

A satellite-style map of the North Pacific Ocean. The map shows the Bering Sea to the west, the Gulf of Alaska to the north, and the North Pacific Ocean to the south. Overlaid on the map are numerous green and yellow dots and lines, representing movement tracks of top predators. The tracks are most concentrated in the central and eastern North Pacific, with a significant cluster of red and yellow dots near the coast of North America. Labels for 'Bering Sea', 'Gulf of Alaska', and 'North Pacific Ocean' are visible on the map.

Do You Come Here Often?

The Making of Biological Hotspots

Use Ocean Tracks to discover where top predators congregate in the North Pacific Ocean. Research behaviors of these animals in their hotspots, examine overlap between species hotspots, and draw conclusions about the oceanographic conditions that define these hotspots over space and time. Finally, consider how a better understanding of the characteristics and locations of these important habitats help us conserve and manage species more effectively as you explore the question:

What do patterns in oceanographic and animal movement data tell us about the biological functions of hotspots in the North Pacific Ocean?

Engage

What makes a hotspot a “hot” spot? The term hotspot can mean a lot of different things. In geology, a hotspot is a place where volcanoes form. In society, a hotspot can be an area of political, military, or civil unrest or the trendiest night club in town. In the tech world, a hotspot is where you can connect your favorite electronic device to a wireless internet connection. Any way you slice it though, a hotspot is essentially a place of high interest, activity, or popularity. The same is true in the ocean and in Ocean Tracks.

CLASS DISCUSSION

As a class, discuss the following questions.

1. *What oceanographic conditions and biological factors might attract animals to a particular area?*
2. *What patterns would you look for in tracking data to determine where a hotspot is located?*

In this module, you will use Ocean Tracks to identify hotspots and investigate the question:

What do patterns in oceanographic and animal movement data tell us about the biological functions of species’ hotspots in the North Pacific Ocean?

Learning Objectives

- Identify oceanic regions that appear to be species hotspots and biodiversity hotspots.
- Identify oceanographic features that align with hotspots.
- Analyze data to relate an organism’s hotspot location to the relevant ecological function.



Explore

PART 1: PREDICTING HOTSPOTS

Before you jump into looking for hotspots in Ocean Tracks data, take a minute to consider the kinds of hotspots you might find: hotspots visited by multiple species and hotspots for a single species.

Two Types of Biological Hotspots in Ocean Tracks

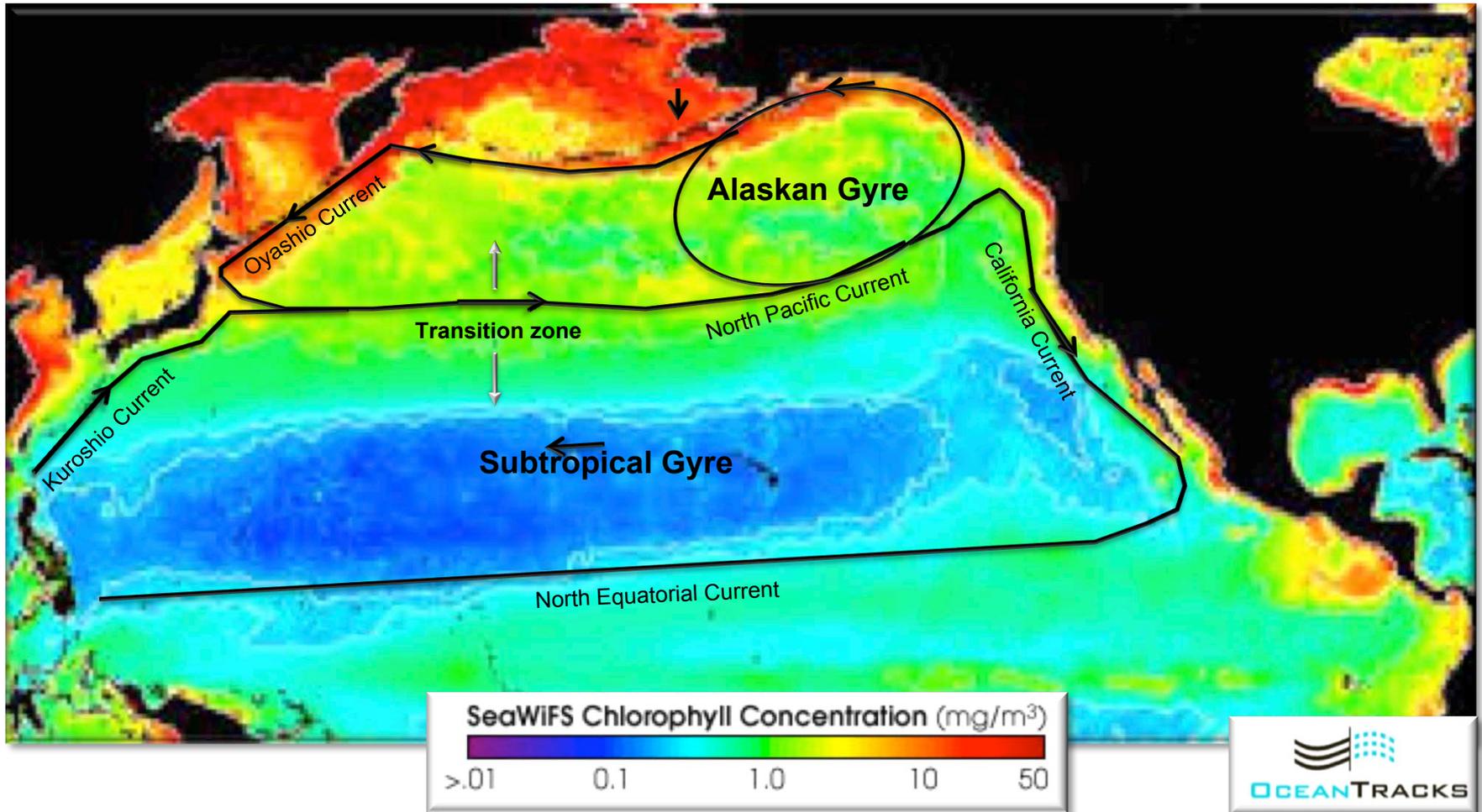
1. Biodiversity hotspots are areas that are used by many different species. In other words, these areas have high biological diversity.
2. Species hotspots are areas that are used by many individuals of the same species. These areas are important to one particular species, but may or may not have high biological diversity.

- Look carefully at Figure 1 on the next slide. Print a copy or save an image of the map.
- Spend some time thinking about the oceanographic factors that may be important for defining a biological hotspot.



Explore

Figure 1. Annually averaged, surface chlorophyll *a* distributions in the North Pacific Ocean, with major physical oceanographic, circulation features.



Explore

EXPLORE PART 1 QUESTIONS

1. *Based on your analysis of Figure 1 on slide 4, write a hypothesis stating where would you expect to find biological hotspots in the North Pacific Ocean and why you chose the location(s). Remember, a hypothesis is a **testable explanation** that is based on prior observations and knowledge.*
2. *On your printed or saved image of Figure 1, mark and label your predicted hotspot location(s) along with the oceanographic processes or conditions you identified that led you to choose your predicted location(s).*

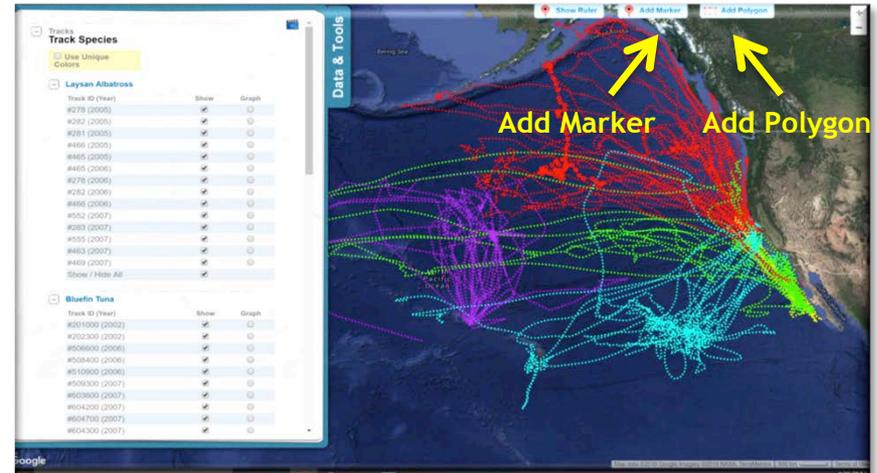


Explore

PART 2: MAKING TRACKS

Use Ocean Tracks to find out what parts of the North Pacific are most commonly traveled by four species of marine predators.

- Go to <http://oceantracks.org/map>.
- Use the **Data & Tools** Tab to access the **Tracks** menu.
- For each species, select the **Show All** tracks option to display all of the tracks for all four species at once. Be patient—this may take a while. You're loading a LOT of data into the interface!



EXPLORE PART 2 QUESTIONS

1. *What patterns do you notice in where these animals go?*
2. *Where do the tracks overlap for members of each species? Where do they overlap for more than one species? Use the **Add Polygon** Tool to draw boxes around areas of overlapping tracks and the **Add Marker** tool to add labels to the locations that you think are the hotspot(s) for that species. Your labels should include the name of the species' whose tracks pass through each polygon. Save a screenshot of your annotated map.*
3. *What questions do you have about the data patterns you have identified? Which tracks and/or areas of the North Pacific Ocean would you like to investigate further? Why?*

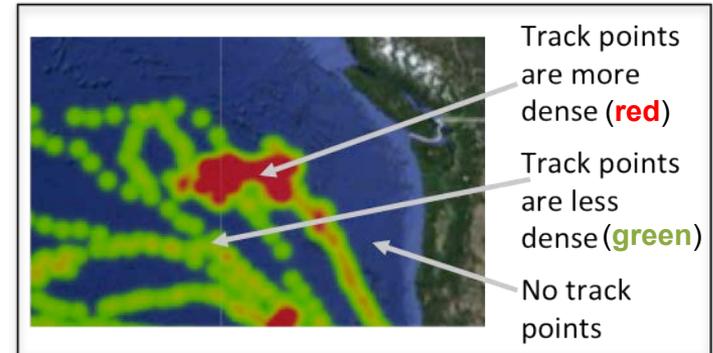


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PART 3: FINDING SPECIES HOTSPOTS

In this section, you'll use the Ocean Tracks hotspot tool to more accurately locate species hotspots in the North Pacific.

- Choose one species to investigate further. Leave all tracks displayed for this species. **Hide All** tracks for the other 3 species. Check the **Use Unique Colors** box at the top of the **Tracks** menu to make it easier to distinguish individual tracks from one another.
- Click the **+** to expand **Overlays** in the **Data & Tools** tab. Check the **Show Hotspot Map** box to turn on the hotspot tool. TIP: Once the Hotspot Map is turned on, click the **Hide Tracks** button to make it easier to see the hotspots on the map. (Learn more about the hotspot tool in the Ocean Tracks Library: <http://oceantracks.org/library/the-hotspot-tool/>.)
- Use the **Add Marker** tool to add a label to your map with the name of your chosen species. Save a screenshot of the labeled map.



The Ocean Tracks hotspot tool measures the density of points in a particular area.

EXPLORE PART 3 QUESTIONS

1. Compare the locations highlighted by the hotspot tool to the locations you identified in Part 1 as potential hotspots on the map in Figure 1. Discuss both similarities and differences.
2. What behavioral patterns would you expect to see for this species inside their hotspot(s)? What behaviors you would expect to see outside the hotspot(s)? What additional data would help you answer these questions? TIP: Use the Ocean Tracks Library (<http://oceantracks.org/library>) to learn more about typical behaviors of your chosen species.

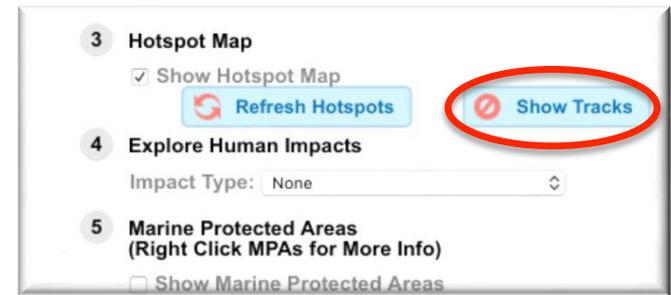


Explore

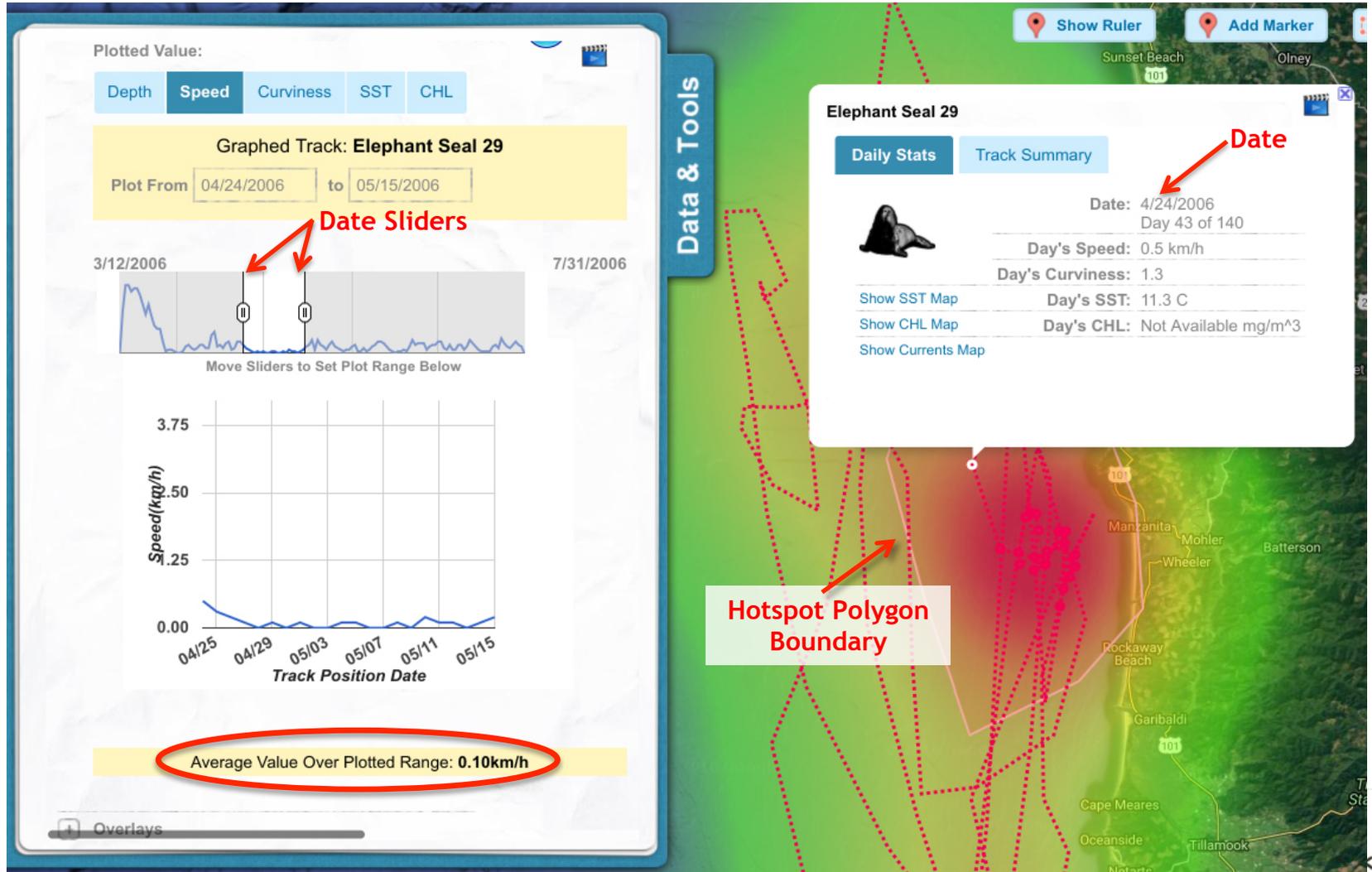
PART 4: ECOLOGICAL FUNCTION OF HOTSPOTS

Now, take a look at some of the other data available in Ocean Tracks that might help you determine what animals might be doing in the hotspots you have identified.

- With the **Hotspot Map** still turned on, click the **Show Tracks** button under **Overlays**.
- Scroll up to **Tracks** and check the **Show/Hide All** box for the species you are investigating to clear the tracks.
- **Show** and **Graph** a single track for this species.
- Click the **+** to expand the **Tools** menu and explore the behavior of this individual within one of the hotspot regions you have identified. To select the proper time interval:
 - Click on a few data points inside one of your marked hotspots on the map to determine the time interval over which the animal is within the hotspot (See Figure 2 on slide 9).
 - Under **Tools**, move the time sliders to only display the section of the track that is inside a hotspot.
- Look at graphs for **Depth**, **Speed**, **Curviness**, **CHL**, and **SST**.



Explore



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- Make a table like the one below, to record measurements for this track inside the hotspot. **NOTE:** If you are not familiar with the concept of **Curviness**, you can learn about it in the Ocean Tracks Library (<http://oceantracks.org/library/the-curviness-tool/>).
- Add measurements for at least 4 other individuals of this species whose tracks cross through the hotspot.
- Make a separate table for behavior outside the hotspot. Consider the animals' movements either just before or just after their time inside the hotspot region.

Table 1: Inside Hotspot

Animal Species/ ID	Average Speed (km/h)	Average Depth (m)	Curviness	Month/Year	Length of Stay (days)	Average CHL (mg/m ³)	Average SST (°C)
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EXPLORE PART 4 QUESTIONS

Analyze the data you have collected for both inside and outside your chosen hotspot.

1. *Compare and contrast the patterns of behavior you observed in the data both inside and outside the hotspot (e.g., average swimming speed, frequency/depth of dives, etc.). Cite specific Speed, Depth, & Curviness data in your response.*
2. *How well do these observed behaviors match your predictions? Describe both similarities and differences.*
3. *Consider the oceanographic conditions you observed both inside and outside the hotspot.*
 - a) *How can CHL and SST data help you understand the ecological function (the way organisms use, influence, and alter the environment) of some hotspots? Explain your reasoning*
 - b) *What can you infer from the data about the oceanographic conditions members of your chosen species prefer?*
4. *What might these oceanographic conditions behaviors indicate about the function the hotspot you have identified serves for this species? What additional information or data concerning the animals' movements and oceanographic conditions in and around the hotspot may be helpful in identifying the function this hotspot serves for your species?*
5. *How does understanding the characteristics and locations of species hotspots help us conserve and manage species more effectively?*



Synthesize

In this section, you will communicate your findings in a scientific poster. Before you get started, read one of the journal articles below to learn more of what scientists know about your chosen species and how it uses different areas of the ocean to help you refine your explanation of the hotspot you investigated.

Read the paper below that corresponds to the species you investigated. As you read, note the higher resolution data collection and analysis techniques utilized by the researchers, as compared to the data available in the Ocean Tracks interface.

- **Albatross:** Kappes, M. A., Shaffer, S. A., Tremblay, Y., Foley, D. G., Palacios, D. M., Robinson, P. W., ... & Costa, D. P. (2010). Hawaiian albatrosses track interannual variability of marine habitats in the North Pacific. *Progress in Oceanography*, 86(1), 246-260. <http://tinyurl.com/jh3kmce>
- **Elephant seals:** Robinson, P. W., Costa, D. P., Crocker, D. E., Gallo-Reynoso, J. P., Champagne, C. D., Fowler, M. A., ... & Yoda, K. (2012). Foraging behavior and success of a mesopelagic predator in the northeast Pacific Ocean: insights from a data-rich species, the northern elephant seal. *PloS one*, 7(5), e36728. <http://tinyurl.com/jm7xkhx>
- **Bluefin Tuna:** A. M. Boustani, R. Matteson, M. Castleton, C. Farwell, B. Block. 2010. Movements of Pacific bluefin tuna (*Thunnus orientalis*) in the Eastern North Pacific revealed with archival tags. *Progress in Oceanography* 86:94-104. <http://tinyurl.com/jtbn3d9>
- **White sharks:** Jorgensen, S. J., Arnoldi, N. S., Estess, E. E., Chapple, T. K., Rückert, M., Anderson, S. D., & Block, B. A. (2012). Eating or meeting? Cluster analysis reveals intricacies of white shark (*Carcharodon carcharias*) migration and offshore behavior. *PloS one*, 7(10), e47819. <http://tinyurl.com/hyd9rnh>



Synthesize

Assemble data and observations from your work on the Explore section of this module in the form of a scientific poster (see basic template below). The goal of this poster is to display your findings in a clear, concise, and visually interesting manner.

Title

Author, Institution

HYPOTHESIS (100 words or less)

State your hypothesis (from Explore Part 1) about where you expected to find hotspots in the North Pacific and why you chose those locations.

INTRODUCTION (200 words or less)

Write a brief overview of your hotspot investigation, including what species you chose and why (Explore Part 2), as well as how the data were collected. (TIP: Check the Ocean Tracks **Library** <http://www.oceantracks.org/library> for more information about your chosen species).

METHODS (100 words or less)

Describe the data you used to locate hotspots in Explore Part 3. Explain what the measurements represent and be sure to include units. Use figures and images to help convey this information.

RESULTS

Include the measurement data tables (Explore Part 4) you used to draw your conclusions. Also include relevant map screenshots.

CONCLUSIONS

In bullet form, state your conclusions about the location and ecological function of one biological hotspot for your chosen species. Explain how you arrived at your conclusions. Provide evidence, including reference to specific Ocean Tracks data values, to support your claims. To justify your conclusions, you should also refer to (and appropriately cite) relevant information from the journal article you read and any other resources you may have used. It's okay if your original hypothesis wasn't correct. If that was the case, include a revised hypothesis to accommodate your new findings, and describe further investigations you might do to confirm your new hypothesis.

