



Principal Investigator Meeting

October 14-16, 2008

Appendix A

Hypothesis-based groupings of the BEST and BSIERP hypotheses.

Major BSIERP and BEST hypotheses are listed first, followed by BSIERP sub-hypotheses.

Group 1: Hypotheses for discussion

BSIERP 1. Climate-induced changes in physical forcing will modify the availability and partitioning of food for all trophic levels through bottom-up processes.

BEST a. How does external forcing affect the timing, extent, thickness, and coverage of sea ice?

BEST b. How does climate variability affect the transfer of primary production to the plankton and benthos, the fish, birds, cetaceans, and other upper-trophic predators on the shelf?

In addition, there are sub-hypotheses associated with BSIERP hypothesis 1:

- a. Earlier sea ice retreat expected as a result of warming will result in a later (May-June), warm-water spring phytoplankton bloom, increased coupling with zooplankton and greater pelagic secondary productivity. Benthic secondary productivity will decrease.
- b. Reduced frequency and intensity of summer storms will reduce surface mixing and increase sea surface temperature, thereby increasing stratification. A substantial decrease in summer winds will result in a mixed layer that is shallower than the euphotic zone, extensive subsurface primary production and depletion of nutrients in the entire water column. There will be no fall phytoplankton bloom. A moderate decrease or no change in the intensity of summer storms will reduce replenishment of nutrients to the euphotic zone, lowering summer primary and secondary production. Both scenarios will reduce juvenile fish production by reducing their condition (energy density) and over-wintering capability.
- c. Earlier spring transition will lengthen the period of time of organized onshore flow along the Alaska Peninsula, thus transporting larvae away from outer domain piscivores.



Group 2: Hypotheses for discussion

BSIERP 2. Climate and ocean conditions influencing water temperature, circulation patterns and domain boundaries impact fish reproduction, survival and distribution, the intensity of predator-prey relationships and the location of zoogeographic provinces through bottom-up processes.

BEST a. How does external forcing affect the timing, extent, thickness, and coverage of sea ice?

BEST b. How does climate variability affect the transfer of primary production to the plankton and benthos, the fish, birds, cetaceans, and other upper-trophic predators on the shelf?

BEST c. Has the loss of ice cover in the eastern Bering Sea affected the structure and function of the planktonic and benthic communities by exposing the upper ocean to wind earlier in the season or for a longer period of time?

In addition, there are sub-hypotheses associated with BSIERP hypothesis 2:

- a. As heat content increases, the area suitable for spawning and foraging by subarctic species will expand northward and subarctic species will occupy areas formerly occupied by Arctic species.
- b. Reduced cold pool extent will increase overlap of inner domain forage fish and outer domain piscivores.
- c. Strength of frontal boundaries will weaken due to absence of the summer cold pool, allowing expansion of the inner domain and juvenile and forage fish habitat there. Weaker winds will enhance this effect.
- d. Sporadic reversals to cold conditions (e.g., 1999) will have strong effects on the subarctic community and result in increased interannual variability in abundance and pelagic productivity of piscivorous fish, seabirds and marine mammals.
- e. Expected decreases in benthic productivity will negatively affect feeding and survival of small flatfish and crab, thereby lowering population levels.



Group 3: Hypotheses for discussion

BSIERP 3. Later spring phytoplankton blooms as a result of early ice retreat will increase zooplankton production, thereby resulting in increased abundances of piscivorous fish (pollock, cod and arrowtooth flounder) and a community controlled by top-down processes [Oscillating Control Hypothesis] with the possible trophic consequences:

BEST d. How does climate affect the balance of top-down versus bottom-up control of the zooplankton community?

In addition, there are sub-hypotheses associated with BSIERP hypothesis 3:

- a. Competition with abundant, piscivorous fish species for forage species will lead to a decline in murre, kittiwakes and fur seals.
- b. Growing populations of humpback and fin whales increasingly will both consume and compete with forage fish (juvenile pollock) for zooplankton (euphausiids and copepods). By reducing the prey base of forage fish, whales not only reduce the amount of forage fish available to other predators, but also their quality (lipid content).
- c. In a top-down control community, fishing will reduce the degree of top-down control of forage species (including juvenile pollock) by adult pollock, cod and arrowtooth flounder. Owing to light exploitation rates, top-down control by arrowtooth flounder will increase, as will their level of competition with piscivorous fish, seabirds and marine mammals. As a result of these two processes, arrowtooth flounder will determine ultimate community composition, such that the climax community will be arrowtooth flounder-dominated (similar to the Gulf of Alaska).



Group 4: Hypotheses for discussion

BSIERP 4. Climate and ocean conditions influencing circulation patterns and domain boundaries will affect the distribution, frequency and persistence of fronts and other prey-concentrating features and thus the foraging success of marine birds and mammals largely through bottom-up processes.

BEST c. Has the loss of ice cover in the eastern Bering Sea affected the structure and function of the planktonic and benthic communities by exposing the upper ocean to wind earlier in the season or for a longer period of time?

In addition, there are sub-hypotheses associated with BSIERP hypothesis 4:

- a. Climate-ocean changes will displace predictably located, abundant prey (hot spots) necessary for successful foraging by central place (seabirds and fur seals while nurturing young) and hot spot (baleen whales, walrus) foragers.
- b. Central place foragers will shift their diet, foraging locations or rookery locations to increase foraging opportunities (based on differential foraging success).



Group 5: Hypotheses for discussion

BSIERP 5. Climate-ocean conditions will change and thus affect the abundance and distribution of commercial and subsistence fisheries.

BEST e. How will subsistence and economic activities in the Bering Sea change?

BEST f. What will be the social implications of the changes in subsistence and economic activities in the Bering Sea?

BEST g. How can studies of past climatic, ecological, and social responses to changes in sea ice extent and character illuminate present trends and future potentials?

In addition, there are sub-hypotheses associated with BSIERP hypothesis 5:

- a. For commercial fishermen, these changes will lead to: 1) a change in home ports and distribution of fishing vessel rents, 2) vessels traveling further, incurring greater fuel costs and peril at sea and 3) greater burden on smaller vessels.
- b. For subsistence users, these changes will lead to: 1) greater reliance on owners of larger vessels that can travel farther to harvest and distribute subsistence goods, 2) decreased consumption of species with decreased local abundance and 3) adoption of new species into the diet as these species colonize local areas.
- c. Current management strategies for fish, seabirds and marine mammals in the Bering Sea are robust to climate scenarios (range of frequencies of cold and warm years) and associated range of trophic relationships and spatial redistributions.