INTEGRATE MODULE SUSTAINING OUR OCEANS

Unit 4

Oceans in Peril: Pressures on Ocean Ecosystems

Climate Change Studies Related to Oceans
Evidence and Interpretation of Environmental Factors

Temperatures Rise

Arctic sea ice melts

Increase In Global Sea Levels

Increase In Ocean Temperatures

As reflective ice disappears, darker ocean waters absorb more heat

Climate Change Studies Related to Oceans
Evidence and Interpretation of Biological Factors

Temperatures Rise

Arctic sea ice melts

Reduced habitat leads to food shortages

Reduced polar bear cub survival

Increase In Ocean Temperatures

As reflective ice disappears, darker ocean waters absorb more heat

Climate Change Studies Related to Oceans
Evidence and Interpretation of Biological Factors

Temperatures Rise

Hydrosphere

Hydrosphere/
Cryosphere

As reflective ice disappears, darker ocean waters absorb more heat

Hydrosphere

Increase In Ocean Temperatures

Atmosphere

Hydrosphere/
Cryosphere

Arctic sea ice melts

Reduced habitat leads to food shortages

Biosphere

Reduced polar bear cub survival

Gray Whale as Ecosystem Sentinel

What is an Ecosystem Sentinel?

- Animals that serve as an indicator of the health of the ecosystem.
- *Seabirds and marine mammals are conspicuous animals that integrate changes in the ecosystem and reflect the existing state of the environment* (Aguirre and Tabor 2004; Boersma 2008; Thiele et a1. 2004).

Gray Whale Global Distribution

Blue areas on map represent gray whale habitat for Western Pacific and Eastern Pacific populations. Labels provided for Western Pacific Stock indicating feeding grounds, breeding grounds and migratory routes.

The Gray Whale Life Cycle; Migratory and Feeding Behaviors

Summer Feeding Grounds – In higher latitudes, gray whales feed from late spring to early fall.

Fall Migration – Southbound whales travel to the breeding lagoons when ice forms in the Arctic, around November.

Mating and Calving Grounds – By January, most gray whales are occupying the breeding areas.

Spring Migration – Northward migration occurs from January through June.

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Winter Mating/Calving | Spring Migration | Summer Feeding | Fall Migration

Environmental Factors

Sea Ice:

- Reduction in sea ice allows gray whales more access to feeding grounds in Arctic areas in the winter.

- Following reduction in sea ice, greater numbers of calves were counted on northbound migration.

Environmental Factors

- Prey Availability: Gray whales are opportunistic feeders and can shift their primary feeding grounds in response to prey densities.
- *"I suspect the gray whales will be among the winners in the great climate change experiment." UC Berkley News Center*

http://newscenter.berkeley.edu/2011/07/06/gray-whales-likely-survived-the-ice-ages-by-changing-their-diets/

Environmental Factors

- Regime Shift = a major reorganization of biota in the northeast Pacific, related to Pacific Decadal Oscillation.

The Pacific Decadal Oscillation (PDO) is a long-term ocean fluctuation of the Pacific Ocean with cool and warm phases oscillated every 20–30 years.

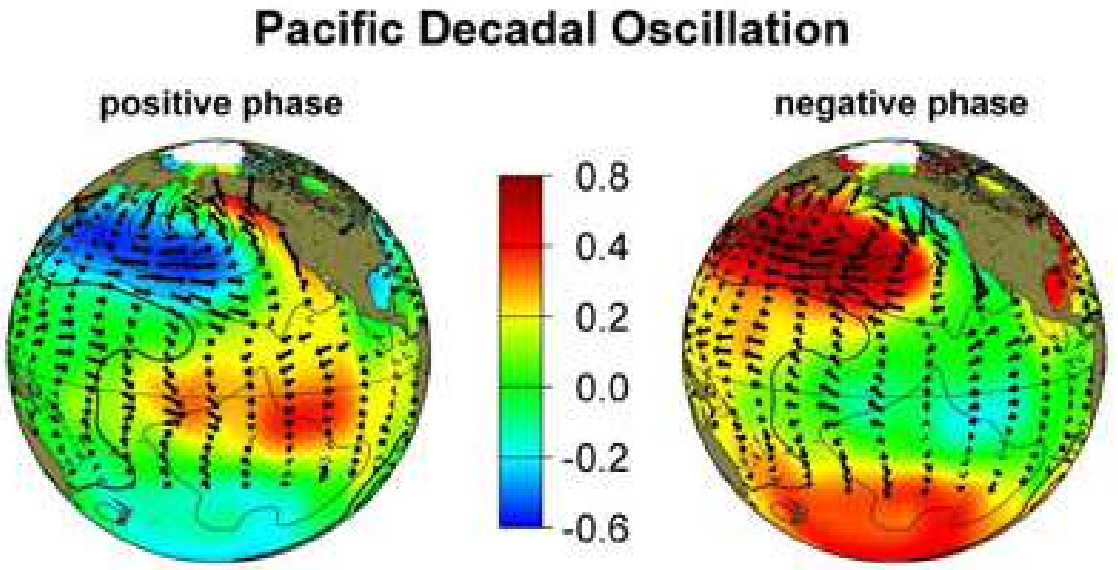


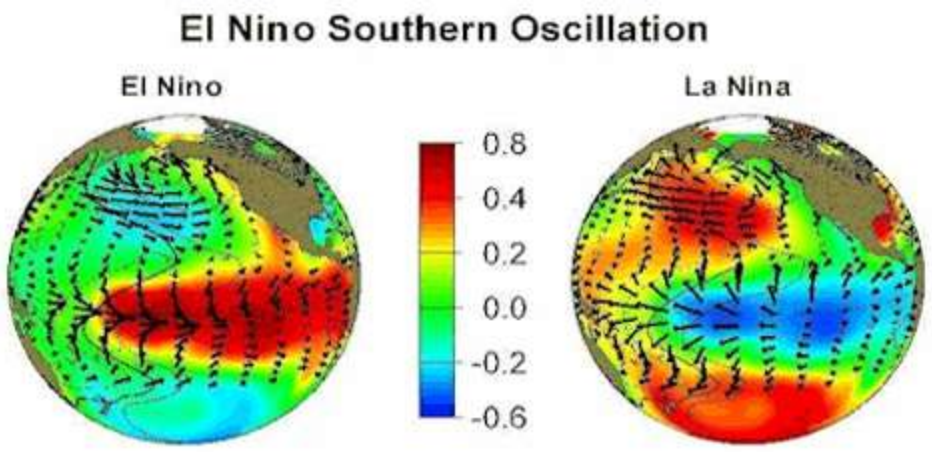
Image courtesy of Stepen Hare and Nathan Mantua, University of Washington, units are degrees Celsius

- During the 1970s warm phase, gray whales showed a one-week delay in southbound migration.

Environmental Factors

- Warm El Nino and Cold La Nina extremes
- El Nino is a disruption of the ocean-atmosphere system which causes ocean temperatures to increase by a few degrees.

- Mothers and calves have shown changes in occupancy and departure time from breeding lagoons in response to the extremes of ocean temperatures correlated with El Nino Oscillation events in the Pacific Ocean.



Activity – Gallery Walk

1) Group Assignment
- Concept/Change in gray whale behavior
- Evidence

2) Station Rotations

1) Evidence

2) Interpretation/ Change In Environment

3) Category of Life Cycle

4) Review and Comment

3) Group Report

Orally summarize evidence and interpretation for class at original station

Rotation 1 – Change in Distribution and/or Behavior of Gray Whale

List the evidence for this scientific study provided in the "Marine Mammals As Ecosystem Sentinels" article.

Rotation 2 – Interpretation Related to Climate Change

Propose a scientific reason for the scientific study provided to you in the last rotation. This reason should be related to climate change, or interpretation for this noted evidence.

Rotation 3 – Life Cycle Affected

Categorize the evidence and interpretation as to which part of the Gray Whale Life Cycle is most affected, feeding (wintering grounds), breeding (summering grounds), or migration route.

Rotation 4 – Review Evidence and Interpretation.

- 1) Review the posts provided by the first 3 rotations.
- 2) Agree or disagree with the evidence and interpretation.
- 3) Note any changes in writing on the poster. Include comments, additional facts or evidence, or alternative interpretations.

Wrap Up/Summary

Reference	Evidence	Interpretation
Rugh et al. 2001	One-week delay in southbound migration	Response to late 1970s regime shift in the North Pacific (see text)
Perryman et al. 2002	Increase in calf production coincident with ice-free Chirikov Basin in early spring	Response to early access to prime feeding areas by pregnant females
Urban et al. 2003	Reduction in calf numbers and changes in timing of occupation of breeding lagoons by gray whales	Response to 1997–1998 El Nino perturbation of the North Pacific ecosystem
Moore et al. 2003	Lack of gray whales feeding during July in the Chirikov Basin	Response to benthic prey decline in the Chirikov Basin and possible enhancement of prey base in southern Chukchi
Moore et al. 2007	Gray whales feeding year-round offshore Kodiak Island, Alaska	Response to localized prey availability along the migration route
Stafford et al. 2007	Gray whale calls detected in the western Beaufort Sea over the winter of 2003–2004	Response to reduction in sea ice, providing access to Arctic areas over winter

Station Design Template

Four stations – poster paper taped to walls or places on flat tables around room

Screen/White Board

Station 1
Southbound Migration
Evidence:
Interpretation:
Life Cycle Stage:

Station 2
Calf Numbers And Lagoon Occupancy
Evidence:
Interpretation:
Life Cycle Stage:

Center of room (wall posters version)
or filled with table tops (larger groups)

Station 3
Feeding Year Round
Evidence:
Interpretation:
Life Cycle Stage:

Station 4
Gray Whale Calls
Evidence:
Interpretation:
Life Cycle Stage:

- Instructor Labels Station Number and Scientific Study (Underlined)
- Students fill in Evidence, Interpretation and Life Cycle Stage during rotations

Sample Station Poster – Completed

- **Station 1**: Southbound Migration
- **Evidence**: One-week delay in southbound migration, as noted by coastal whale counts
- **Interpretation**: Response to the late 1970s regime shift in the North Pacific
- **Life Cycle Affected**: Migration