animal Movement button to animate the track on the map.

- Watch carefully as the seal makes its migratory journey. Pay attention to where it goes, how fast or slow it travels, and how straight or curvy its path is along the track.

NOTE: Refer to the North Pacific Ocean section of the Ocean Tracks Library (http://oceantracks.org/library/the-north-pacific-ocean/the-north-pacific-transition-zone-and-transition-zone-chlorophyll-front) for a description of the locations of important features in the study region.

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. Record the average speed and curviness of the entire elephant seal track in your table (see Figure 3 on Slide 6 for how to find these values). **NOTE:** You can 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. Record the fastest and slowest speeds, and the highest curviness value in your table. Notice that as you hover, the corresponding track point will also be highlighted on the map.

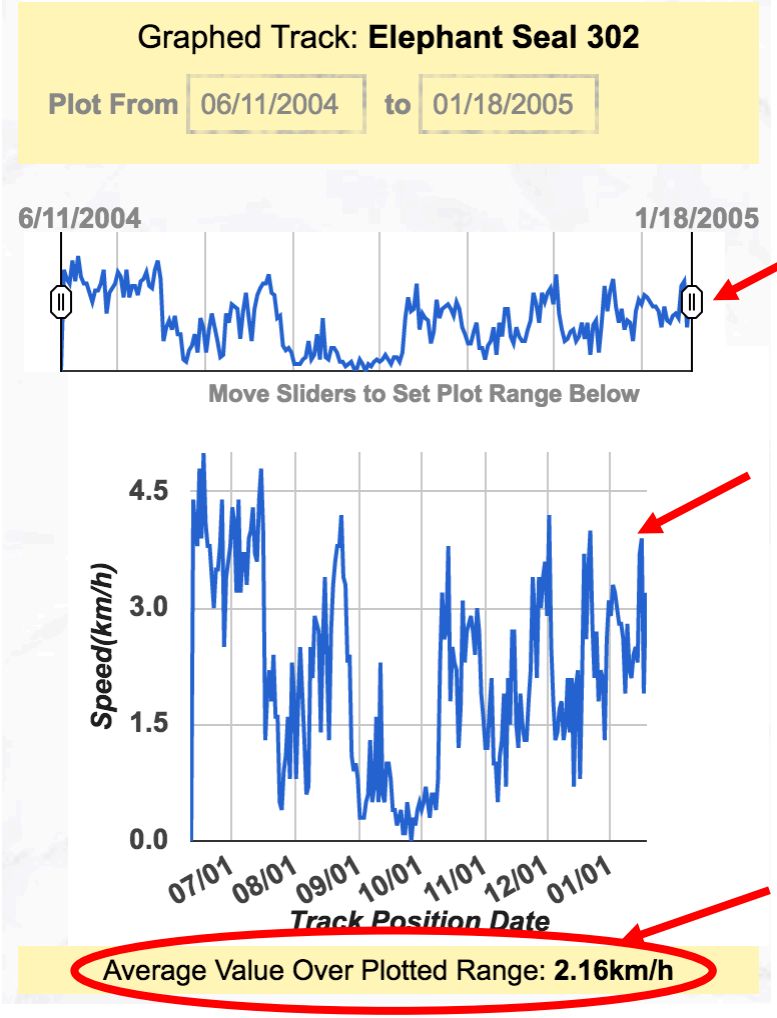
Table 1.

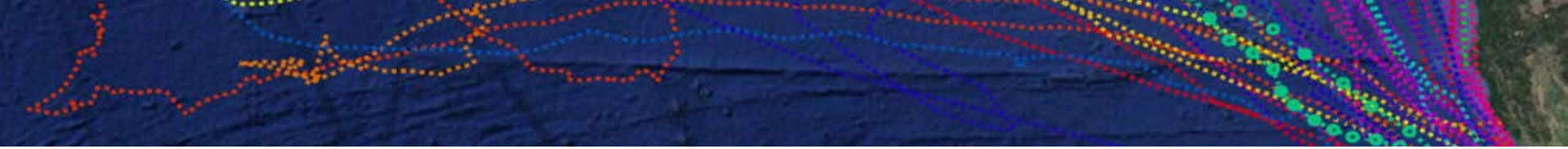
Track ID	Date of Departure from Shore	Date Returned to Shore	Number of Days at Sea	Track Start and End Locations	Locations Visited While at Sea *	Avg. Speed (entire track)	Fastest Speed (entire track)
302							

Track ID	Slowest Speed (entire track)	Average Curviness (entire track)	Fastest Curviness (entire track)
302			

* **Note**: Make reference here to locations described in the Ocean Tracks Library (e.g., North Pacific Transition Zone, NPTZ).

Figure 3. Instructions for how to find average values for a portion or all of an animal's track





Explore

EXPLORE PART 1 QUESTIONS

1. *Where was the seal when it reached its fastest speed? What do you think the seal could be doing when the speed is high?*
2. *Where was the seal when it reached its slowest speed? What do you think the seal could be doing when the speed is low?*
3. *Where was the seal when it reached its highest curviness value? What do you think the seal could be doing when the curviness values are high?*
4. *Where was the seal when it reached its lowest curviness value? What do you think the seal could be doing when curviness values are low?*

Explore

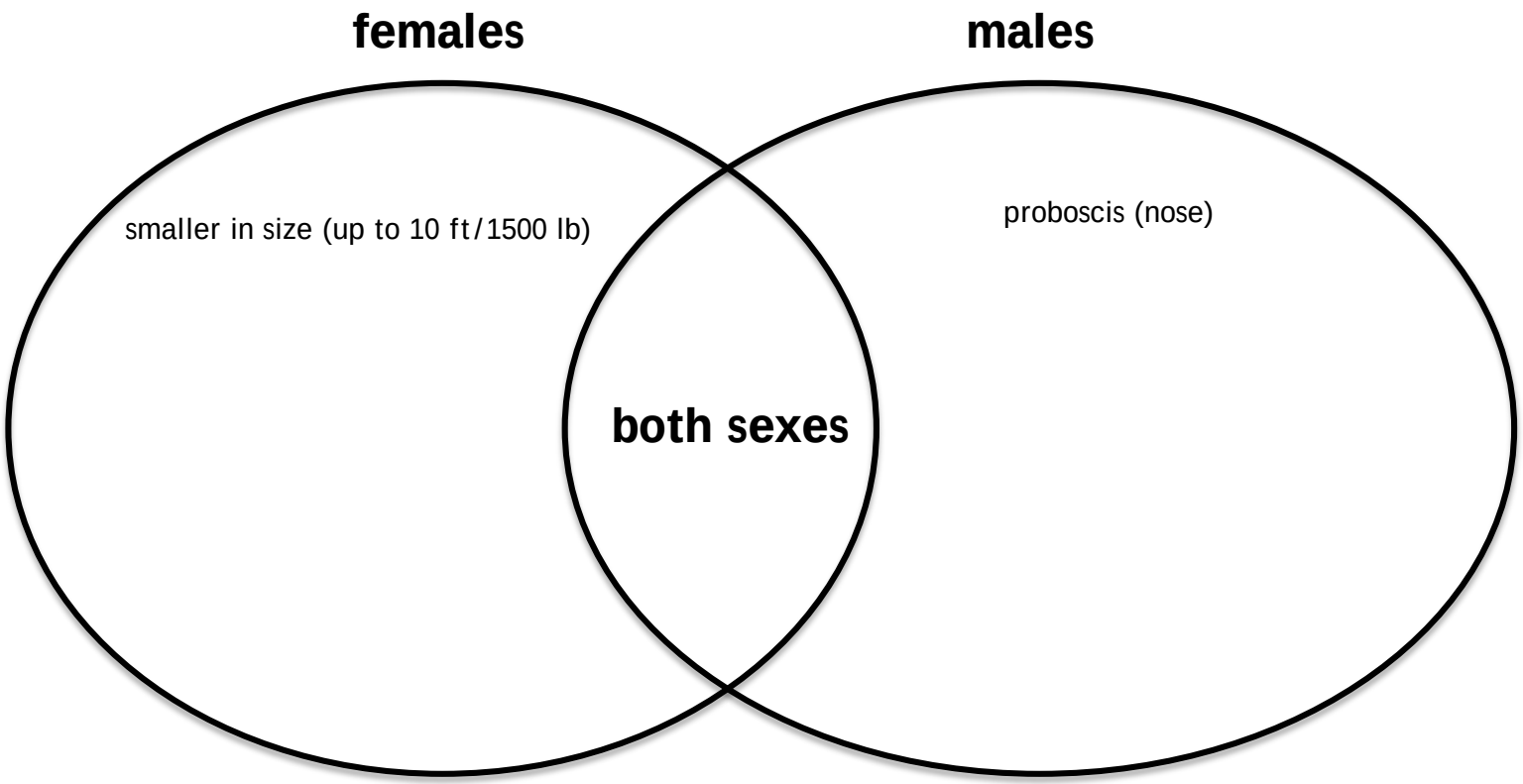
PART 2: COMPARE BEHAVIORS OF MALE AND FEMALE ELEPHANT SEALS

You will now learn more about the differences between male and female elephant seals and obtain useful clues for determining the sex of an elephant seal from its track.

- Create a Venn diagram like the one started on Slide 9.
- Use the information from the following sources to learn about similarities and differences between male and female elephant seals and add them to your Venn diagram:
    - Ocean Tracks Library http://oceantracks.org/library/
    - Earthguide: Elephant Seals Lifestyle http://earthguide.ucsd.edu/elephantseals/lifestyle/index.html
    - The timeline in Figure 4 on Slide 10.

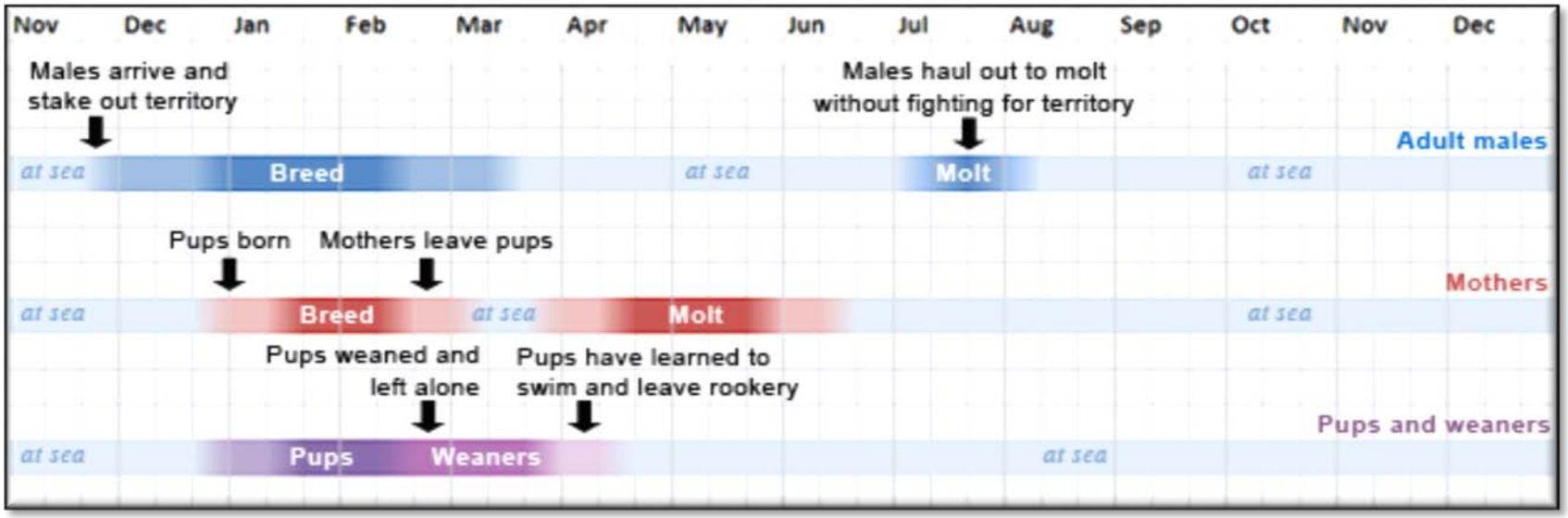
Explore

VENN DIAGRAM

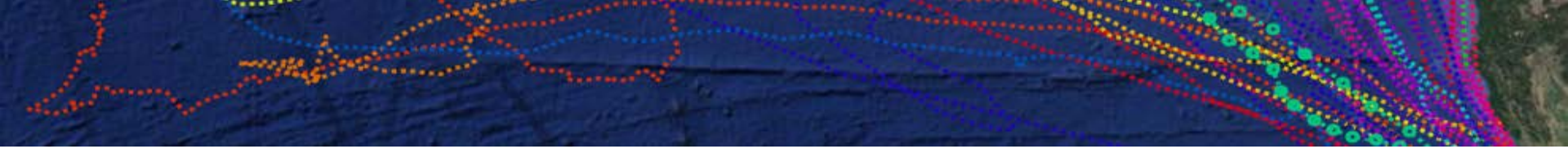


Explore

Figure 4. Timeline of Elephant Seal Annual Schedule



Source: ***Earthguide***

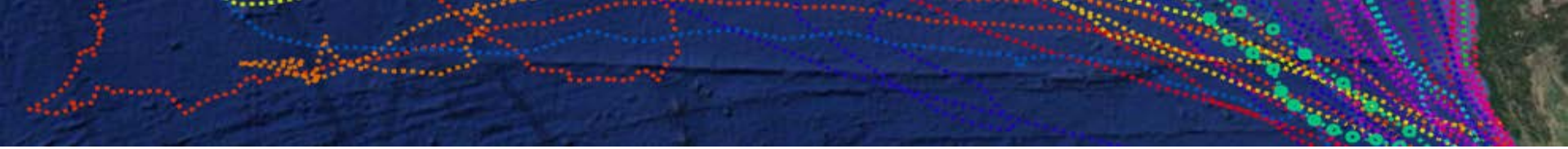


Explore

- Now that you have an understanding of some of the similarities and differences between male and female elephant seals, read the abstract for the paper "Foraging Ecology of Northern Elephant Seals" on Slide 12 to learn more about what scientists have learned about the sexes of elephant seals using tracking technology. If interested, read the full text of the paper: Le Boeuf, B. J., Crocker, D. E., Costa, D. P., Blackwell, S. B., Webb, P. M., & Houser, D. S. (2000). Foraging ecology of northern elephant seals. *Ecological Monographs, 70*(3), 353–382. http://tinyurl.com/leboeuf-full
- Add any relevant information from this abstract to your Venn diagram.

EXPLORE PART 2 QUESTIONS

1. *What was the prediction the scientists involved in the study were testing?*
2. *What data did the scientists collect?*
3. *What were some of the key differences that scientists found in the foraging locations of male and female elephant seals?*
4. *How does the amount of time seals spend in their foraging locations differ between male and female elephant seals?*
5. *What are the prey differences between male and female elephant seals? How is this linked to the shape of their dives?*
6. *Were the scientists able to support their prediction?*



Explore

Ecological Monographs, 70(3), 2000, 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

EXPLORE PART 3: INVESTIGATE FORAGING LOCATIONS OF ELEPHANT SEAL #302

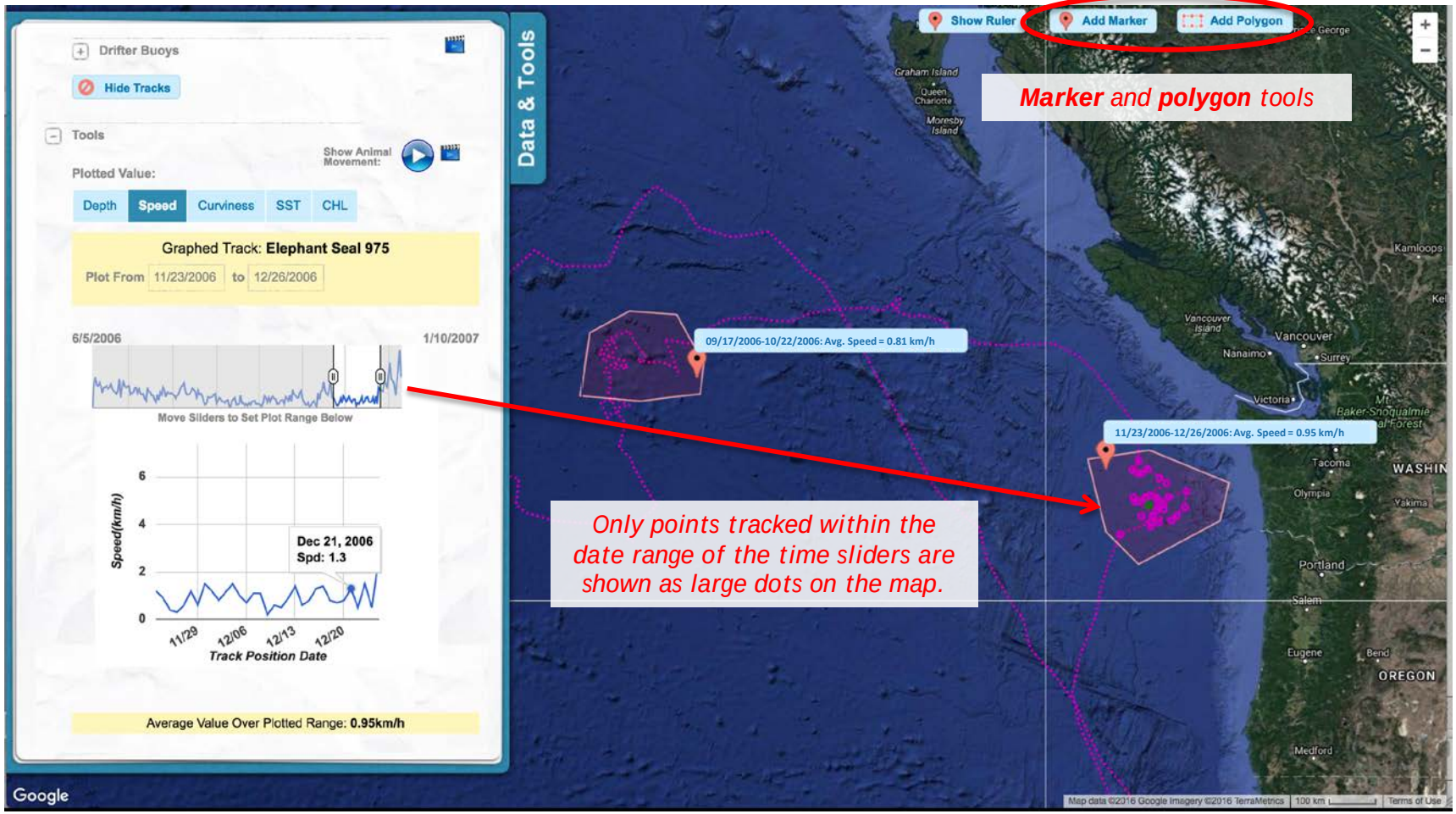
Now after learning about the characteristics of elephant seals and their behaviors, you know that feeding behaviors differ between males and females. Using this information, take a closer look at track #302 to identify possible foraging locations.

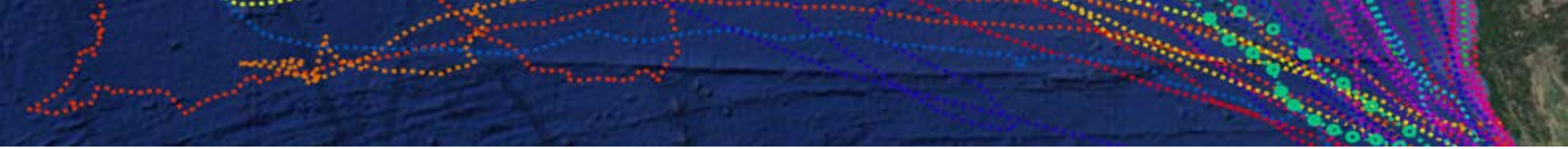
- Based on your observations of the track in motion and the speed and curviness data, identify two sections of the track in which you think the elephant seal is likely foraging for food. Also identify one area that you believe is not a foraging location.
- Use the **Add Polygon** tool to draw a shape around your two potential foraging locations and the one location you've identified as an area where the seal is unlikely to be foraging. 

    - Click on **Add Polygon** 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 under **Tools** 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 that section of the track. Repeat for your additional polygons.
- Refer back to the abstract from the Lebouf et al. paper. Use the polygon tool to outline the areas recorded in their study as being foraging areas for male and female elephant seals. Label each polygon as either "foraging locations for males" or "foraging locations for females."
- Save a screenshot of your annotated map. (See Figure 5 on Slide 14 for an example and helpful tips.)

Explore

Figure 5. Example Annotated Screenshot for Elephant Seal #975





Explore

EXPLORE PART 3 QUESTIONS

1. *What specific features of the track for Elephant Seal #302 led you to choose the potential foraging areas you selected? Reference specific date ranges, locations, and the shape of the track in your response.*

2. *What specific features of the track for Elephant Seal #302 led you to choose the potential non-foraging location you selected? Reference specific date ranges, locations, and the shape of the track in your response.*

3. *Now consider the speed and curviness values inside and outside of the foraging areas. How do these values inside your feeding area polygons compare to your non-foraging polygons? How does this comparison support or not support your foraging location choices? Use specific data values and/or averages in your explanation.*

4. *How do these potential feeding areas compare with the foraging areas described for male and female elephant seals in the Le Boeuf et al. paper?*

5. *What other data would help you identify the seal's foraging locations and whether this animal is male or female?*

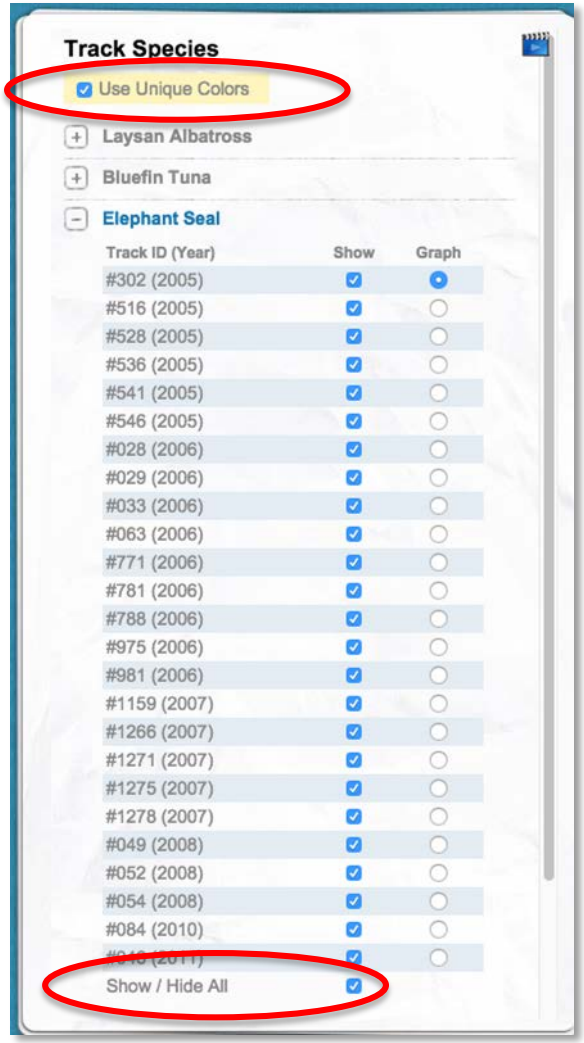
Explore

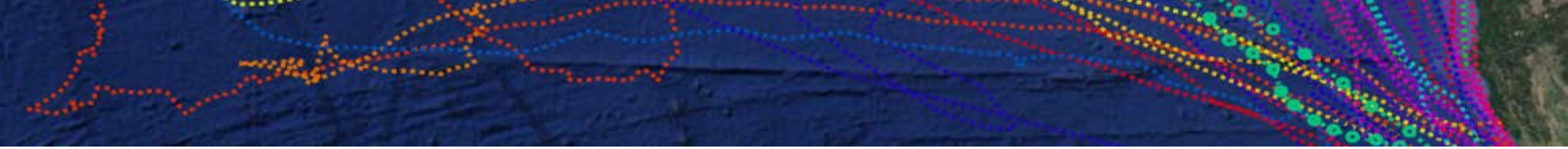
PART 4: COMPARE TRACK #302 TO OTHER TRACKS

Now, let's look at the other elephant seal tracks available in the Ocean Tracks interface 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.
- At the top of species list, 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 between the tracks.
- Make a table like Table 2 on Slide 17, and fill in the missing data for Elephant Seal #302. You should transfer the data values you've already recorded in Table 1.

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 2.

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	10,816.89 km	NPTZ	3.2 km/hr	-559.11 m
771	2/17/06	5/17/06	88	5,713.97 km	NPTZ	3.3 km/hr	-475.54 m
975	6/5/07	1/10/07	219	7,877.28 km	Off coast of Washington/ B.C.	2.25 km/hr	-529.86 m
1271	6/9/07	1/31//08	236	9,217.54 km	Gulf of Alaska	2.78 km/hr	-516 m
084	9/5/08	1/7/08	124	9,544.72 km	Aleutian Islands	2.22 km/hr	-585.83 m
046	3/17/11	7/13/11	118	6,793.41 km	Gulf of Alaska	1.67 km/hr	-544.59 m

Explore

EXPLORE PART 4 QUESTIONS

1. *How do the track data for Elephant Seal #302 compare with the data from the other seals? Use actual data points as examples to support your answers to the following questions:*

   a. *What similarities do you see between Elephant Seal #302's track data and the other seal tracks?*

   b. *What differences do you see between Elephant Seal #302's track data and the other seal tracks?*

   c. *What other patterns do you see in these data?*

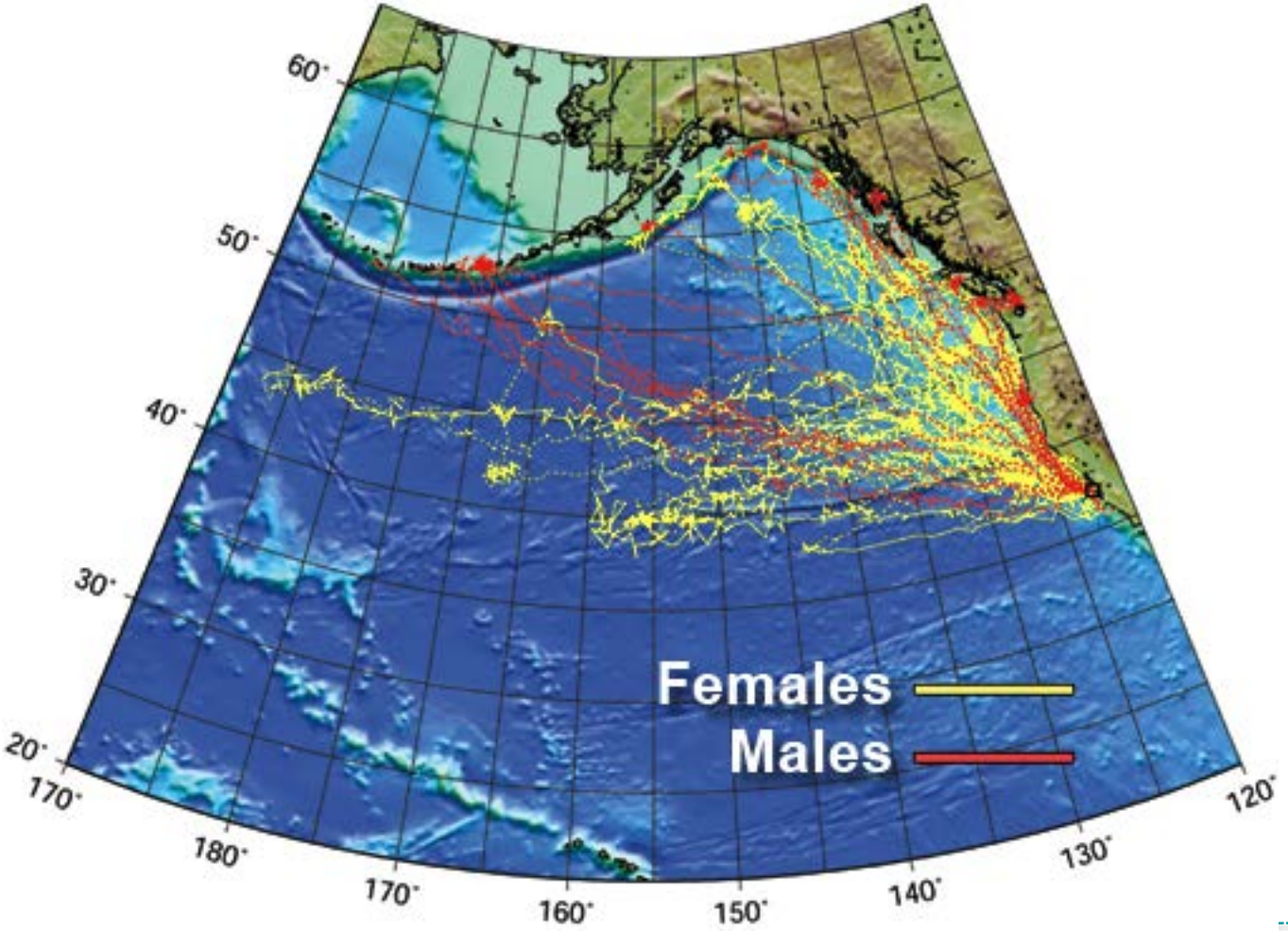
Examine Figure 6 on the next slide, showing elephant seal track patterns for male and female elephant seals as described in the paper "Foraging Ecology of Northern Elephant Seals" by Le Boeuf et al.

2. *What differences do you notice between the shapes of the tracks of male elephant seals compared with those of female elephant seals? What similarities do you notice?*

3. *How do the shapes of these tracks compare with the shape of Elephant Seal #302's track?*

4. *Based on your knowledge of elephant seal characteristics and the data you have collected in* ***Table 1****, can you find an example of a track other than Elephant Seal #302 in the Ocean Tracks interface that appears to belong to a female elephant seal? a male elephant seal? Along with your examples, identify the information and data that support your choice.*

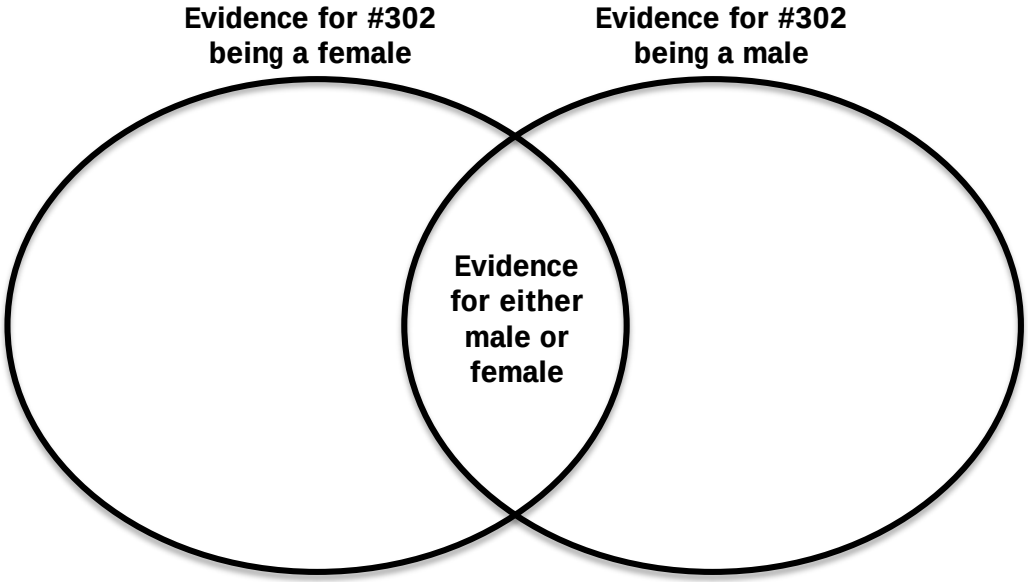
Figure 6. Male and Female Elephant Seal Migration Routes



Explore

PART 5: SORT YOUR EVIDENCE

Review the data you've collected throughout the module about Elephant Seal #302's migratory path, foraging locations (including track characteristics in these locations), timing of its migration, duration of time at sea, speed, and depth. Think about how these pieces of data fit into the Venn diagram below. Use the previous Venn diagram you made as a reference. Sort your evidence as supporting the conclusion that the seal is male or female. You might also find evidence that doesn't clearly distinguish the two sexes, which can go into the section where the two circles overlap. Don't worry if all your evidence doesn't neatly support one conclusion or another!



Synthesize

FINAL REPORT

Use the Venn diagram on the previous slide to develop a claim about whether Elephant Seal #302 is 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. **Your claim**: Based on your research, what conclusion have you come to? Is Elephant Seal #302 male or female?

2. **Your argumen**t: Explain how you arrived at your conclusion. (See Slide 23 for an example.)

    - How strongly does your evidence support your claim? Your assessment of strength should be based on how much evidence there is in the circle on the previous slide corresponding to the sex you chose vs. the sex you didn't choose. Show and describe the evidence you used to support your claim. This may include notes from your research, tables, graphs, and screenshots.

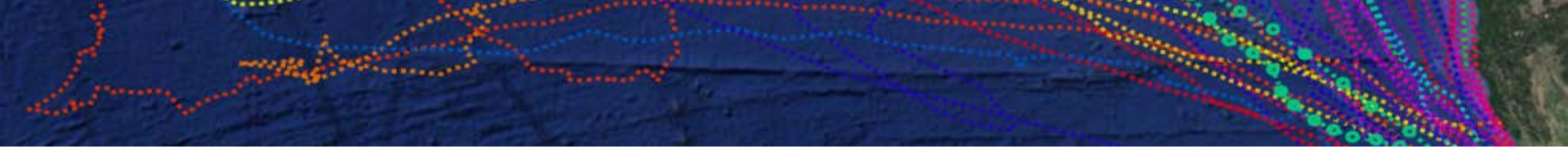
    - Explain why you selected each piece of evidence and how it helps support your claim.

3. **A 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 (see your Venn diagram on the previous slide)?

    - How would you rebut this counterclaim? Explain why your original claim is stronger than the counterclaim.

(CONTINUED ON NEXT SLIDE)



Synthesize

4. Your results: Using this case study, what did the tracking data reveal about the biology of ocean-going species and how they interact with their ocean environment?

Explain, in paragraph form, what you have learned about this question. Include responses to the following questions in your explanation.

- Thinking about the data in Ocean Tracks and in the Le Bouf et al. paper, what track features gave clues as to what male and female elephant seals eat?
- How does this information demonstrate the different roles male and female elephant seals play in their ecosystems?

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. 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:** Track Summary Statistics showing that track #046 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.