

Polar Bears in Peril – Climate Change Culprit?

Objectives

By the end of this lesson, students will be able to:

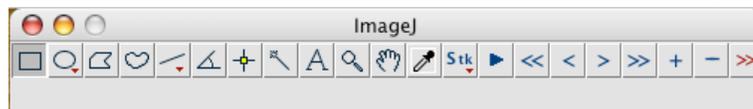
1. Use Image J, a public domain Java-based image processing software application (<http://rsbweb.nih.gov/ij/download.html>), to make measurements on an image.
2. Use Excel to plot data, create trend lines, and make predictions based on the data trend.
3. Explain why polar bears and other arctic wildlife that is dependent on pack and sea ice is threatened by climate change.

Introduction

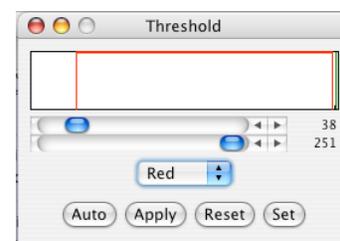
There has been much media attention in recent years to the changing conditions in the Arctic. Sea ice appears to be forming later and melting away sooner in regions such as the Hudson Bay. Animals like polar bears and walrus, which depend on the pack ice for a variety of reasons, could be affected by these changes – should they remain a long-term trend in the arctic climate.

To get an overview of monthly sea ice changes, you'll animate this stack of 333 satellite images to make a movie. This will allow you to review nearly 20 years of data in a matter of minutes. Enjoy the show!

1. In **Image J**, open the file *Sea Ice Extent.tif* by choosing **File > Open > Sea Ice Extent.tif**.
2. In **ImageJ**, start the animation by choosing **Image > Stacks > Start Animation**.
 - **Image > Stacks > Stop Animation** stops the animation.
 - Use Animation Options to control the speed, or use the "." and "," keys on your keyboard to move forward or back one frame at a time.
 - You could also choose to have the stack tools to show up in the tool bar. This will give you a controller for your animation.



3. Watch the movie carefully enough to get a sense of the changes in sea ice over a single year. You can look at the file names in the upper left corner of the window to see what month is being displayed.
 - What happens to sea ice over a year?
 - What month would you estimate has the most sea ice each year?
 - What month appears to have the least sea ice?
4. Close the stack *Sea Ice Extent.tif* and open the stack **NovemberStackA.tif**.
5. How can we measure the amount of sea ice coverage on Hudson Bay? To do it, we need some way of determining what is ice and what is not. This can be accomplished by using an **ImageJ** tool called **Threshold**.
6. Choose **Image > Adjust > Threshold**
Pixels that have values between 38 (15% ice) and 250 (100% ice) represent ice covered pixels. Threshold the image to highlight values from **38** to **251**. By using 251 instead of 250, you also select the pole hole region.

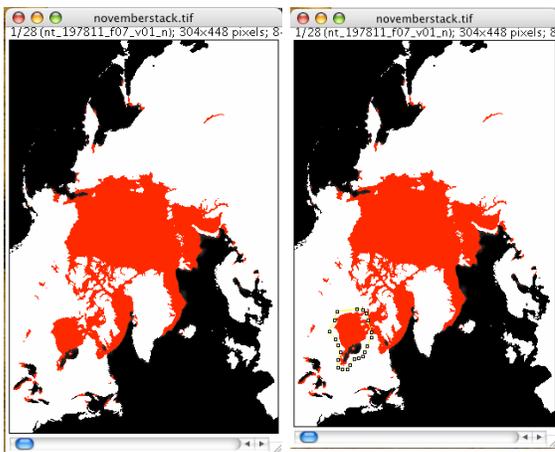


Do **NOT** click anything else in the Threshold window; simply close the Threshold window.

- Find Hudson Bay on your stack by referring to this map.



- Select the **polygon tool** in **ImageJ**. On the first image in your November stack, draw a polygon around Hudson Bay. The boundaries of the region that you select do not need to be exact, but you will want to select all of Hudson Bay and avoid other ice water areas such as lakes.



- To set ImageJ to record the measurements you want, choose Analyze > Set Measurements
- Check the boxes next to Area, Limit to Threshold, and Slice Number. Uncheck any other boxes. Click OK.
- Choose Analyze > Clear Results to delete any previous measurements from the Results file.
- Choose Analyze > Measure to have ImageJ count and record the number of highlighted pixels inside your selection.
- Advance to the next slice using the "." (period) key on your keyboard, then press Apple/M to record the measurement. Continue measuring for each slice in your stack. Each measurement you make will generate a new row in the Results table. Note: Don't worry if you measure a slice twice, this can be cleaned up in the next part of the process.

	A	B	C
1	Area	Slice	
2	1	1269	1
3	2	504	2
4	3	817	3
5	4	294	4
6	5	937	5
7	6	394	6
8	7	816	7
9	8	992	8
10	9	1453	9
11	10	717	10
12	11	352	11
13	12	1015	12
14	13	403	13
15	14	660	14
16	15	967	15
17	16	1178	16
18	17	176	17
19	18	688	18
20	19	289	19
21	20	539	20
22	21	50	21
23	22	229	22
24	23	377	23
25	24	290	24
26	25	623	25
27	26	100	26
28	27	457	27
29	28	336	28

When you have measured all 28 slices, save your Results so you can bring them into Excel for graphing.

- Click your Results window to make it active. Choose **File > Set File Extension** and enter **.xls** as the File Extension for tables.
- Choose **File > Save as...** and name your file **NovemberResults**. Save it in your **Documents** folder.
- Save your stack again.
- Open the **NovemberResults.xls** file from your Documents folder.

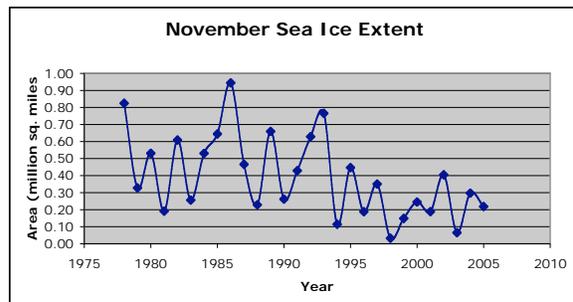
18. Column A shows your measurement number. Column B is the area covered by sea ice in each slice (in pixels). Column C is your slice number.
19. Add the word "Year" as a header label in the first column. You'll replace the numbers in this column from ImageJ with the year they represent: in cell A2 type 1978. In cell A3, type =A2+1 then fill the formula down through the rest of the column.
20. Now that you have the years, you will not need the Slice column (Column C) so you can delete it. Select the entire column and choose **Edit > Delete**.
21. Add a new column between Columns A and B. Enter a label in the top cell of the new column (cell B1). Type "Area (millions of square kilometers)."
22. Enter this formula in cell B2: $=(C2*625)/1000000$
This will multiply the area in C2 (the number of pixels covered by ice) by the area of a pixel (625 km²) and divide by 1 million. The result will be the total ice extent (area) in millions of km².
 - Copy this formula down column B.
 - Format the cells as numbers, and limit them to two decimal places.
 - Save your file.

	A	B	C
1	Year	Area (millions of km2)	Area
2	1978		1269
3	1979		504
4	1980		817
5	1981		294
6	1982		937
7	1983		394
8	1984		816
9	1985		992
10	1986		1453
11	1987		717
12	1988		352
13	1989		1015
14	1990		403
15	1991		660
16	1992		967
17	1993		1178
18	1994		176
19	1995		688
20	1996		289
21	1997		539
22	1998		50
23	1999		229
24	2000		377
25	2001		290
26	2002		623
27	2003		100
28	2004		457
29	2005		336

	A	B	C
1	Year	Area (millions of km2)	Area
2	1978	0.82	1269
3	1979	0.33	504
4	1980	0.53	817
5	1981	0.19	294
6	1982	0.61	937
7	1983	0.26	394
8	1984	0.53	816
9	1985	0.64	992
10	1986	0.94	1453
11	1987	0.47	717
12	1988	0.23	352
13	1989	0.66	1015
14	1990	0.26	403
15	1991	0.43	660
16	1992	0.63	967
17	1993	0.77	1178
18	1994	0.11	176
19	1995	0.45	688
20	1996	0.19	289
21	1997	0.35	539
22	1998	0.03	50
23	1999	0.15	229
24	2000	0.25	377
25	2001	0.19	290
26	2002	0.40	623
27	2003	0.07	100
28	2004	0.30	457
29	2005	0.22	336

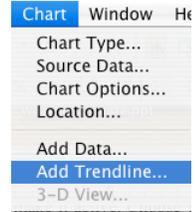
So, what does your data really show? Do polar bears have to wait longer each year to head out onto the ice? Next you will use Excel to graph your data to look more closely at the trend.

23. Select the Year and Area (millions of km2) columns (columns A and B) then click the **chart wizard icon** or choose **Insert > Chart** from Excel's menu bar.
24. Make an **XY (Scatter) graph** with points and smooth lines. Put Time (in years) on the X axis and Sea ice extent (in millions of square kilometers) on the Y axis.
 - Highlight the cells you are going to graph, Year and Area.
 - Click on the **chart wizard button**.
 - Choose "XY" scatter.
 - Choose next, next and finish. Your graph should look something like this.



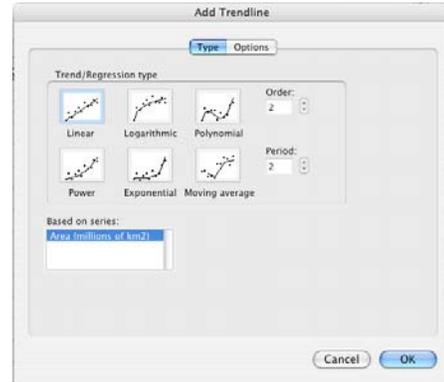
25. Add a linear trendline to your graph. Click your graph, then choose **Chart > Add trendline** and click the **Linear** option.

- What does the general slope of your trendline say about sea ice in Hudson Bay since 1979?

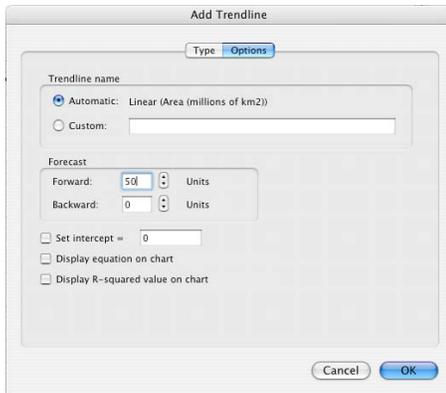


- Describe the relationship shown by your trendline.

- At the rate of decline shown by your chart, how much ice would you predict will be in Hudson Bay in November, 50 years from now?



26. With your chart active, click the Options tab to project your trendline into the future. Set the Forecast field to go Forward by 50 units (years).



- What year does your trendline predict there will no longer be sea ice on Hudson Bay?

Are we facing a real threat to our environment? What more should be done to investigate the potential harmful effects of a warmer Arctic?

Polar Bears in Peril – Climate Change Culprit?

Teachers Guide

Objectives

By the end of this lesson, students will be able to:

1. Use Image J, a public domain Java-based image processing software application (<http://rsbweb.nih.gov/ij/download.html>), to make measurements on an image.
2. Use Excel to plot data, create trend lines, and make predictions based on the data trend.
3. Explain why polar bears and other arctic wildlife that is dependent on pack and sea ice is threatened by climate change.

Relevant High School Science Content Expectations (Michigan Department of Education)

E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.

E5.4D Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere).

Technology Content Standards (MDE)

Content Standard 2: All students will use technologies to input, retrieve, organize, manipulate, evaluate, and communicate information.

Advanced Preparation

Download and install Image J on the computers in your lab, if it is not already present. Also copy the following files to a folder that the students will have access to:

1. Sea Ice Extent.tif (stack)
2. NovemberStackA.tif

Vocabulary Teachers should be familiar with the following terms/tools

stack

image

threshold

pixel

polygon tool

trendline

Introduction

There has been much media attention in recent years to the changing conditions in the Arctic. Sea ice appears to be forming later and melting away sooner in regions such as the Hudson Bay. Animals like polar bears and walruses, which depend on the pack ice for a variety of reasons, could be affected by these changes – should they remain a long-term trend in the arctic climate.

To get an overview of monthly sea ice changes, you'll animate this stack of 333 satellite images to make a movie. This will allow you to review nearly 20 years of data in a matter of minutes. Enjoy the show!

1. In **Image J**, open the file *Sea Ice Extent.tif* by choosing **File > Open > Sea Ice Extent.tif**.
2. In **ImageJ**, start the animation by choosing **Image > Stacks > Start Animation**.
 - **Image > Stacks > Stop Animation** stops the animation.
 - Use Animation Options to control the speed, or use the "." and "," keys on your keyboard to move forward or back one frame at a time.
 - You could also choose to have the stack tools to show up in the tool bar. This will give you a controller for your animation.

3. Watch the movie carefully enough to get a sense of the changes in sea ice over a single year. You can look at the file names in the upper left corner of the window to see what month is being displayed.
 - What happens to sea ice over a year? **The amount of coverage changes seasonally.**
 - What month would you estimate has the most sea ice each year? **February**
 - What month appears to have the least sea ice? **August**
4. Close the stack *Sea Ice Extent.tif* and open the stack **NovemberStackA.tif**.
5. How can we measure the amount of sea ice coverage on Hudson Bay? To do it, we need some way of determining what is ice and what is not. This can be accomplished by using an **ImageJ** tool called **Threshold**.
6. Choose **Image > Adjust > Threshold**

Pixels that have values between 38 (15% ice) and 250 (100% ice) represent ice covered pixels. Threshold the image to highlight values from **38 to 251**. By using 251 instead of 250, you also select the pole hole region.

Do **NOT** click anything else in the Threshold window; simply close the Threshold window.

7. Find Hudson Bay on your stack by referring to this map.
8. Select the **polygon tool** in **ImageJ**. On the first image in your November stack, draw a polygon around Hudson Bay. The boundaries of the region that you select do not need to be exact, but you will want to select all of Hudson Bay and avoid other ice water areas such as lakes.
9. To set ImageJ to record the measurements you want, choose Analyze > Set Measurements
10. Check the boxes next to Area, Limit to Threshold, and Slice Number. Uncheck any other boxes. Click OK.
11. Choose Analyze > Clear Results to delete any previous measurements from the Results file.
12. Choose Analyze > Measure to have ImageJ count and record the number of highlighted pixels inside your selection.
13. Advance to the next slice using the "." (period) key on your keyboard, then press Apple/M to record the measurement. Continue measuring for each slice in your stack. Each measurement you make will generate a new row in the Results table. Note: Don't worry if you measure a slice twice, this can be cleaned up in the next part of the process.

When you have measured all 28 slices, save your Results so you can bring them into Excel for graphing.

14. Click your Results window to make it active. Choose **File > Set File Extension** and enter **.xls** as the File Extension for tables.
15. Choose **File > Save as...** and name your file **NovemberResults**. Save it in your **Documents** folder.
16. Save your stack again.
17. Open the **NovemberResults.xls** file from your Documents folder.
18. Column A shows your measurement number. Column B is the area covered by sea ice in each slice (in pixels). Column C is your slice number.
19. Add the word "**Year**" as a header label in the first column. You'll replace the numbers in this column from ImageJ with the year they represent: in cell **A2** type **1978**. In cell **A3**, type **=A2+1** then fill the formula down through the rest of the column.
20. Now that you have the years, you will not need the Slice column (Column C) so you can delete it. Select the entire column and choose **Edit > Delete**.
21. Add a new column between Columns A and B. Enter a label in the top cell of the new column (cell B1). Type "**Area (millions of square kilometers)**."

22. Enter this formula in cell B2: $=(C2*625)/1000000$ This will multiply the area in C2 (the number of pixels covered by ice) by the area of a pixel (625 km²) and divide by 1 million. The result will be the total ice extent (area) in millions of km².
- Copy this formula down column B.
 - Format the cells as numbers, and limit them to two decimal places.
 - Save your file.

So, what does your data really show? Do polar bears have to wait longer each year to head out onto the ice? Next you will use Excel to graph your data to look more closely at the trend.

23. Select the Year and Area (millions of km²) columns (columns A and B) then click the **chart wizard icon** or choose **Insert > Chart** from Excel's menu bar.
24. Make an **XY (Scatter) graph** with points and smooth lines. Put Time (in years) on the X axis and Sea ice extent (in millions of square kilometers) on the Y axis.
- Highlight the cells you are going to graph, Year and Area.
 - Click on the **chart wizard button**.
 - Choose "**XY**" **scatter**.
 - Choose next, next and finish. Your graph should look something like this.
25. Add a linear trendline to your graph. Click your graph, then choose **Chart >Add trendline** and click the **Linear** option.
- What does the general slope of your trendline say about sea ice in Hudson Bay since 1979?
The amount of sea ice has been declining.
 - Describe the relationship shown by your trendline.
The relationship is inverse – as time increases, sea ice coverage decreases.
 - At the rate of decline shown by your chart, how much ice would you predict will be in Hudson Bay in November, 50 years from now?
Zero. The arctic will be ice free year round.
26. With your chart active, click the Options tab to project your trendline into the future. Set the Forecast field to go Forward by 50 units (years).
- What year does your trendline predict there will no longer be sea ice on Hudson Bay?
~ 2020

Are we facing a real threat to our environment? What more should be done to investigate the potential harmful effects of a warmer Arctic?





