Determinants of the Distribution and Abundance of Seabirds at Sea

Potential for Interaction with Fisheries

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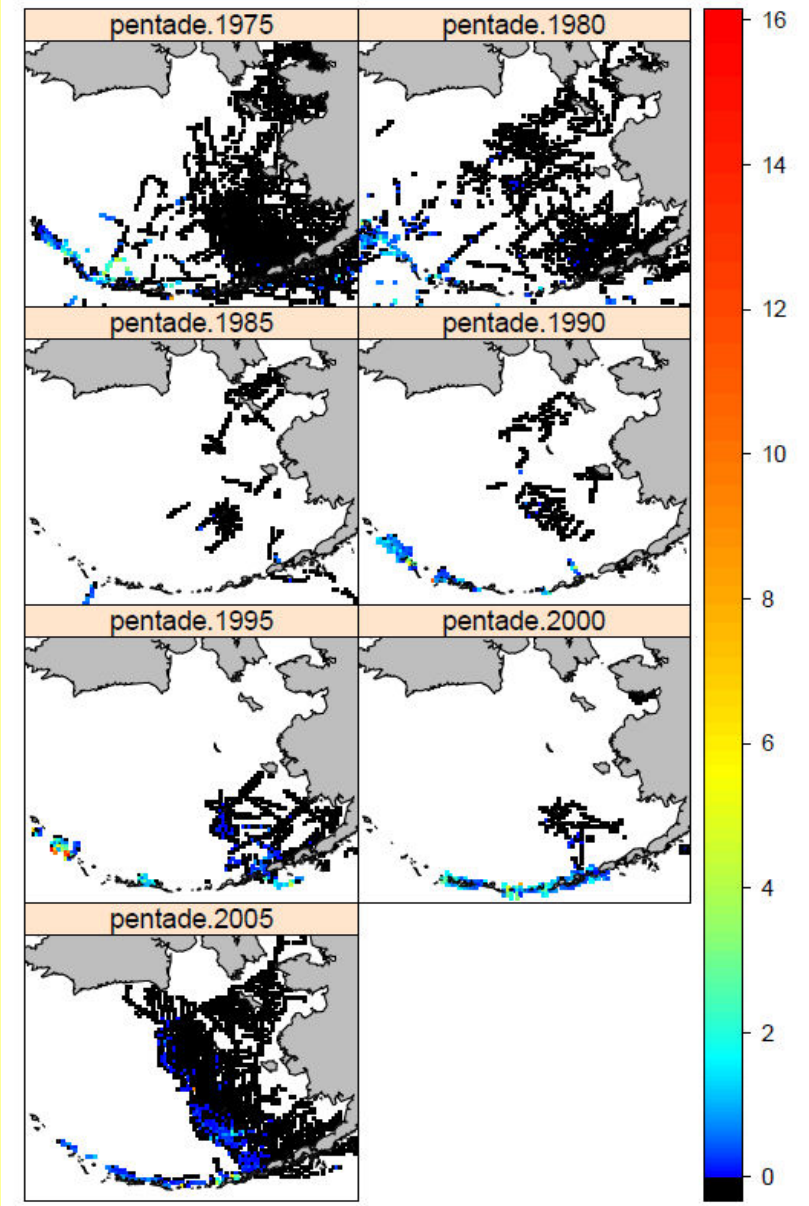
- **Funding Cycles: Steady is Critical**

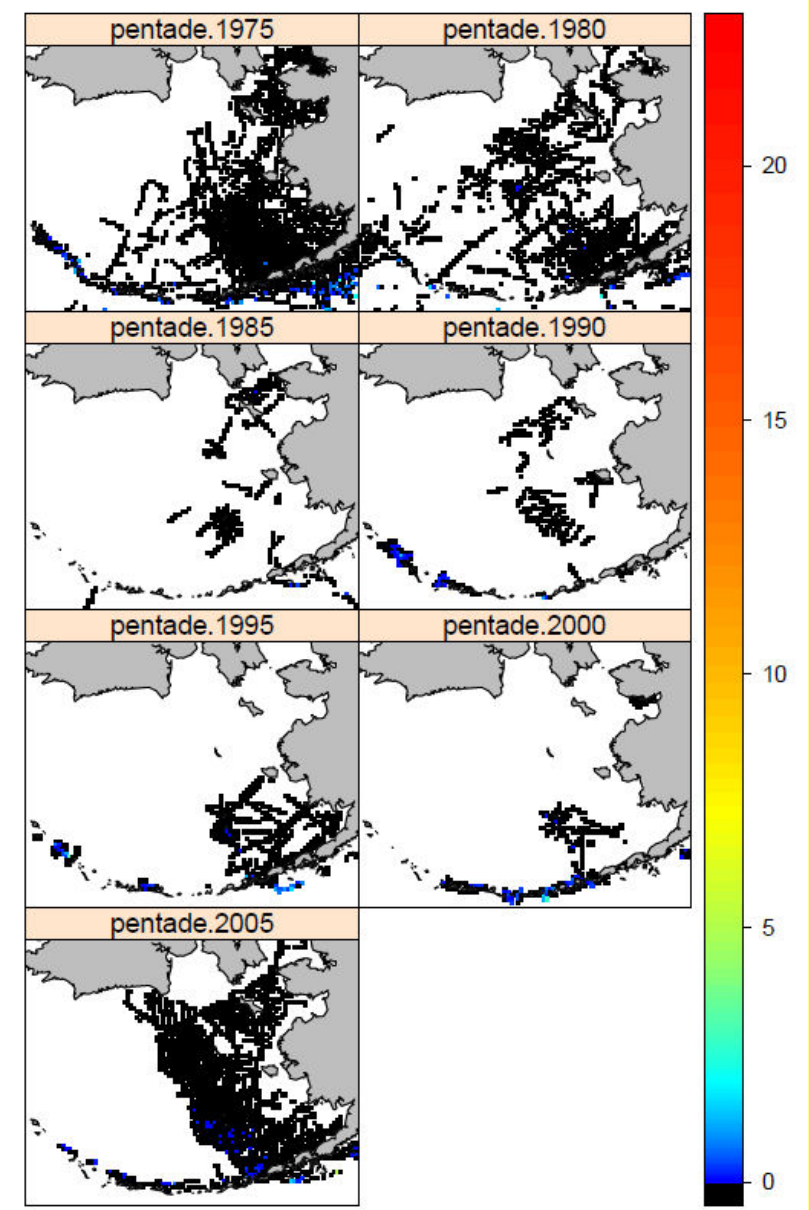
Scales of Variability in Space and Time

- **Warm Regions and Hotspots**
  - Production-driven “Warm Regions”
  - Small-scale “hotspots”
  - Differentiating a patch from a hotspot
- **Scales of Temporal Variability**
  - Tidal Rhythms
  - Seasonal Spawning Migrations
  - Inter-annual and Inter-decadal Variation
- **Are Baselines a Useful Concept?**

Albatrosses have Increased in the Bering Sea



Laysan Albatross *Phoebastria immutabilis* densities

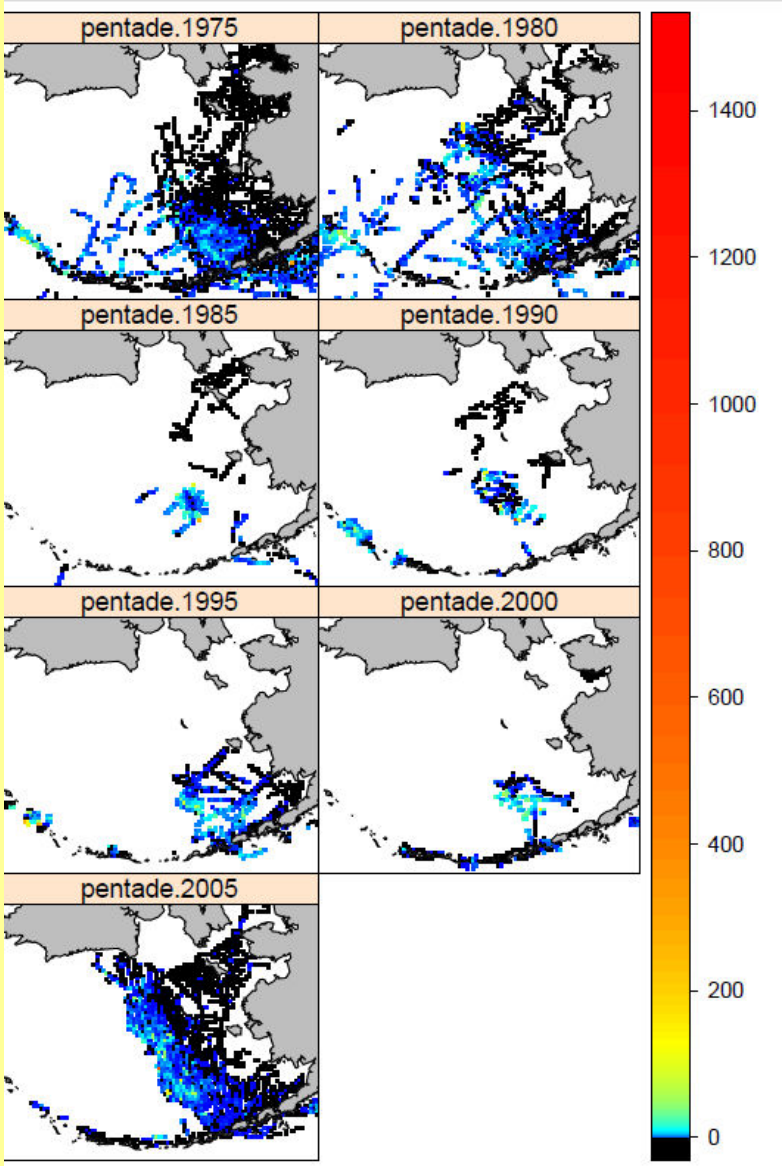


Black-footed Albatross *Phoebastria nigripes* densities

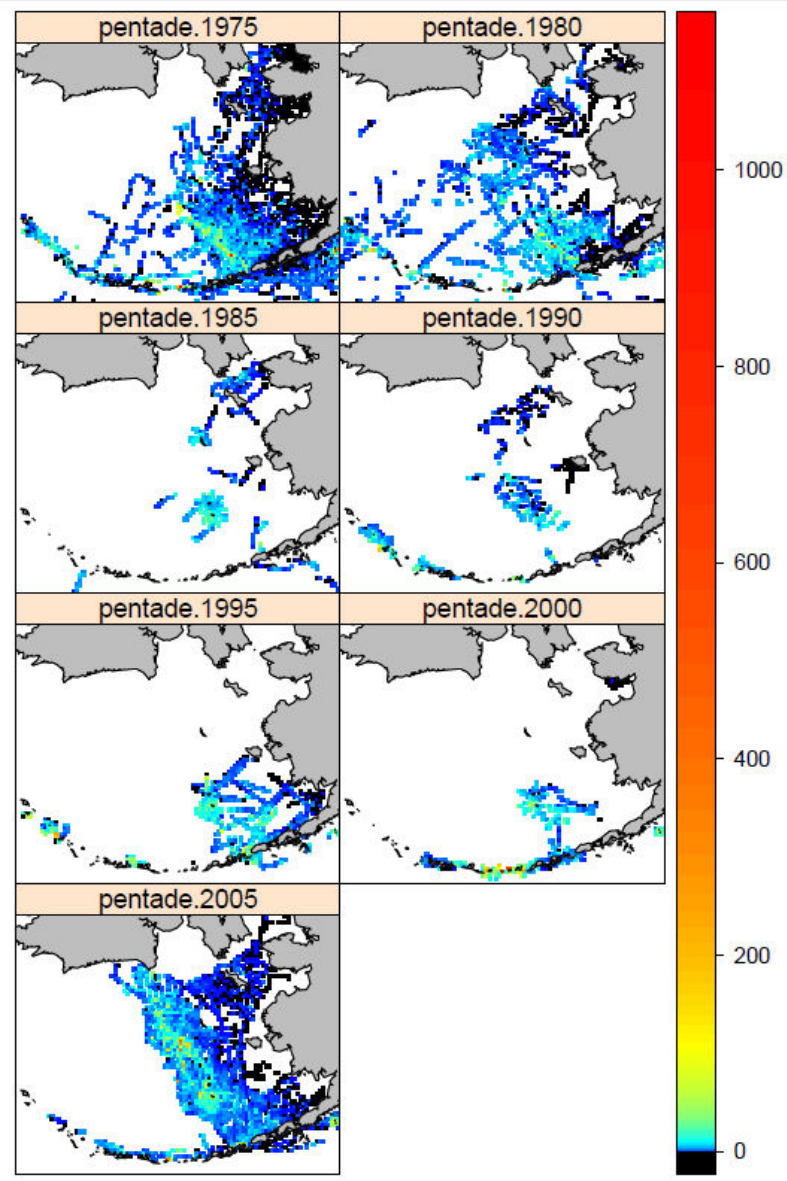
What is a “Warm region”?

- **Region of Enhanced Productivity**
  - **Shallow Pycnocline**
  - **Upwelling**
  - **Examples: Eastern Tropical Pacific**
    Outer Shelf of the Bering Sea
    Gulf Stream Eddies
- **Too Big to Protect**
- **Likely an Area of Enhanced Interaction between Seabirds and Fisheries**

Storm-Petrels & Fulmars Use the Outer Shelf



Fork-tailed Storm-petrel *Oceanodroma furcata* densities



Northern Fulmar *Fulmarus glacialis* densities

“Aggregation Hotspots”

- Predictable in Time and Space
- Places with high rates of trophic transfer- foraging areas
- “Significant proportion” of local or world population
  - What is “Significant”?
  - If destroyed, what would be considered a significant impact at the population level?
- Places of major conservation Importance

Hotspots for Trophic Transfer

- **Two major classes of mechanisms**
  - **Heightened Productivity**
  - **Prey behavior working against physical gradients**
- **Many different spatial scales**
  - **Whole sub-arctic compared to sub-tropical Pacific Ocean- not very informative**
  - **Mesoscale Regions of heightened productivity**
  - **Oceanic frontal systems**
  - **Tidal fronts and rips**

Productivity-driven Hotspots

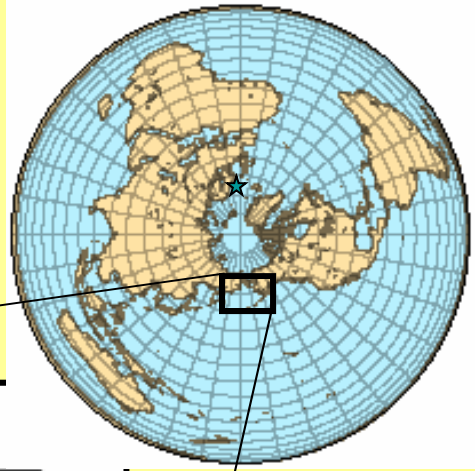
St. Lawrence Island Polynya, Bering Sea

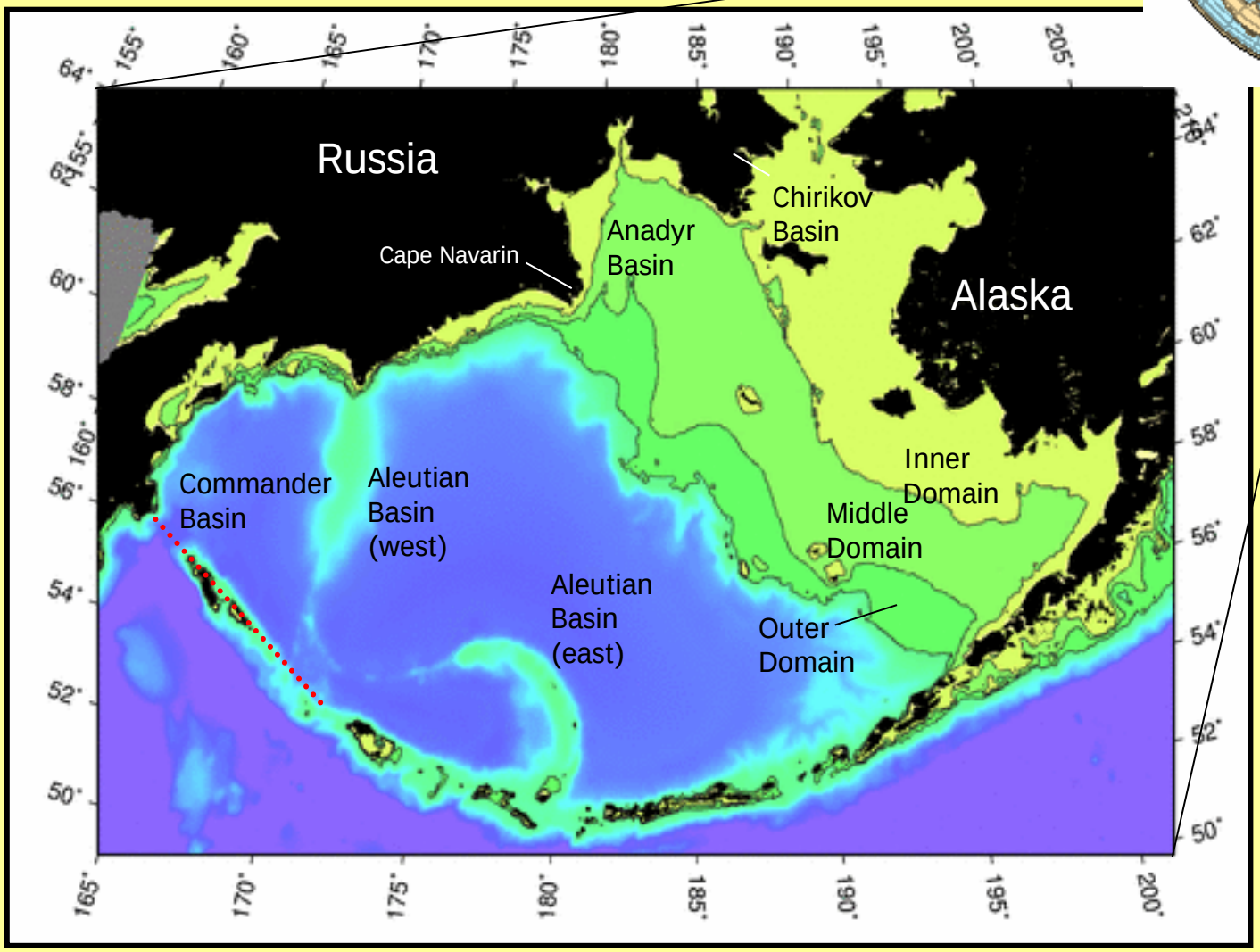
- **Latent heat polynya**
  - **Strong pelagic-benthic coupling**
  - **Important area for sea ducks and walrus**

Male Spectacled Eider

USFWS Photo

The Bering Sea





Modified from: Aydin et al. (2002) and Mueter unpbl

St. Lawrence Island Polynya

9 January 1999

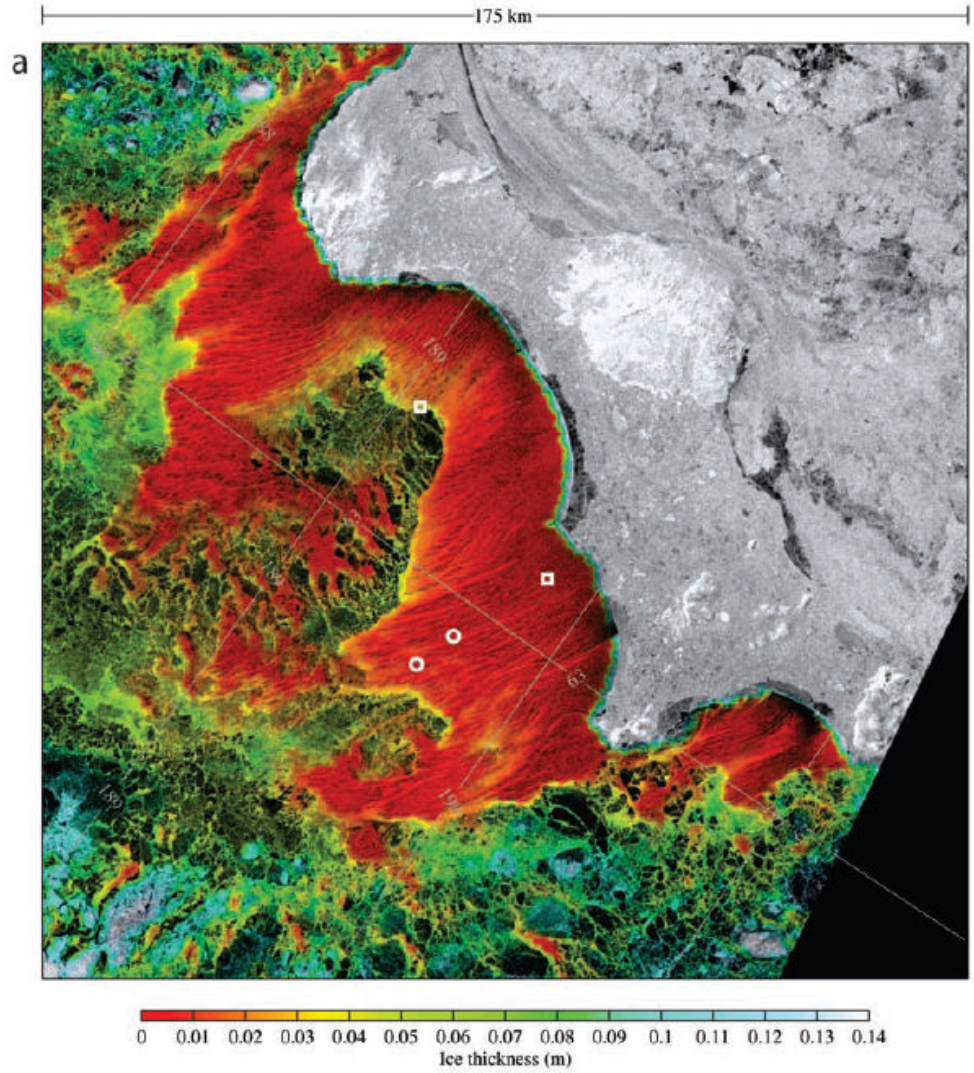


Figure 4. Composite SAR and AVHRR images of the St. Lawrence Island polynya. The colors correspond to the thermal or AVHRR thicknesses; the texture and detail correspond to the SAR. The

From Drucker et al. 2003 JGR

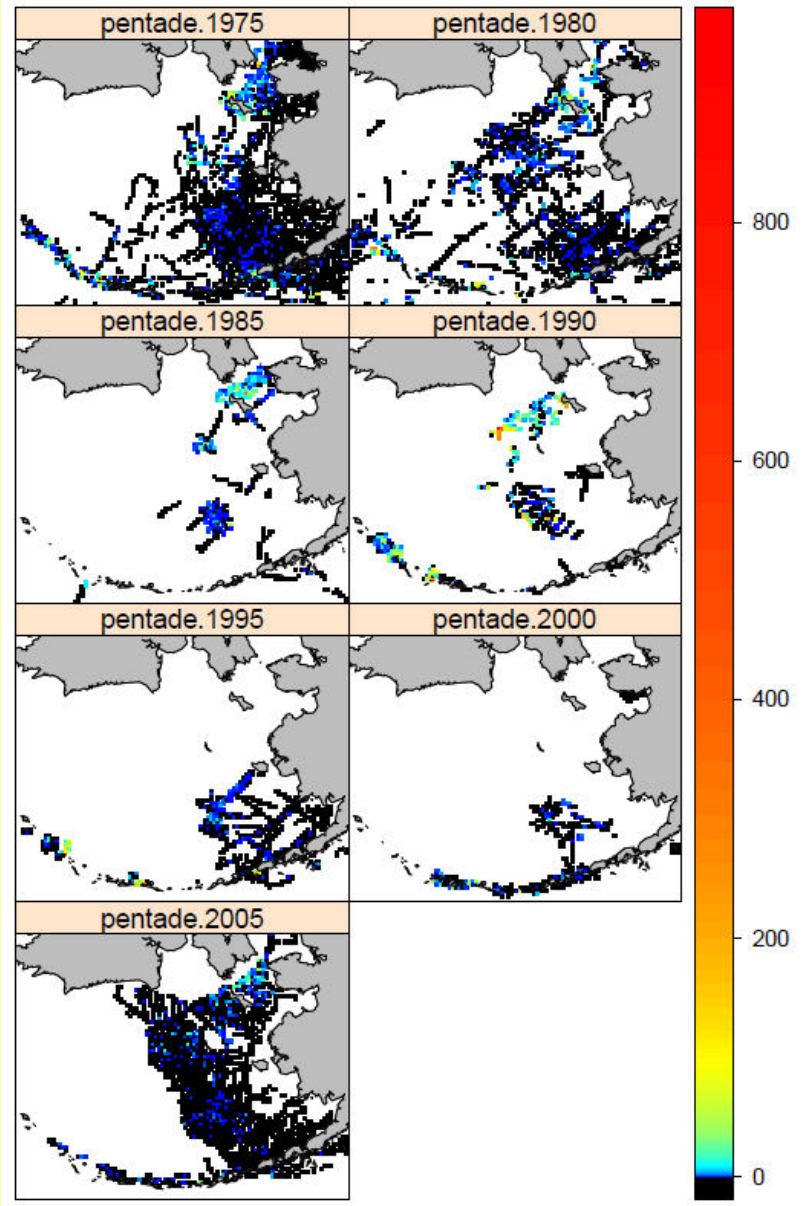
Benthos Collected in the St. Lawrence Is. Polynya

Spectacled Eiders at Lead

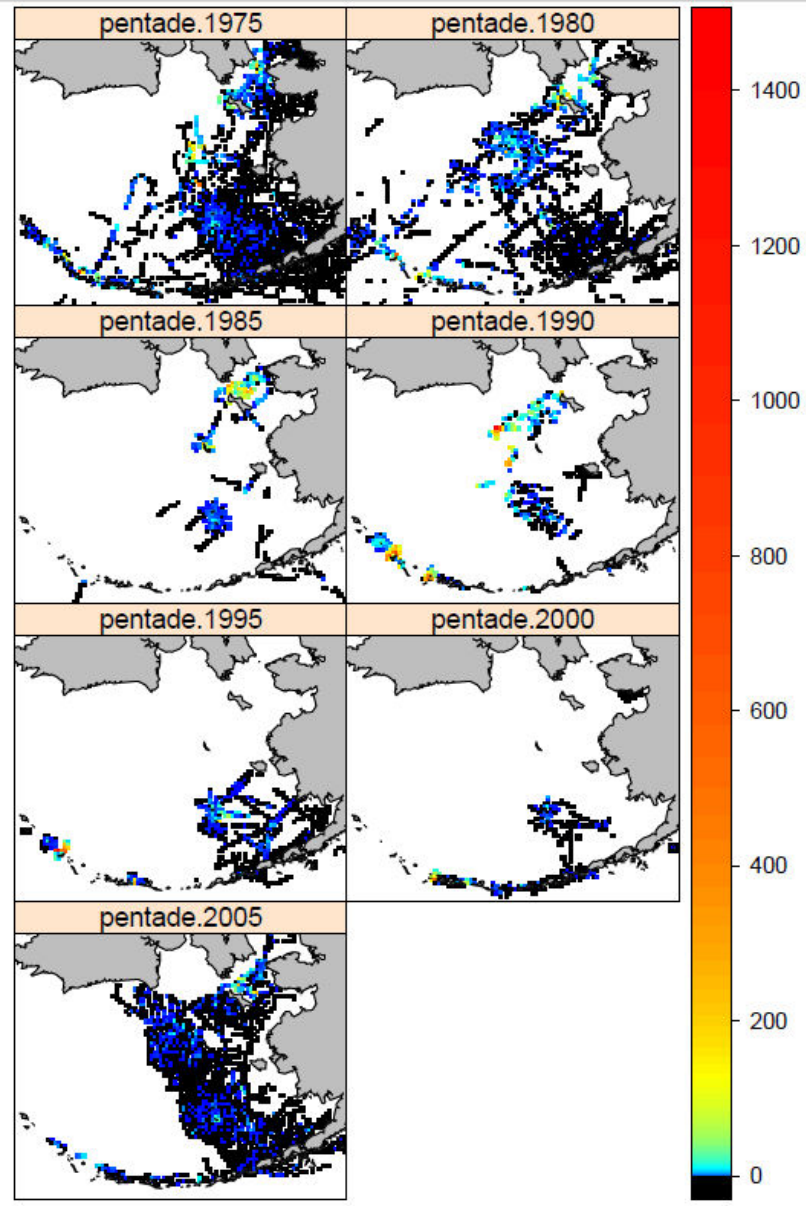
Biophysically-Forced Hotspots

- Require source from which prey advected to be long-lasting
- Prey behavior works against physical gradient
- Many sources of gradients
  - Light
  - Density
  - Depth preferences
  - Convergence- with need to stay high
  - Divergence with need to stay low
  - Eddies

Hotspots for Least and Crested Auklets



Crested Auklet *Aethia cristatella* densities



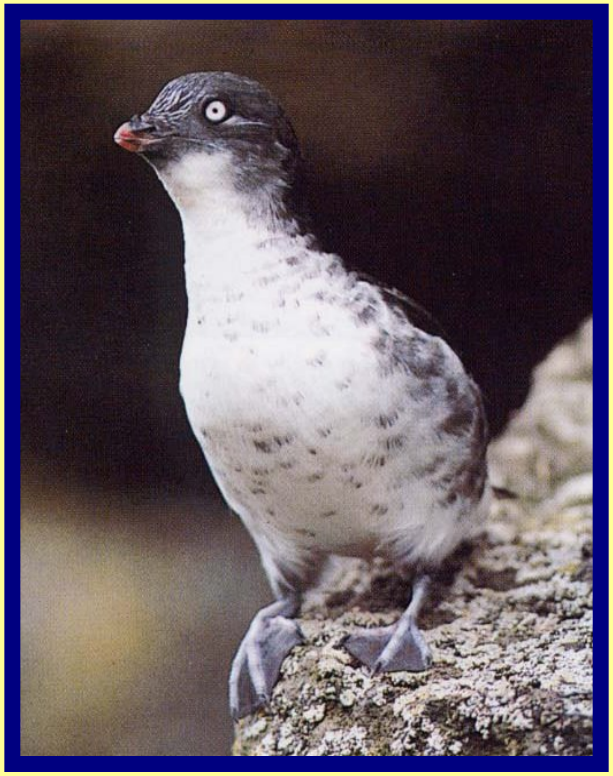
Least Auklet *Aethia pusilla* densities

Three of Five Auklet Species that Forage in Passes of the Aleutian Archipelago

Parakeet Auklet
Cyclorrhynchus psittacula

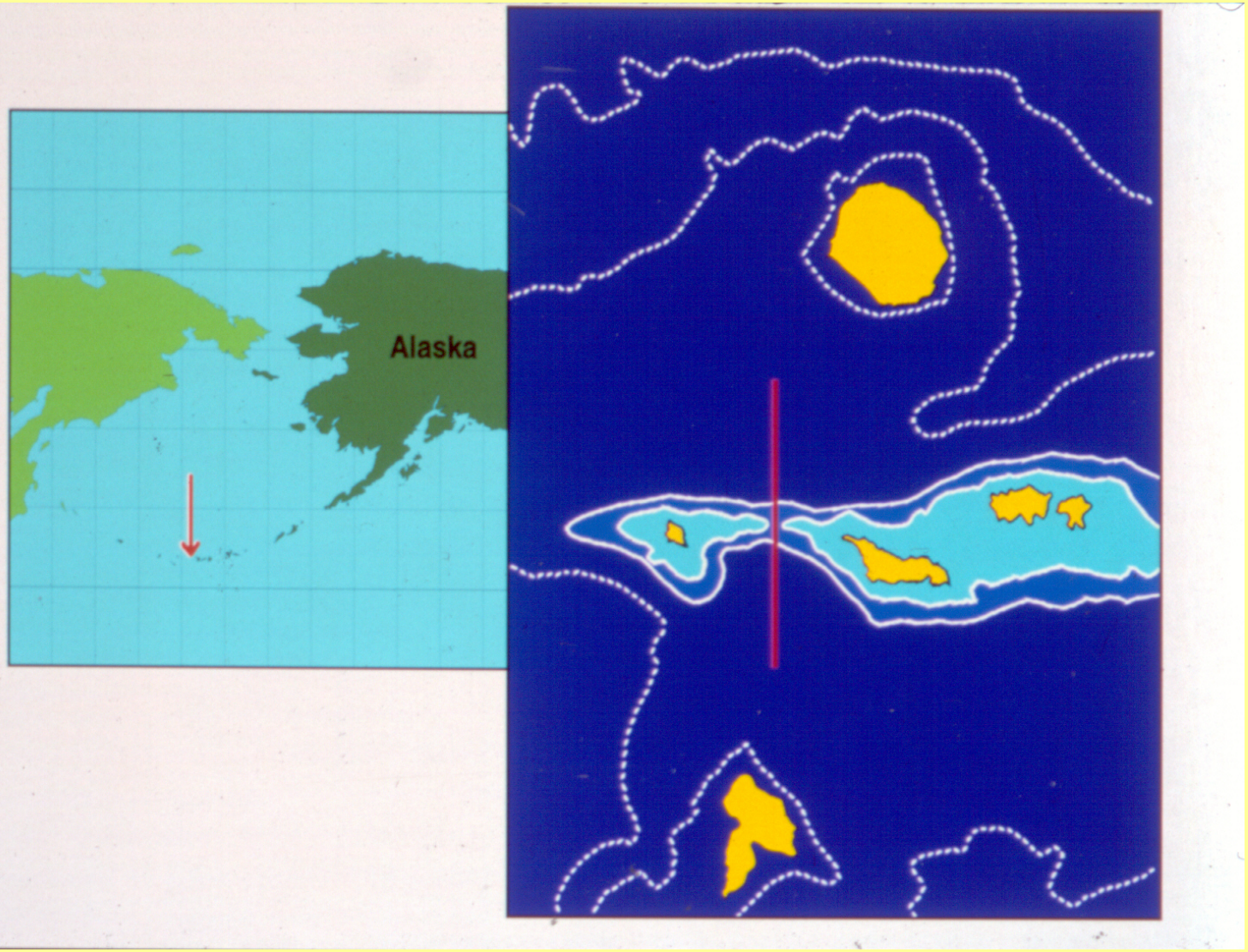
Crested Auklet
Aethia cristatella

Least Auklet
Aethia pusilla



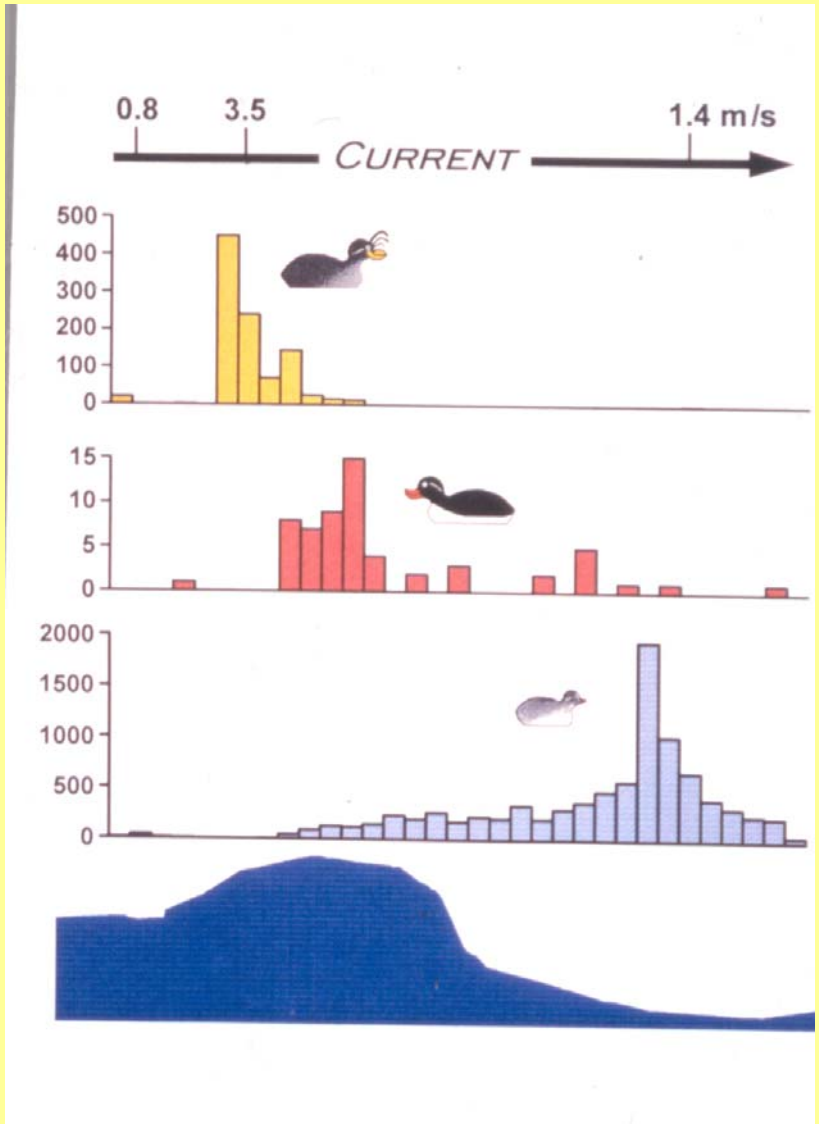
Pictures from:
Enticott, J. and D. Tipling. 1997. Seabirds of the world; the complete reference.

Location of Delarof Islands



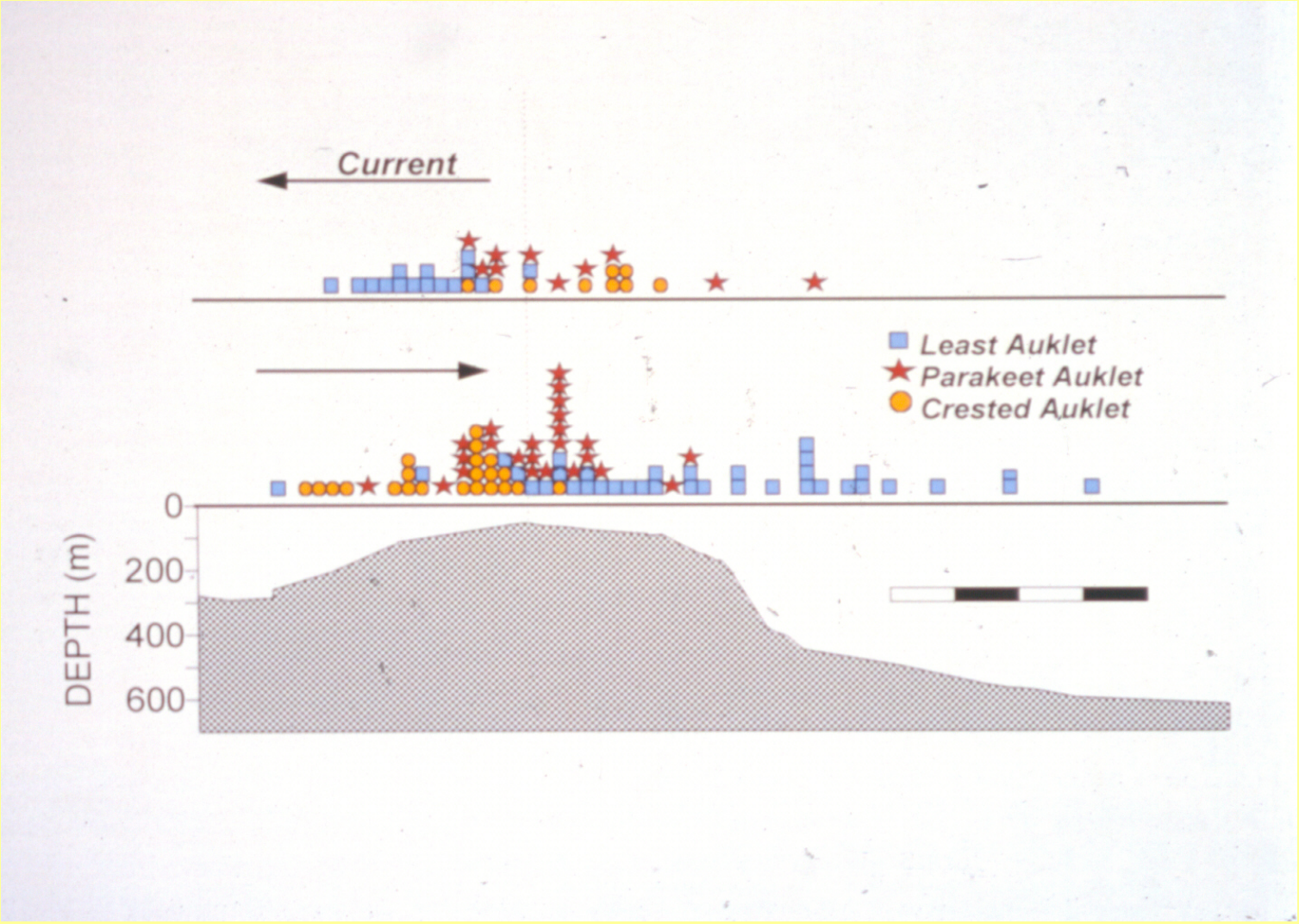
Bird Flocks on Water Upstream of Standing Waves over Sill

Distribution of Auklets on a single crossing of Delarof Pass

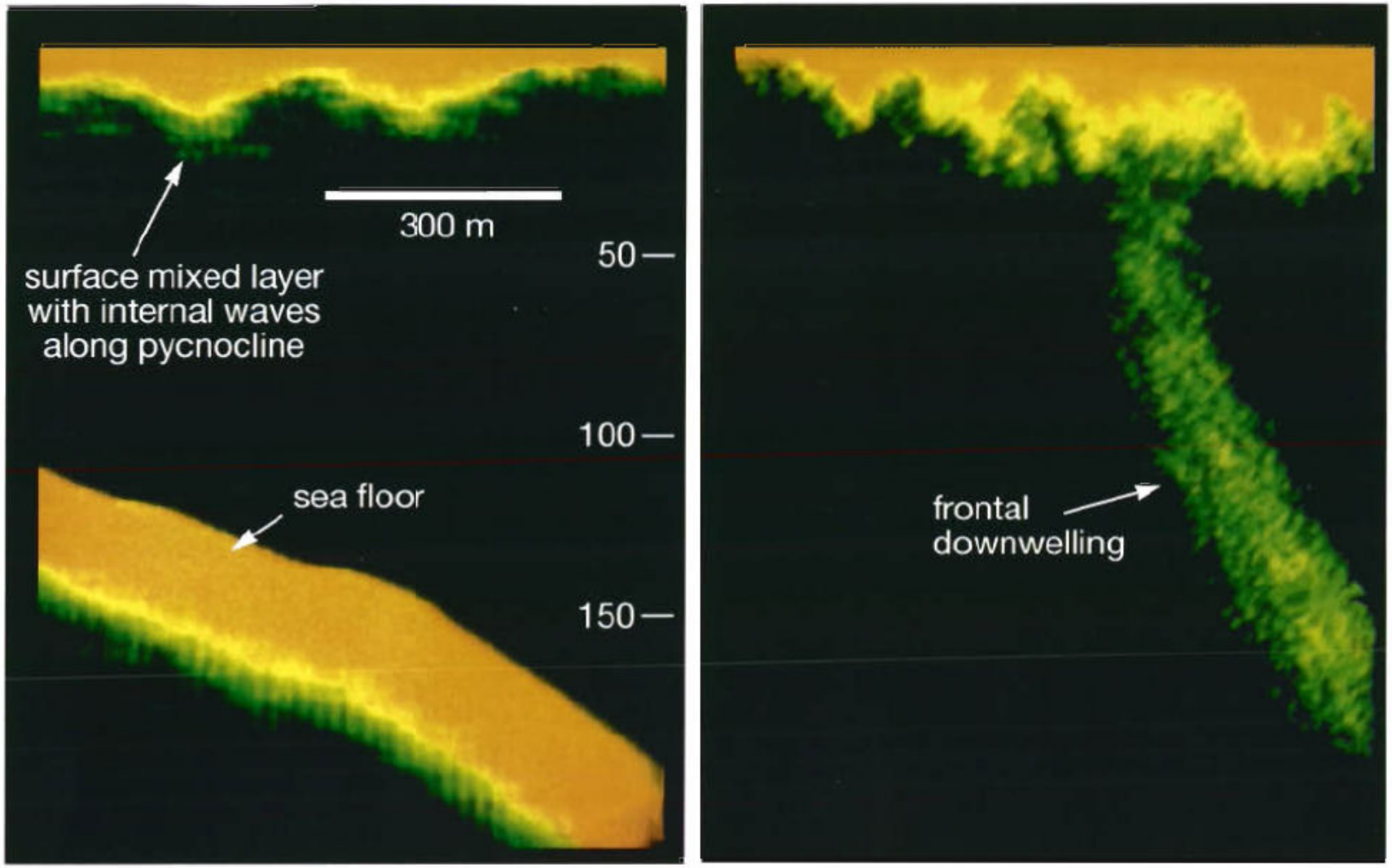


Distribution of Modes for Three Species of Auklets

Delarof Pass



Bridge Depth-Sounder Showing Internal Waves and Downwelling



Echogram Showing Upwelling of Euphausiids and Downwelling of Bubbles

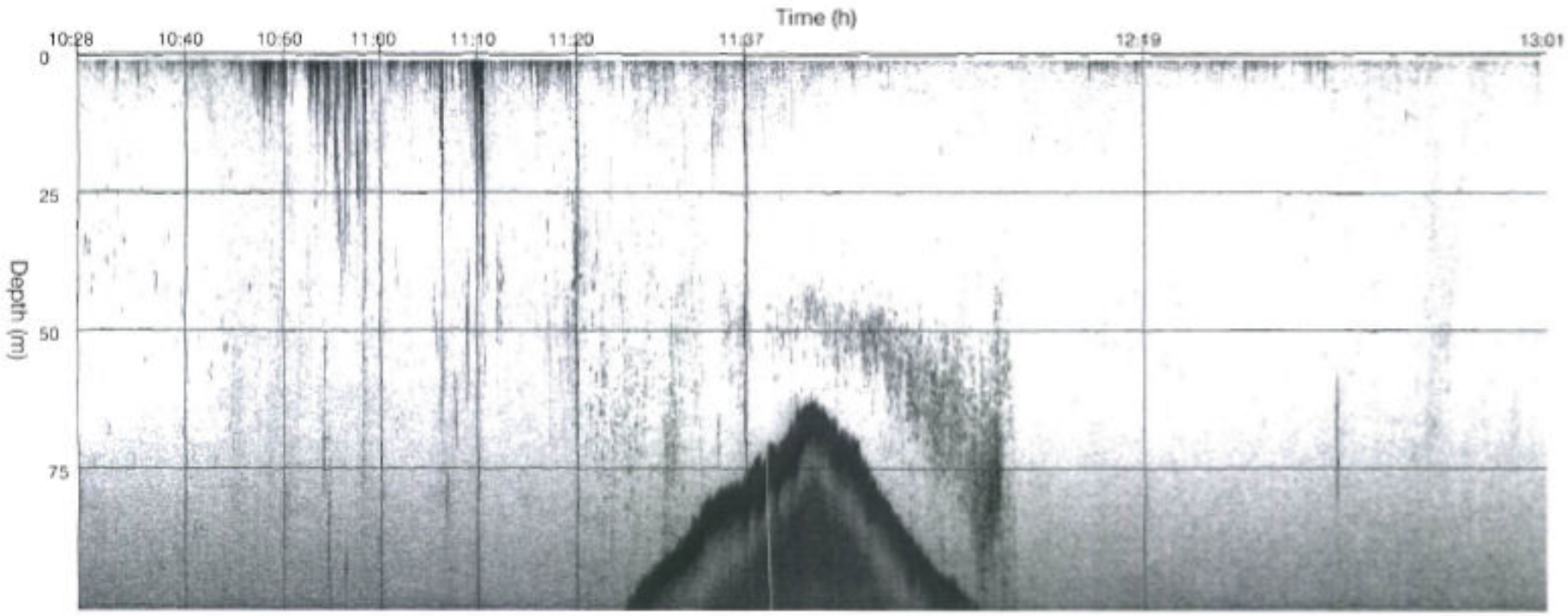
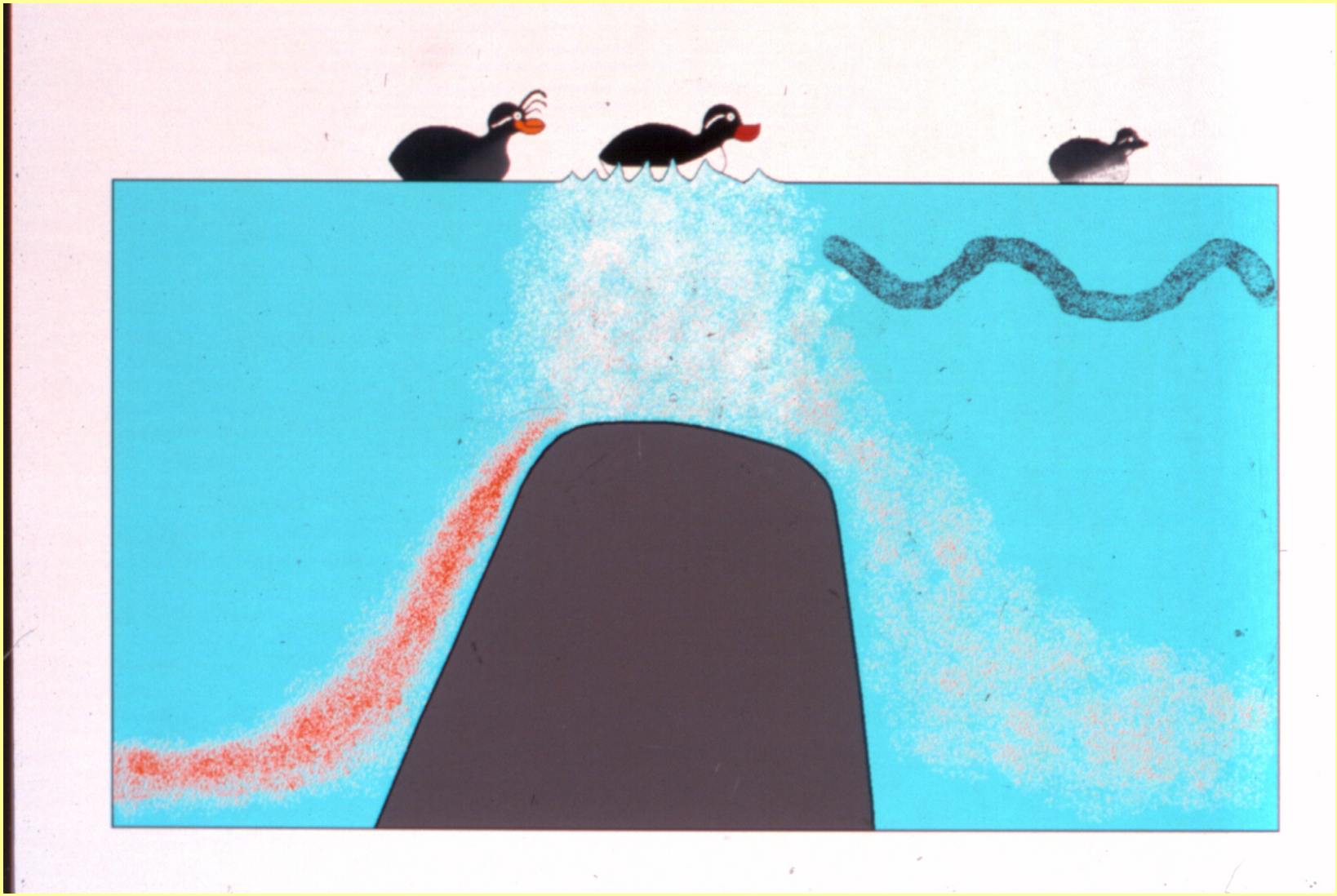
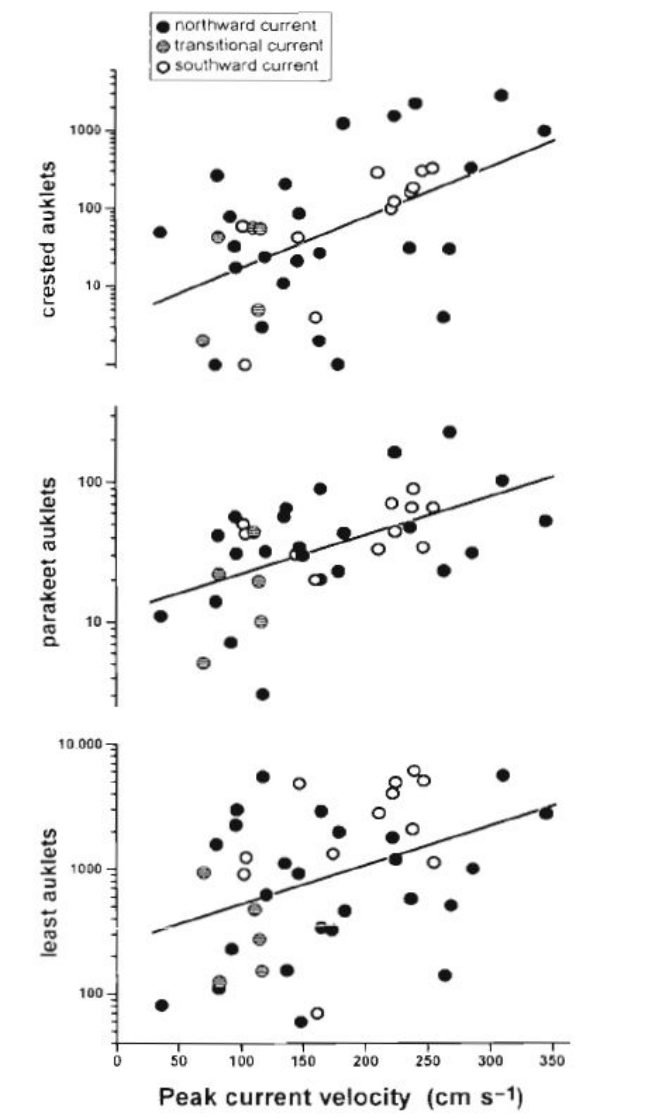


Fig. 6. Copy of an echogram from 20 July 1993 at 10:28 to 13:01 h showing biomass near the bottom on the upstream side of the sill and strong spikes of backscatter on the downstream side of the sill where the convergences occurred. Note the faint undulations in the bottom of the near-surface zone of echoes, indicating the presence of internal waves. The tide is ebbing to the south, from right to left

Cartoon of Processes that facilitate Auklet Foraging at the Delarofs

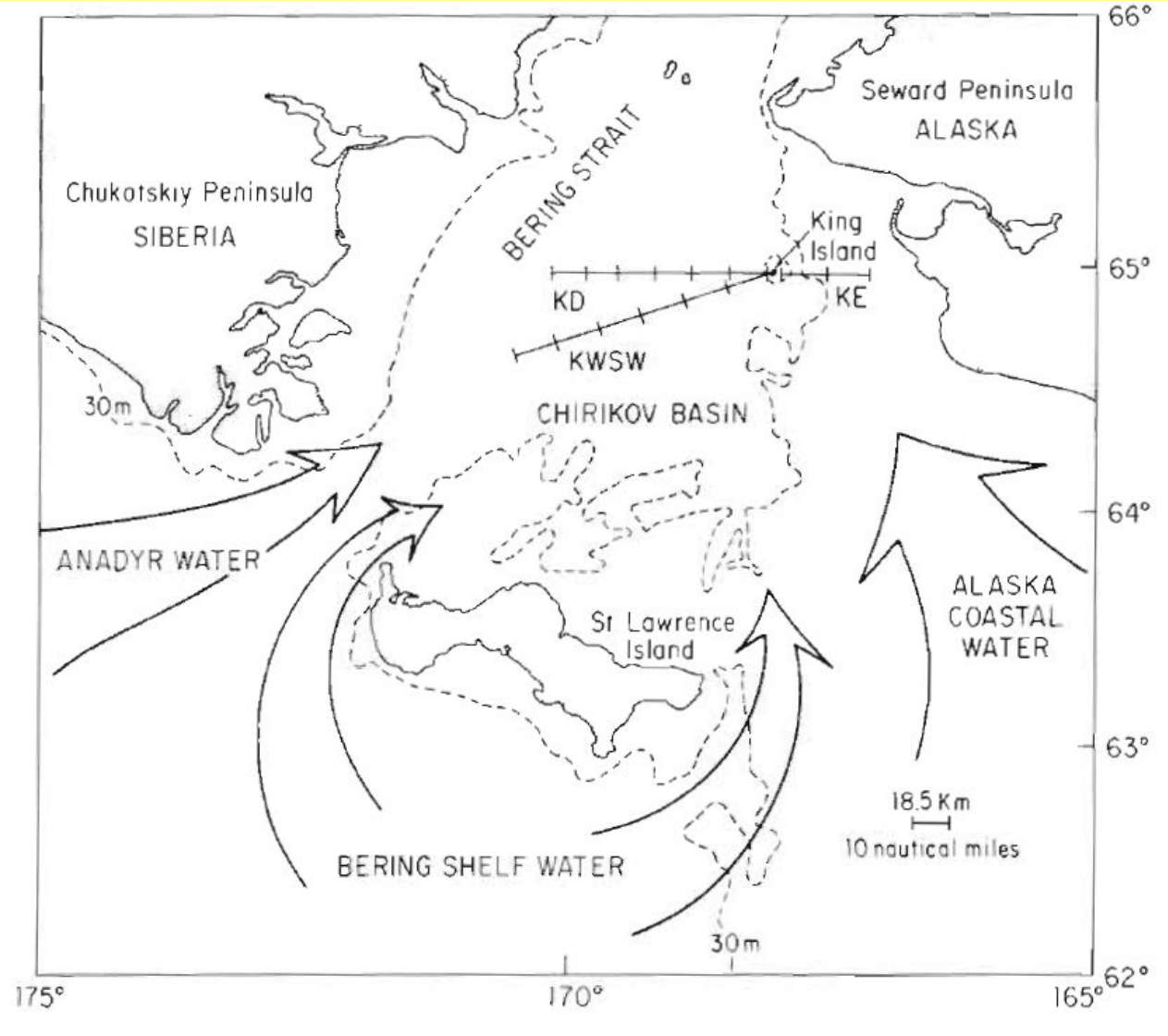


Relationship Between Auklet Numbers and Tidal Velocity

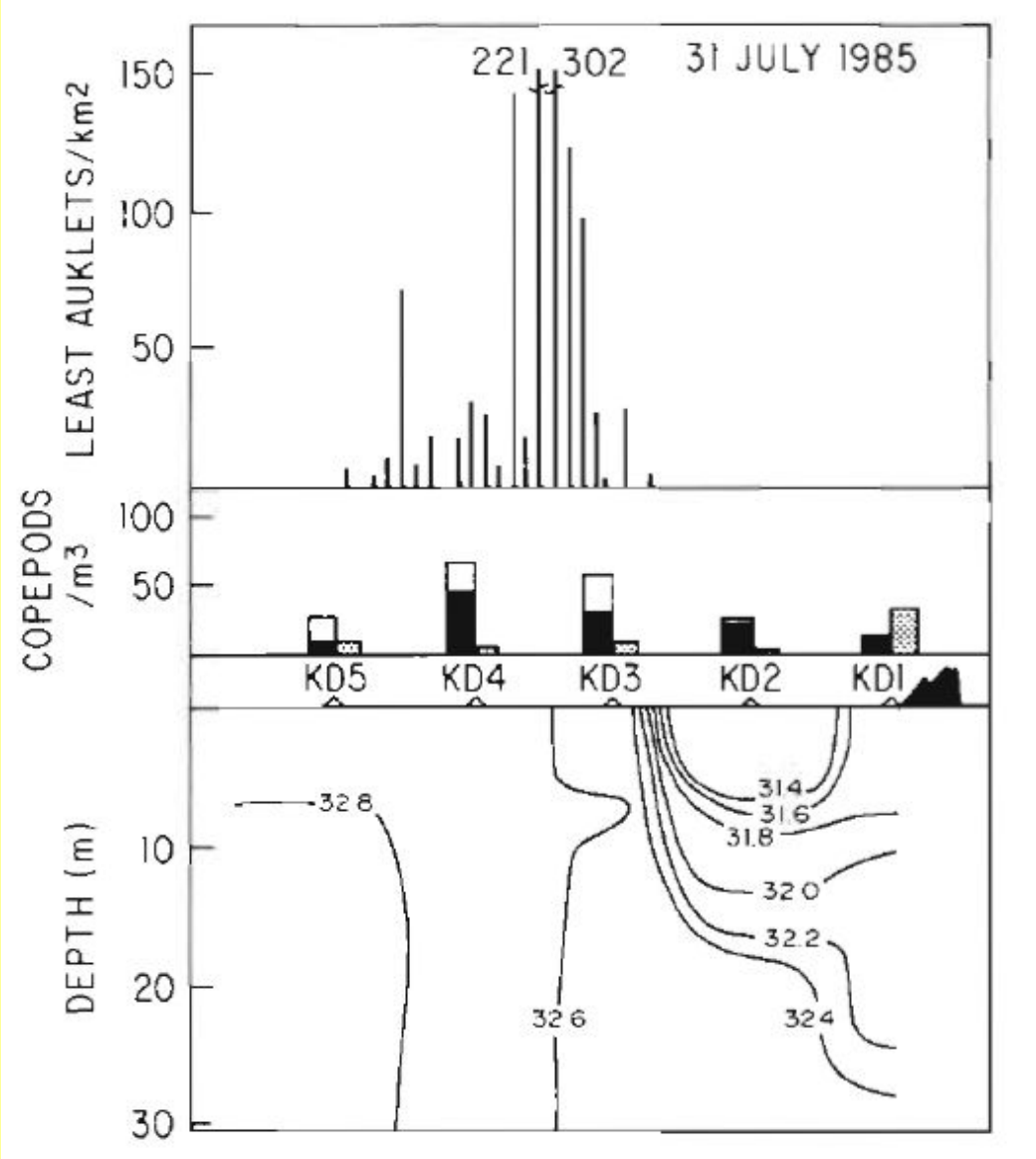


Least Auklets

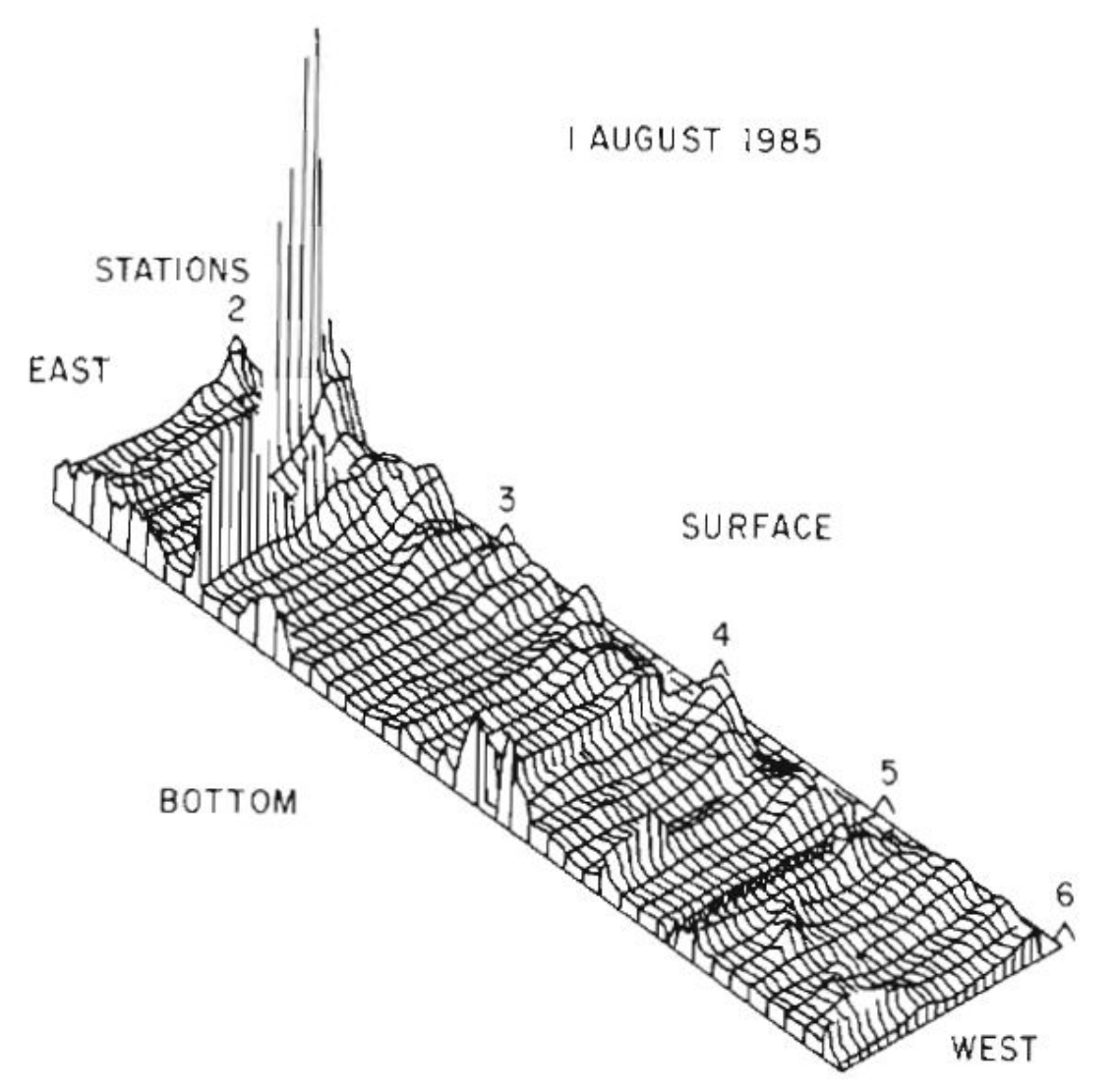
Map of the Northern Bering Sea Showing Currents



Least Auklets Massed near a Front



Echogram of Zooplankton by Depth



Impacts of Varying Prey Availability

- **Competition for Prey**
  - **Fisheries for Forage-Fish**
  - **Management for Large Populations of Predatory Fish that are Competitors**
- **Provisioning of Prey**
  - **Offal and Discards as Subsidies**
- **Indirect Impacts**
  - **Consequences of Removal of Subsidies**

Management Issues

- **Minimize Mortality of Adult Seabirds (Bycatch)**
- **Prey Availability a Key tie between Ocean Management and Colony Management**
  - **Distribution and Abundance of Forage Fish**
  - **Management Options**
  - **Limits to Management**
- **Monitoring is not a Dirty Word!**
  - **Just call it “Development of a Time-Series”**
- **Funding Cycles: Steady is Critical**