Climate Change: Impacts on Coastal and Marine Ecosystems

- **Temperature** => organism metabolism => productivity and species interactions
- **Precipitation** & sea-level rise => water balance of coastal ecosystems/migration
- **Patterns of winds and currents** =>
  1. Upwelling/downwelling => nutrients and oxygen &
  2. Regional temperatures => geographic distributions of marine species
- **Temperature + Freshwater** => stratification => ocean productivity
- **CO2 + temperature** => coral reefs
- **All of the above** => wetlands, estuaries
GLOBEC

To advance our understanding of the structure and functioning of the global ocean ecosystem, its major subsystems, and its response to physical forcing so that a capability can be developed to forecast the responses of the marine ecosystem to global change

A study of Global Ocean Ecosystem Dynamics, FY: 1990-2010
Estuarine Food Web (trophic levels)
Australia: 
Marine life change
➢ changes to ocean chemistry (ie. acidification) impeding the ability of organisms to build shells
➢ ocean circulation influencing population dynamics
➢ change in cloud cover and sea ice affecting light supply to the ocean surface.
Arctic marine food web. Ice algae at the base of the marine food web may have already been affected by warming over the last few decades.
Coastal Systems

- Predicting effects of sea-level rise on shallow continental margins, including flooding of wetlands, shoreline erosion, and enhanced storm surges.

- Predicting the effects of climate change on precipitation, wind patterns, and the frequency and intensity of storms
Estuaries

Freshwater from rivers meets and mingles with saltwater from oceans—most biologically productive ecosystems on Earth—source of a food web that begins with conversion of the sun's energy into food energy by marsh plants—are home to only certain types of plants—those that can flourish in the physical conditions peculiar to estuaries—provide critical habitat for certain wild animals at some stage of their lives.
Precipitation and Hydrologic Regime

Freshwater flow regime

Legend:
- Construction of impoundments (e.g. dams and weirs) and water extractions ( ) reduce the inflow of freshwater ( ) into estuaries
- Flushing is reduced in the upper and mid reaches of the estuary
- Salinity increases upstream
- Mangroves and other salt tolerant species (e.g. estuarine/marine fish) ( ) extend further upstream with increased salinity
- Reduced freshwater inflows (i.e. reduced flooding) may result in a loss of connectivity ( ) with adjacent habitats (e.g. floodplain billabongs)
- Siltation is increased in mid and upper estuarine reaches
- The lack of freshwater pulses impacts on the spawning/reproduction, migration and production of estuarine species

Queensland Government
Environmental Protection Agency
Sea-level Rise

Reconstructed satellite images show the Everglades (Florida) of the 1850s (left) and present day (right). The yellow lines are the historical and current border of the Everglades ecosystem.
Open Ocean Systems

- Predicting effects of Sea Water Temperature.
- Predicting the effects of changes in mixing and circulation (nutrient supply to euphotic zone)
- Predicting the effects of winds patterns (transport of plankton)
- Sea level rise (melting water + warmer sea)
- Feedback mechanisms
Temperature and Abundance
Temperature and Species Interaction

Long-term changes in the mean number of marine zooplankton species per association in the North Atlantic from 1960 to 1975 and from 1996 to 1999. The number of temperate species has increased and the diversity of colder-temperate, sub-Arctic and Arctic species has decreased in the North Atlantic. The scale (0 to 1) indicates the proportion of biogeographical types of species in total assemblages of zooplankton.
Water Circulation

Zooplankton Distribution in the KOE

Approach:
Use passive tracers with an eddy resolving model to explore how changes in advection may have impacted different aspects of the KOE zooplankton community.

Hypothesis how physics may affect Zooplankton

Fig. Biogeographical distribution of the copepods community in the Oyashio and the Transition zone before 1976 and after 1981: total abundance (Log inc. 1000 m-3) a), species diversity (H’) b) and the average community size (mm) c). (from Chiba et al submitted)

Courtesy of S. Chiba (JAMSTEC)
Oxygen

- Supply and fluctuations
- Stratification and low oxygen concentration

**HOW THE DEAD ZONE FORMS**

1. During the spring, sun-heated freshwater runoff from the Mississippi River creates a barrier layer in the Gulf, cutting off the saltier water below from contact with oxygen in the air.

2. Nitrogen and phosphorus from fertilizer and sewage in the freshwater layer ignite huge algae blooms. When the algae die, they sink into the saltier water below and decompose, using up oxygen in the deeper water.

3. Starved of oxygen and cut off from resupply, the deeper water becomes a dead zone. Fish avoid the area or die in massive numbers. Tiny organisms that form the vital base of the Gulf food chain also die. Winter brings respite, but spring runoffs start the cycle anew.

Source: Staff research

STAFF GRAPHIC BY DAN SWENSON
Harmful Algae

Eutrophication promotes excessive plant growth and decay, favors simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality.
A weakening of THC would diminish vertical mixing between the ocean surface and the deep sea and would reduce upwelling in temperate and subtropical latitudes. Transport of oxygen from the sea surface to the deep ocean would slow or cease, depriving the deep oceans of their supply of oxygen and slowly rendering them hypoxic (low in oxygen concentrations) or anoxic (lacking in oxygen) as happens now in coastal regions.
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Changes in the atmosphere and oceanography of the Bering Sea in the past 20 years have been suggested as driving the tenfold increase in jellyfish biomass over the middle Bering Sea shelf between 1979 and 1997.
Ocean Acidification and Acoustics

Business as usual: By 2100 pH will drop by 0.6 units => absorption of 200 Hz decreases by 70%. Marine mammals rely on low-frequency sound to find food and mates.
Coral Reefs

Current

- Calcification\growth
- High coral cover
- High structural complexity
- Diversity
- Coral recruitment
- Herbivores
- Coral dependant sp

Future

- Acidification
- Irradiance reduction
- Temperature increases
- Cyclones increase
- Drought/flood
- Reduced calcification/increased erosion
- Low coral cover
- Low structural complexity
- Few sensitive species
- Macrolgal dominance
- COTS
- Few herbivores
- Few coral dependant sp
- Reduced biodiversity, local species extinctions

Direct effects

Indirect effects
Food Chains
A food chain is different from a food web because it illustrates only one energy and nutrient path in an ecosystem. Each platform is a trophic level with one organism that begins with one primary producer and ends with a secondary or tertiary consumer. A typical food chain might go like this: algae-copepod-fish-squid-seal-orca. In this example the orca feeds on the seals and the seals feed on the squid which feed on fish which feed on copepods. The base of the food chain is formed by algae which are eaten by copepods.

Food Webs
Food webs are more intricate than food chains and illustrate the feeding relationships between a number of organisms at different trophic levels in an ecosystem. Food chains are useful to illustrate relationships in a simple way, and food webs are more accurate as they can illustrate more relationships. Another aspect evident in a food web is the diversification of prey by predators in order to survive the loss of one species.

Trophic Levels
Trophic levels are the platforms in the food chain that indicate a position for a particular organism. In a very basic way, a trophic level will indicate whether an organism is a foundation species, primary consumer, or secondary consumer. Information about whether the organism eats plants or animals can also be obtained. Most often trophic levels are used to determine how much energy is lost from the primary producers up to the tertiary consumers. For each trophic level in the food chain, energy is lost due to the laws of thermodynamics. Levels can be diagrammed to form a triangle with the apex formed by tertiary consumers, or apex predators. The primary producers yield the most profit from the energy of the sun. By the time this energy has been transferred up to the higher trophic levels much of it has been lost to the environment.

Symbiosis
Symbiosis is a term most often used to describe two organisms living in a close association that benefits both of their survival. For example, clownfish live in sea anemones that have dangerous stinging tentacles, to which the clownfish are immune because they are protected by an outer layer of mucus.