Birds, Bioaccumulation, and the Bay

Overview: Students act as biologists, analyzing pollution and survival data from Forster's and Caspian Tern colonies in the San Francisco Bay Area. They will learn to manipulate data into formats, allowing them to draw conclusions from it. Students will make educated guesses based on the data, as well as design further experiments that might support the data. This can be carried out as an in class group project or a homework assignment.

Objectives: At the end of this activity, students will:

*be able to write an algebraic formula to answer a question
*be able to translate numerical data into a graph format
*compare data and draw conclusions based on the comparisons
*define bio-accumulation and bio-magnification
*describe one way the individual can impact the process of bio-accumulation/bio-magnification

This activity is based on an actual on-going study. The San Francisco Bay Bird Observatory (SFBBO) in cooperation with the U.S. Fish and Wildlife Service (FWS) has monitored tern populations throughout the San Francisco Bay Area for population health and the effects of pollutants like mercury, PCB's and other chemicals. The study is on-going as of 2004.
See Species Overview sheet and Teacher Data Sheet.
The study was carried out by monitoring tern nests during May and June, the peak of nesting season in the Bay Area. Tern colonies were marked with stakes at the beginning of the season, and then monitored sometimes by scope observation, and also by walk- throughs of the colonies. Eggs were also collected from each site, and sent to a laboratory for pollutant analysis.
Biologists and volunteers participated in this study, watching for many hours with scopes and kayaking out to islands where the terns nested. Hazards of the job include being dive-bombed by the birds, mobbed by many birds at once, and having the occasional whitewash land on your head (hats are recommended).

Species Overview

Terns

Terns are members of the gull family. However, most terns are much more accurate and skillful in their flight compared to gulls. Terns generally live near bodies of water including lakes and marshes. There are many species of terns, but this study focuses on two that can be seen in the San Francisco Bay Area: the Forster's Tern and Caspian Tern. The Forster's Tern is the smaller of the two, feeding on fish as well as flying insects. The Forster's Tern is about half the size of a Western Gull you might see around your school. The Caspian Tern feeds on fish and crustaceans. Both terns feed by hovering above the water (20-50 feet), diving and grabbing just under the water surface. The Caspian Tern is about ¾ the size of a gull.
Terns can be seen in the San Francisco Bay Area primarily in the spring and summer months. Caspian Terns migrate south to Central and South America in the winter months.

Jacksmelt

These fish are fairly common in the San Francisco Bay and can be found near the surface of the water. Jacksmelt feed on small crustaceans and plankton. They can be up to 17 inches long, but most are smaller. The fish are omnivores, eating algae and crustaceans.

Polychaete

Polychaetes are not a species name, but a class of worms (under the phylum Annelida). There are many types of polychaetes, and they can be found in San Francisco Bay water and mud. All polychaetes have many bristles or legs. Polychaetes eat many things, but most filter feed very microscopic particles like plankton.
Sources: The Birder's Handguide, The Sibley Guide to Birds, www.sfbaymsi.org, http://www.delta.dfg.ca.gov/baydelta/monitoring/jack.asp

Terns are high up on the food chain. This means they are on a similar ***trophic level*** *as people. A tern eats fish that eat water insects that eat algae. People also eat fish, that eat water insects that eat algae. Examining a tern*

will give us an idea of how much pollution is in the watershed AND the effects of accumulating the pollution over time.

Scientists at the San Francisco Bay Bird Observatory in the South Bay designed and conducted a study on Terns and pollutants. The study was carried out by monitoring Tern nests during May and June, the peak of nesting season in the Bay Area. Tern colonies (groupings of nests) were flagged at the beginning of the season, and then monitored sometimes by scope observation, and also by walk-throughs of the colonies. Scientists kept track of egg hatching, chick mortality from predators or other causes, as well as eggs that were discarded. Eggs were also collected from each site, and sent to a laboratory for pollutant analysis.

Your worksheet contains data from the study. Your job as a biologist is to arrange the data in a different format so that you can answer some questions about pollution and its effects on Terns. The worksheet has specific questions and tasks for you to complete. The process is similar to what biologists do in their studies.

Tern Data Sheet

Data Definitions:

PPM: parts per million meaning that for every million part of liquid, there is one part of mercury.

Above 0.5 ppm of mercury is known to affect whether or not an egg will hatch as well as bird development in general.

Mercury Concentration By Area and Species

-SPECIES	REGION	Mercury PPM	SPECIES	REGION	Mercury PPM
Caspian	South	1.773	Forsters	South	0.375
Caspian	South	1.367	Forsters	South	0.610
Caspian	South	1.152	Forsters	South	0.727
Caspian	South	0.610	Forsters	South	0.408
Caspian	South	1.012	Forsters	South	0.816
Caspian	Central	0.677	Forsters	South	1.944
Caspian	Central	1.046	Forsters	South	3.334
Caspian	Central	0.713	Forsters	Central	0.699
Caspian	Central	0.723	Forsters	Central	0.463
Caspian	Central	0.419	Forsters	Central	0.537
Caspian	North	1.108	Forsters	Central	0.435
Caspian	North	0.483	Forsters	Central	0.379
Caspian	North	1.114	Forsters	North	0.824
Caspian	North	0.817	Forsters	North	0.564
Caspian	North	0.978	Forsters	North	0.788
			Forsters	North	0.342
			Forsters	North	0.604
			Forsters	North	0.707

Forster's Terns

		total # nests	total # eggs	live chicks	dead chicks	addled eggs
Central Bay	total central bay pop	557	1050	82	76	0
North Bay	total north bay pop	300	707	66	77	297
South Bay	total south bay pop	1545	3404	500	150	185

Caspian Terns

	total # nests	total # eggs	live chicks	dead chicks	addled eggs
south	120	210	27	5	3
central	80	145	36	10	33
north	145	251	95	24	5

Data Definitions

Addled eggs: Term refers to eggs where the embryo dies before hatching. In this study, it refers to eggs that are rejected or pushed out of the nest by the parent bird. Some birds can sense when eggs are "bad," and will push them out of the nest.

Total # eggs: total number of eggs in a population that could have hatched. Does not include dead chicks or addled eggs. Remember, dead chicks and addled eggs represent part of the potential for the population in addition to the total # eggs.

Dead Chicks: includes chicks that may have been predated by gulls, or other predators.

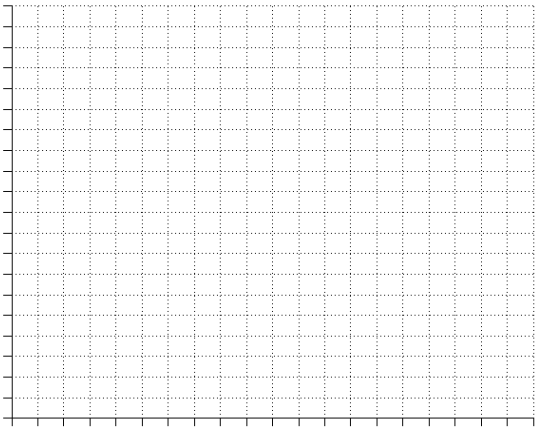
1. Write a formula that calculates the success rate of a tern colony in the form of a percentage (%). Keep in mind you may not use all of the data elements gathered to develop this formula.

2. Find the success rates (%) of Caspian Terns for the North Bay, Central Bay, and South Bay. Show one sample calculation of a success rate.

North Bay
Central Bay
South Bay

2b. Find the success rates (%) of Forster's Terns for the North Bay, Central Bay, and South bay.
North Bay
Central Bay
South Bay

3. Graph the success rates (%) to summarize which colony was the most and least successful. Include the Caspian Tern and Forster's Tern rates on the same graph for comparison. Are there any patterns in the graphs?



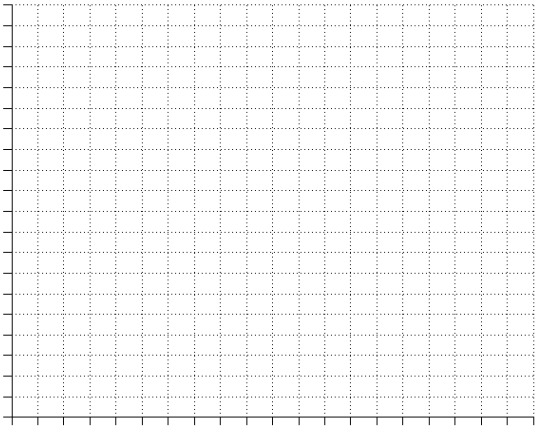
a. What area had the highest success rate for the Forster's Terns? For the Caspian Terns?

b. What area had the lowest success rate for the Forster's Tern?
For the Caspian Terns?

4. Find the average egg mercury (Hg) measurement in the north bay, central bay, and south bay in Forster's Terns. Show one example of your calculations
Sample Calculation
North Bay
Central Bay
South Bay

4b. Repeat the process above for Caspian Terns
North Bay
Central Bay
South Bay

5. Graph the average mercury concentrations for the North, Central, and South Bay areas. Include Caspian Tern and Forster's Tern data on the same graph. Are there any patterns in the graph?



a. What area has the highest mercury concentration in Forster's Tern eggs? In Caspian Tern eggs?

b. What area has the lowest mercury concentration in Forster's Tern eggs? In Caspian Tern eggs?

6.Looking at graphs for success rate and mercury concentration, can you see any patterns? Any relationships between success rate and mercury concentration?

7. Can any strong conclusions be drawn about mercury contamination and its effects on birds in the San Francisco Bay Area? If so, what are the conclusions? If not, what should be done to determine more concrete conclusions?

8. Can any conclusions be drawn about mercury contamination and its potential effects on people in the San Francisco Bay Area?

9. How do the Terns absorb mercury into their bodies, ie where is the mercury coming from? How is the process related to bio-accumulation and biomagnifications?

10. Name some other pollutants that may be entering the watershed directly from our streets and neighborhoods. How are they pollutants reaching the streams/Bay? What can we do to prevent this?