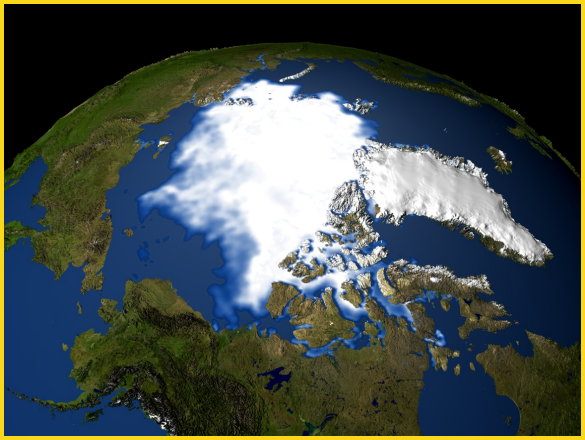
The Chukchi Sea Environmental Studies Program: An integrated ecological investigation of the Arctic ecosystem

Louis Brzuzy - Shell
A. Michael Macrander - Shell
Caryn Rea – ConocoPhillips
Steinar Eldoy - Statoil



Chukchi Sea Environmental Studies Program

- CSESP
- Funded by industry since 2008
  - ConocoPhillips Alaska
  - Shell
  - Statoil
- Operated by a Native Corporation of the North Slope of Alaska

ConocoPhillips Shell Statoil Olgoonik Fairweather LLC

CSESP Overview

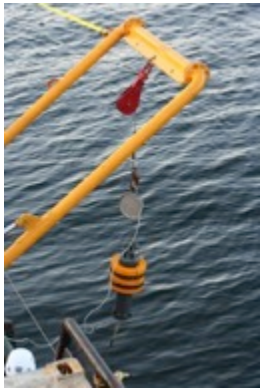
- Multi-year (2008-2014), multi-disciplinary oceanographic study
- **Objectives**:
  - Collect information to understand environment to support oil & gas exploration permitting
  - Build on historical Arctic scientific data
  - Ecosystem approach to baseline data acquisition & analysis
  - Provide a basis for assessing potential impacts from oil & gas activities

CHUKCHI SEA ENVIRONMENTAL STUDIES PROGRAM

Disciplines

- Oceanographic moorings
- Physical oceanography
- Micro/phytoplankton
- Nutrients/zooplankton
- Ocean acidification
- Baseline chemistry
- Benthic ecology
- Fish ecology
- Seabird ecology
- Marine mammal ecology
- Passive acoustics







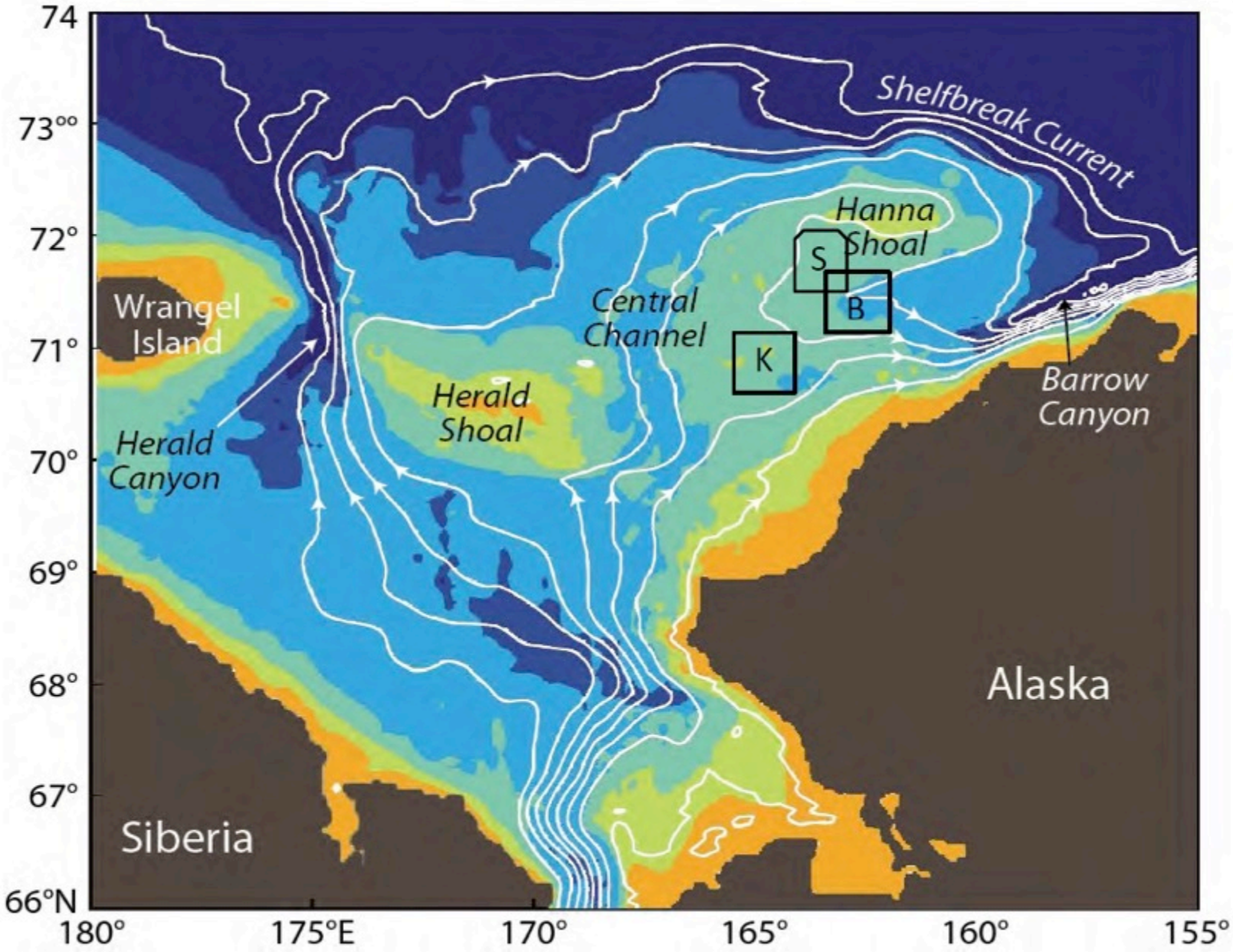
Vessels

- Managed by Aldrich Offshore Services
- 165 x 34 ft

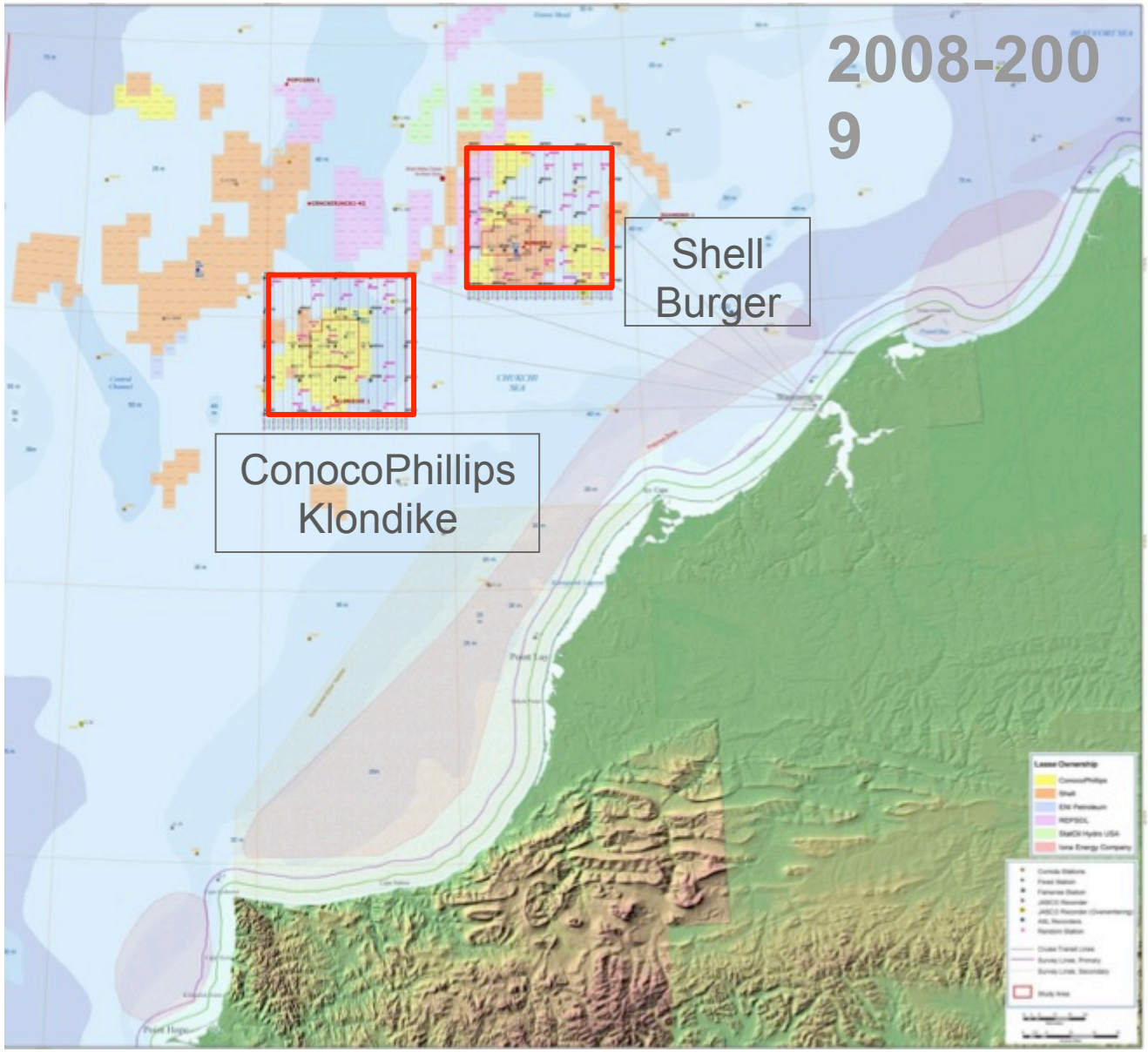
- Owned by Olgoonik Oilfield Services
- 30 x 11 ft

- Managed by Norseman Maritime Charters
- 115 x 28 ft

The Study Area

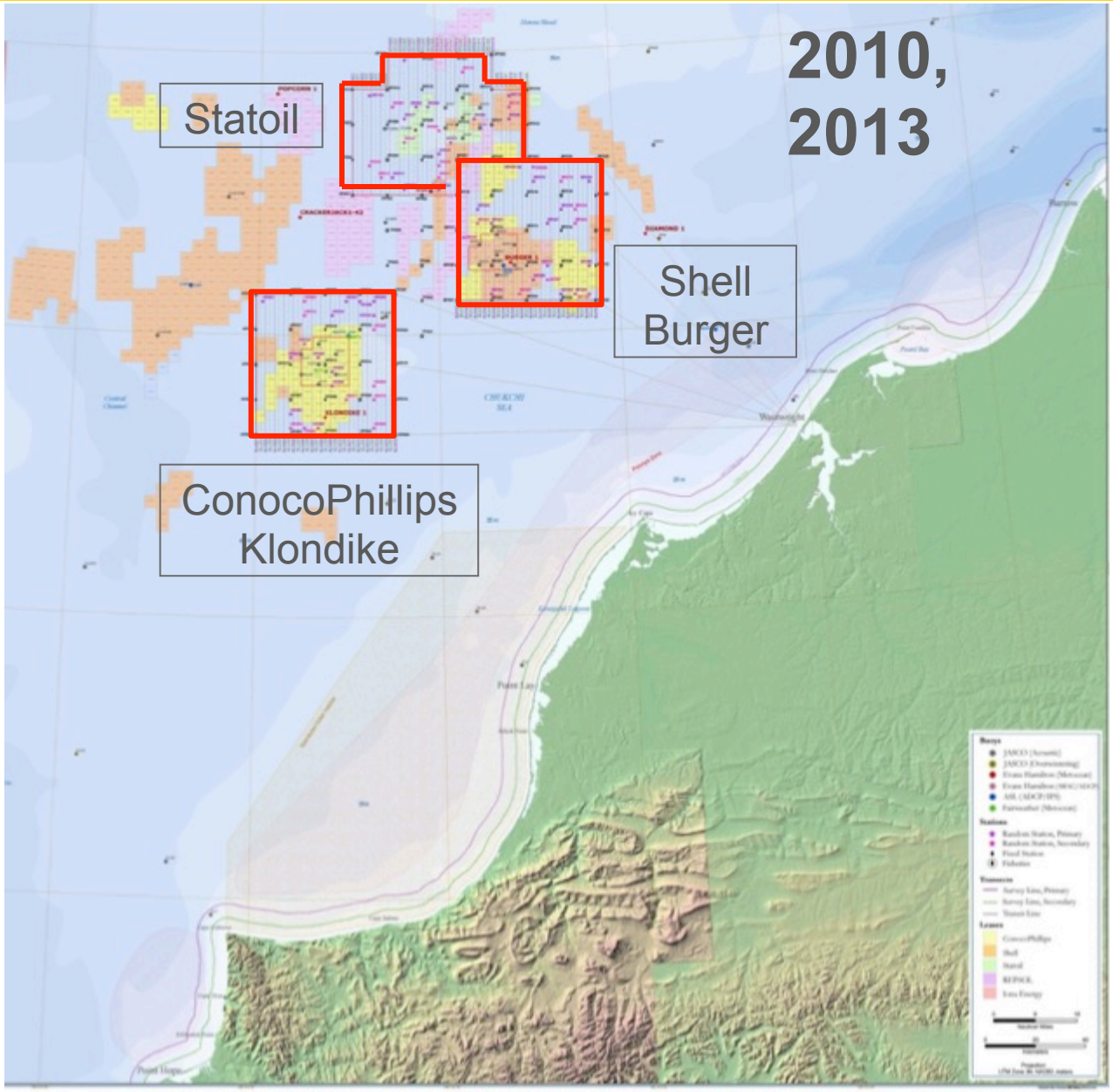


Project Development and Evolution



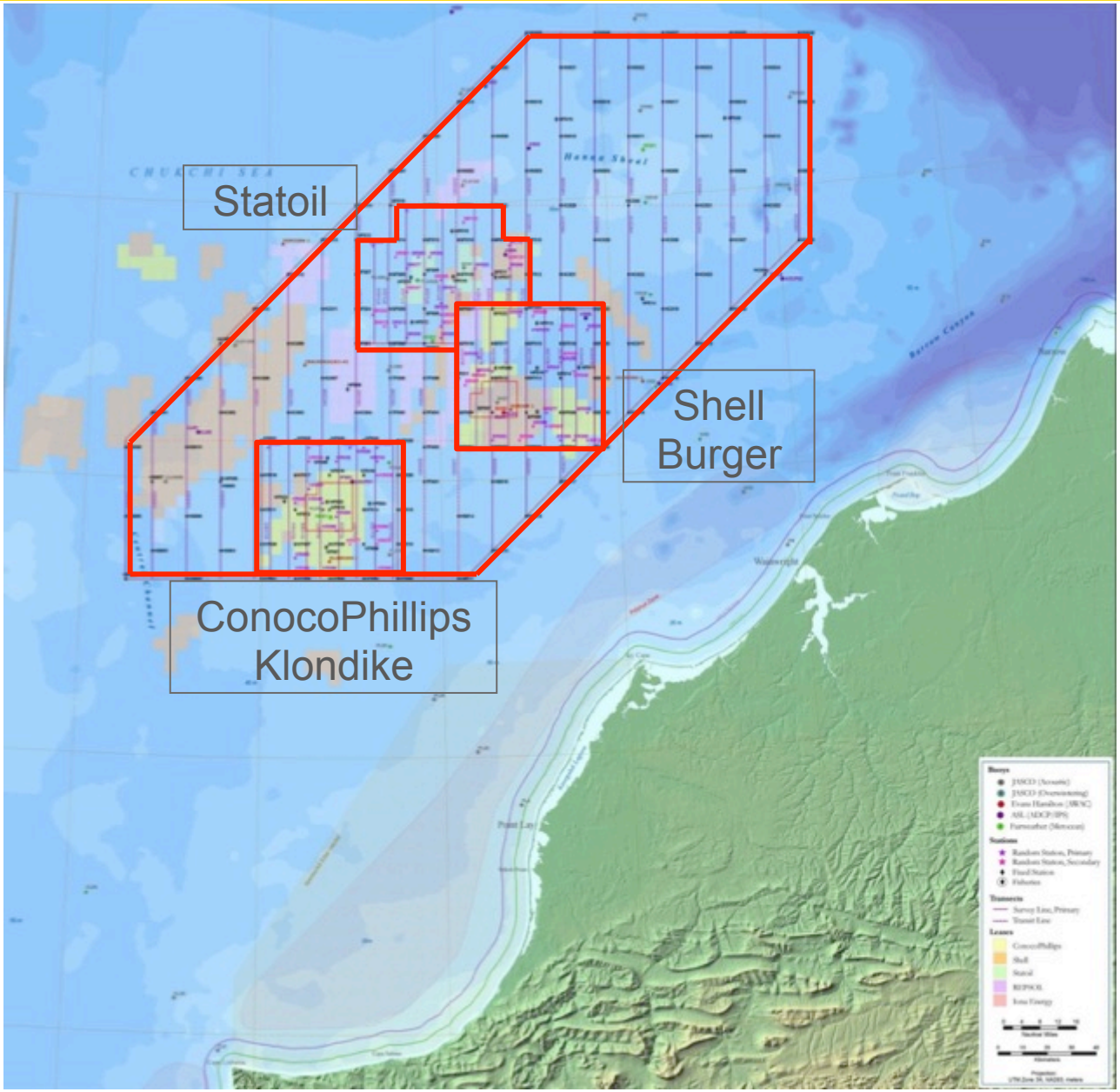
- First two years funded by ConocoPhillips & Shell
- Two study area
- 30 x 30 nm
- Transects 2 nmi
- 25 Stations
- Aug – mid Oct

Project Development and Evolution



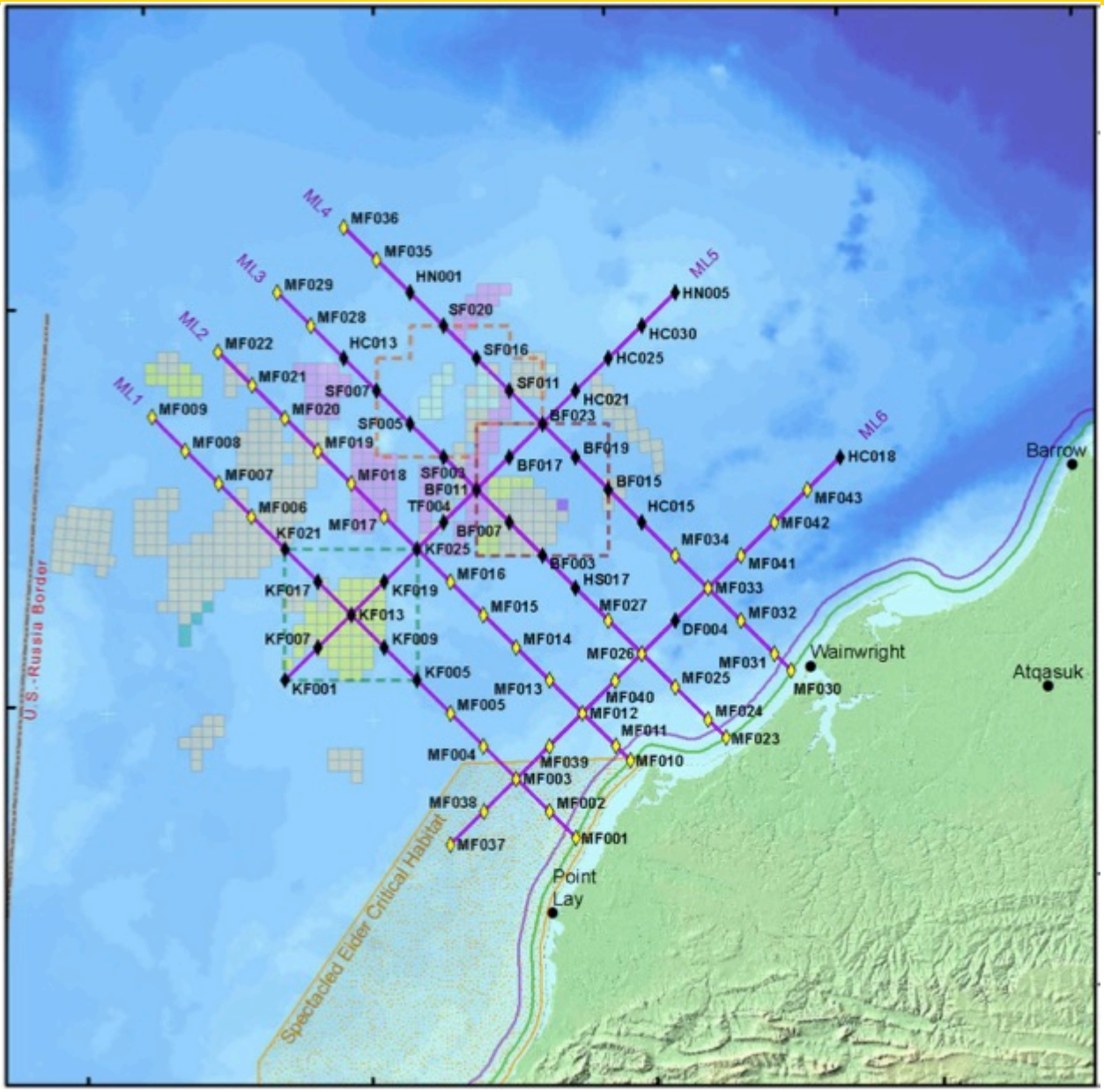
- Three study areas
- 30 x 30 nmi
- Transects 2 nmi
- 25 Stations
- Aug – mid Oct

Project Development and Evolution



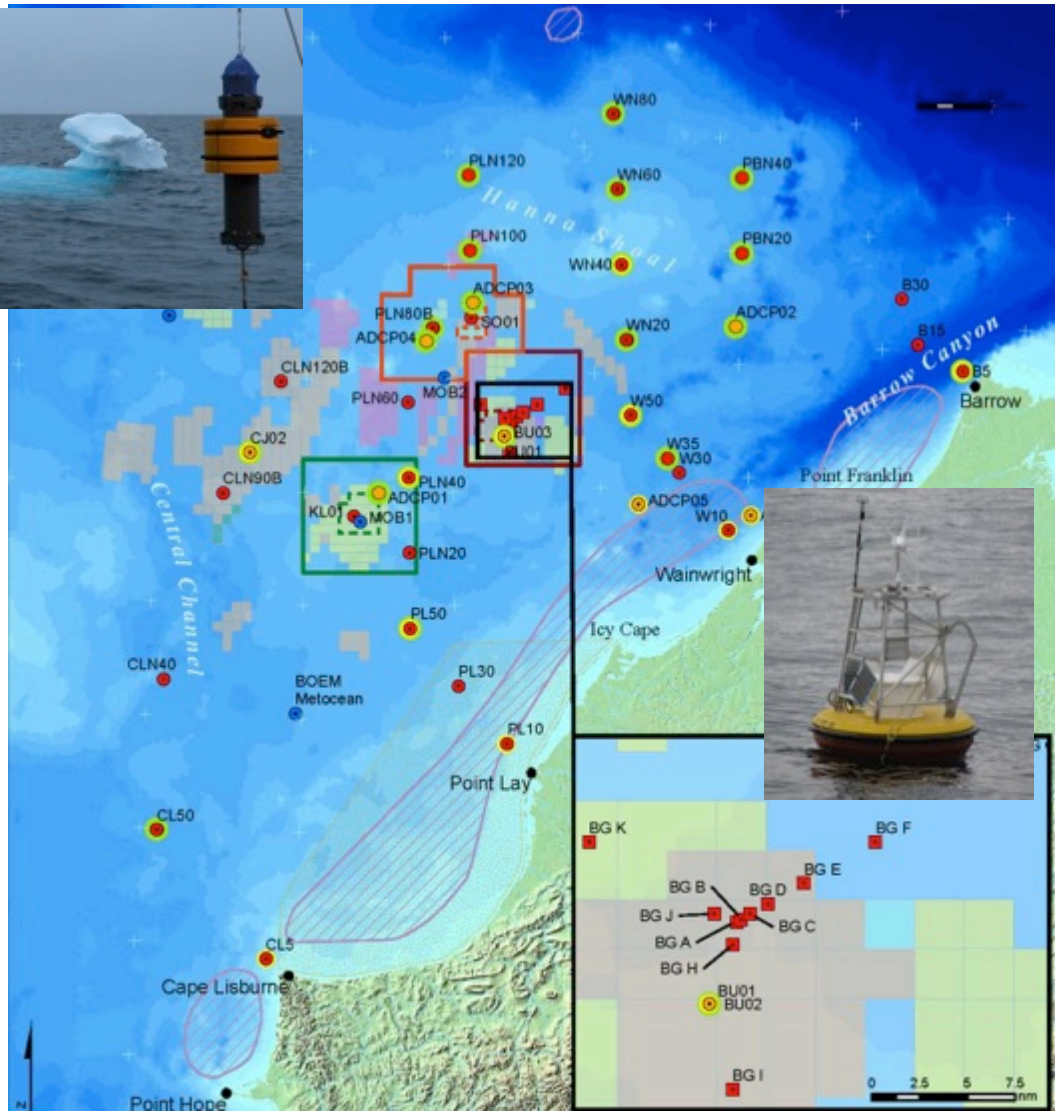
- Three study areas
- Regional study area
- Aug – mid Oct

Project Development and Evolution



- Monitoring lines
- Perpendicular & parallel to coast
- Aug – mid Oct

Instrumentation



ACOUSTIC RECORDERS

- Summering (Jul – Oct) 100% of the time
- Overwintering (Oct – Jul) 20% of the time
- Nearshore locations (Oct – Jul) 2013-2014

ADCP/IPS

- Overwintering (Oct – Jul) 100% of the time

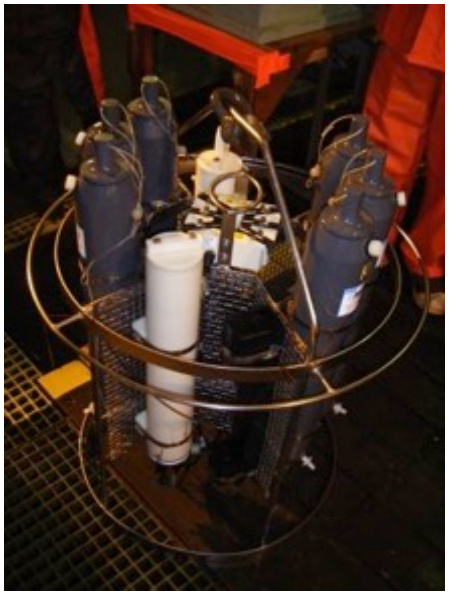
METOCEAN BUOYS

- Summering (Jul – Oct) 100% of the time

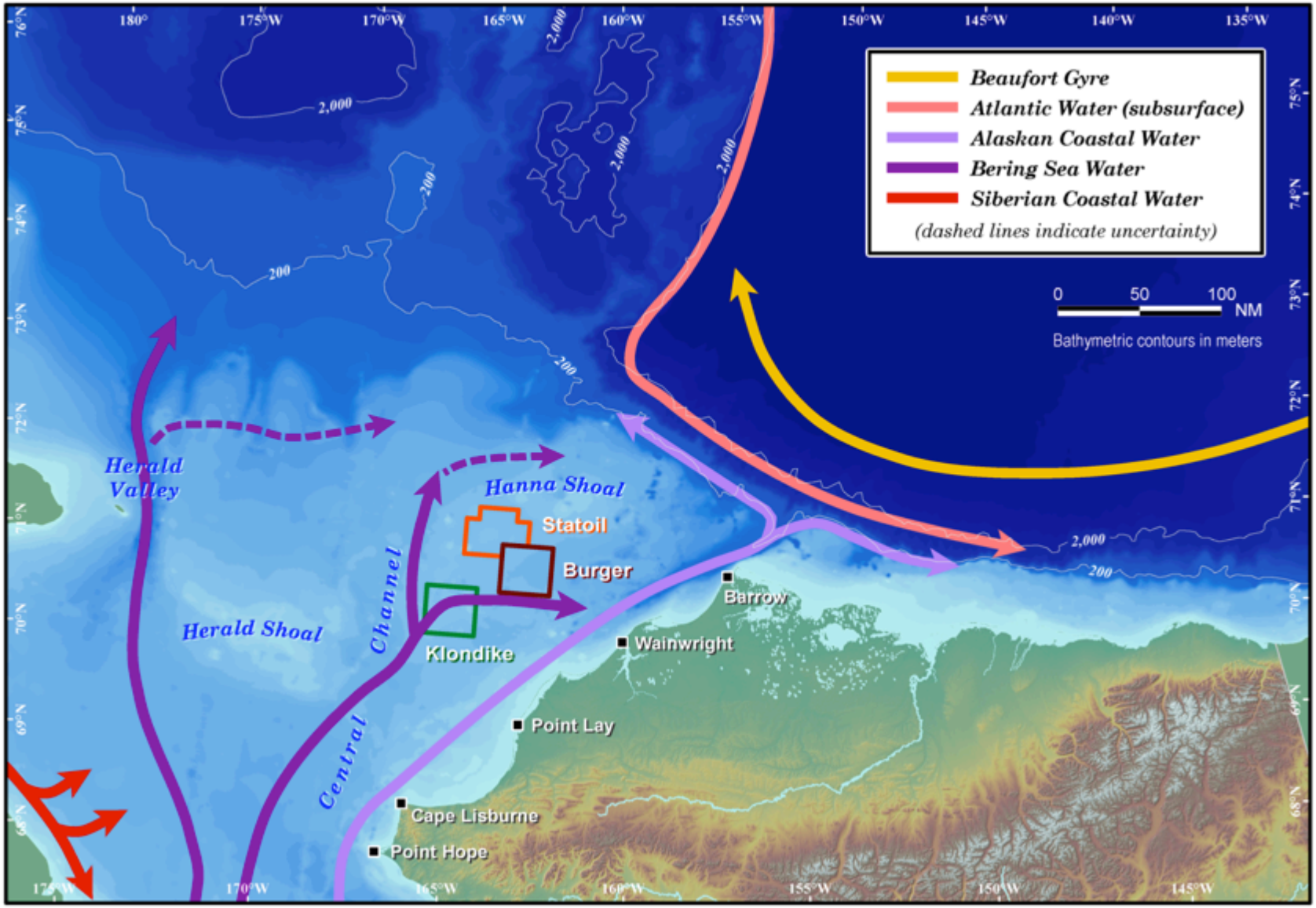
Physical Oceanography

- CTD Rosette
  - CTD=conductivity, temperature, depth
  - 6 bottles that each collect water sample at different depths
  - Water samples are measured for salinity, temperature, nutrients, and chemistry

- Vessel-mounted ADCP
  - ADCP=Acoustic Doppler Current Profiler
  - High frequency acoustic signal to measure salinity and current speed



Physical Oceanography

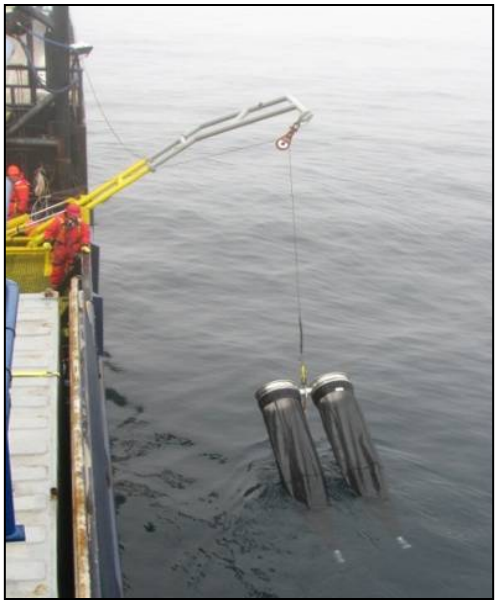


Ocean Acidification

- Added in 2010
- Water collected from CTD
- Samples analyzed for:
  - DIC (dissolved inorganic carbon)
  - pH (acidity)
  - TA (total alkalinity)
  - $pC0_2$ (carbon dioxide)

Zooplankton

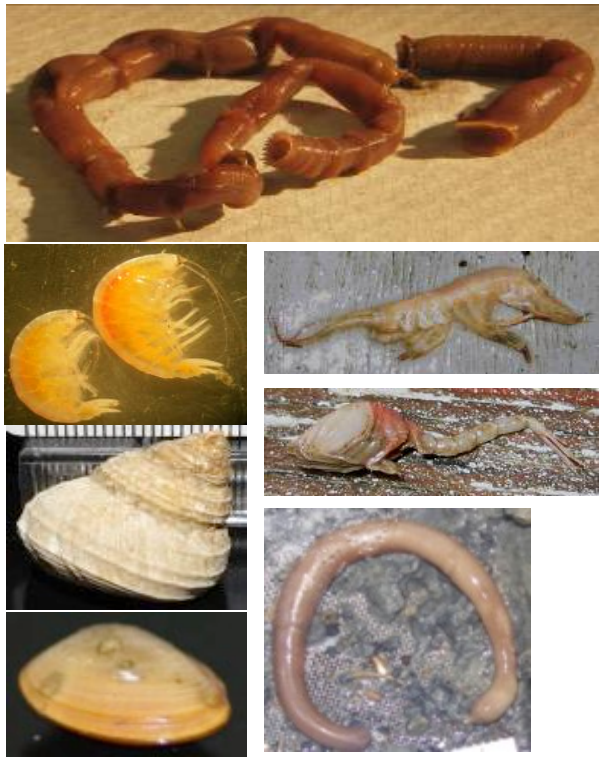
- Two net sizes
  - 150 µm vertical tow (smaller zooplankton species)
  - 505 µm oblique tow (bigger zooplankton species)



Zooplankton

Benthic Infauna

- Infauna are sediment dwelling animals (clams, worms, etc.)



Benthic Infauna

Van Veen Grab

Processing samples

Benthic Epifauna

- Epifauna are organisms living on top of ore closely associated with the sediment surface

Benthic Epifauna

Trawl

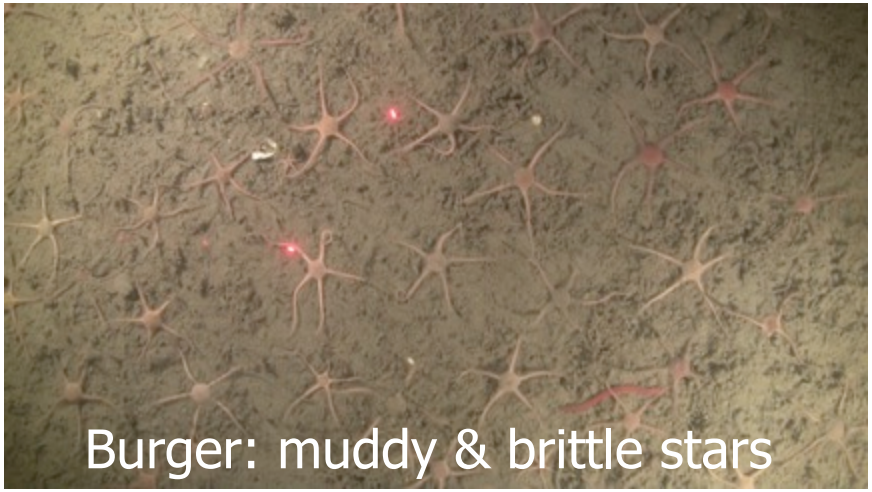
Processing samples

Benthic Epifauna Video / Photo Surveys


Statoil: muddy & more bivalves


Hanna Shoal: muddy, < epifauna


Klondike: rocky to muddy


Burger: muddy & brittle stars

Fish Ecology

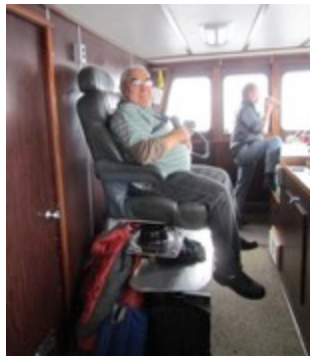
- 2009-2011
  - Benthic trawl
  - Mid-water trawl (2 sizes in 2010)
  - From *R/V Westward Wind* (2009-2010)
  - From *F/V Pandalus* (2011)
- 2011-2013
  - Hydroacoustic tows

Marine Mammals

- Vessel-based line transect procedure
- One dedicated biologist, assisted by Inupiat observer
- Acoustic Recorders

Working with Communities

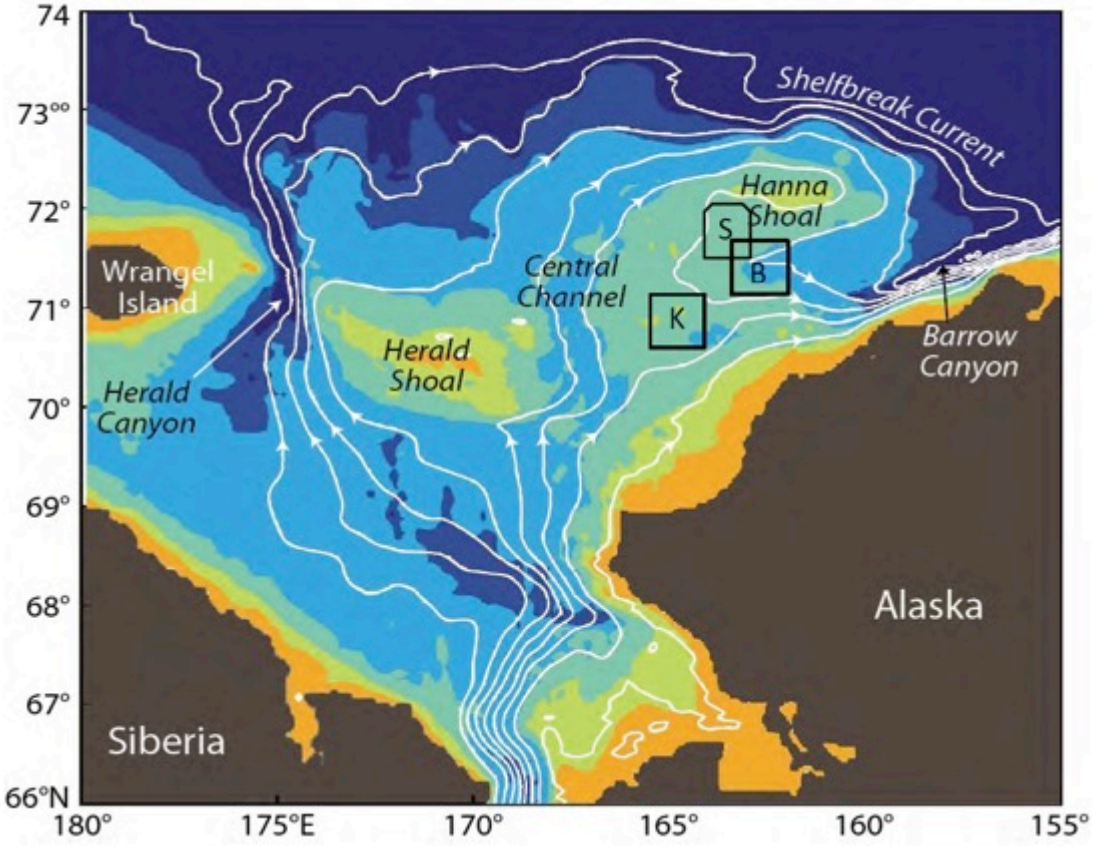
- TEK Workshop for Field Team and Scientists
- Iñupiat Observers
- Wainwright school visit
- Logistics (Wainwright)



What Have We learned?

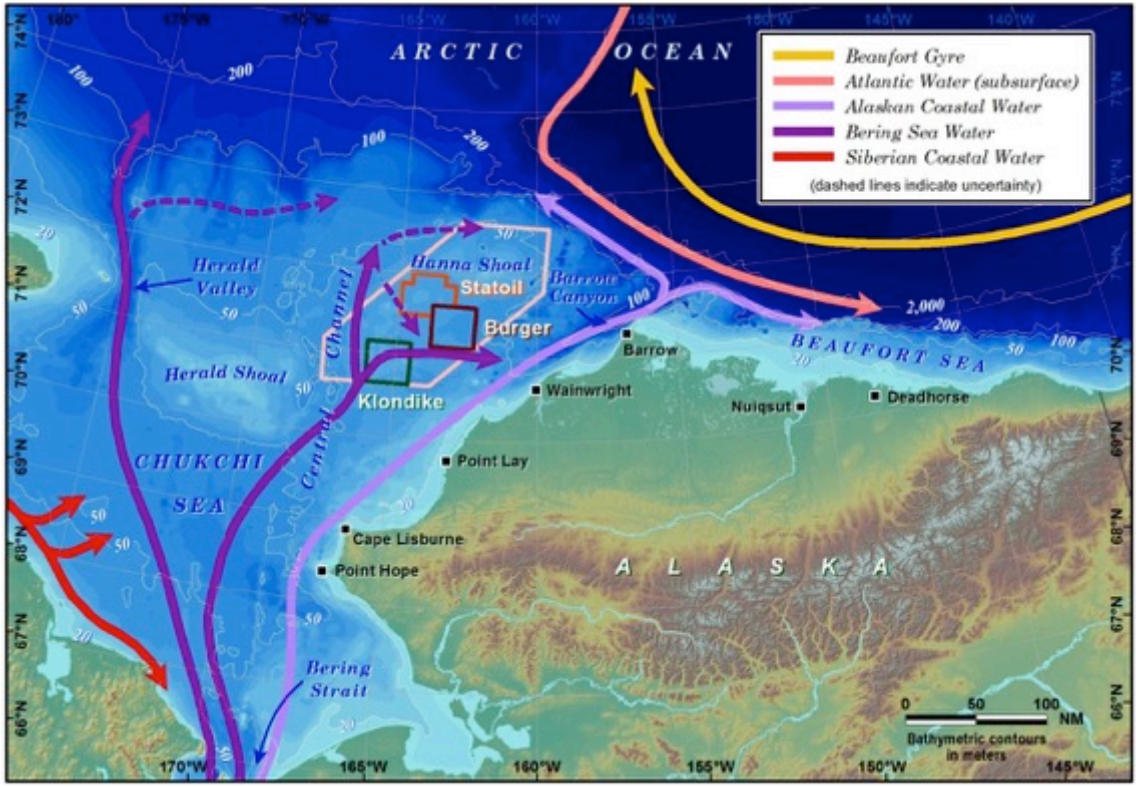
Connection between topography and currents

- Warm nutrient rich water enters from the Bering Sea through the strait
  - Advects zooplankton and phytoplankton
- Topography (shallows, canyons, and valleys) route major currents and mixing patterns
  - Winds are a significant factor in determining intra and inter-annual variability



Water Movement

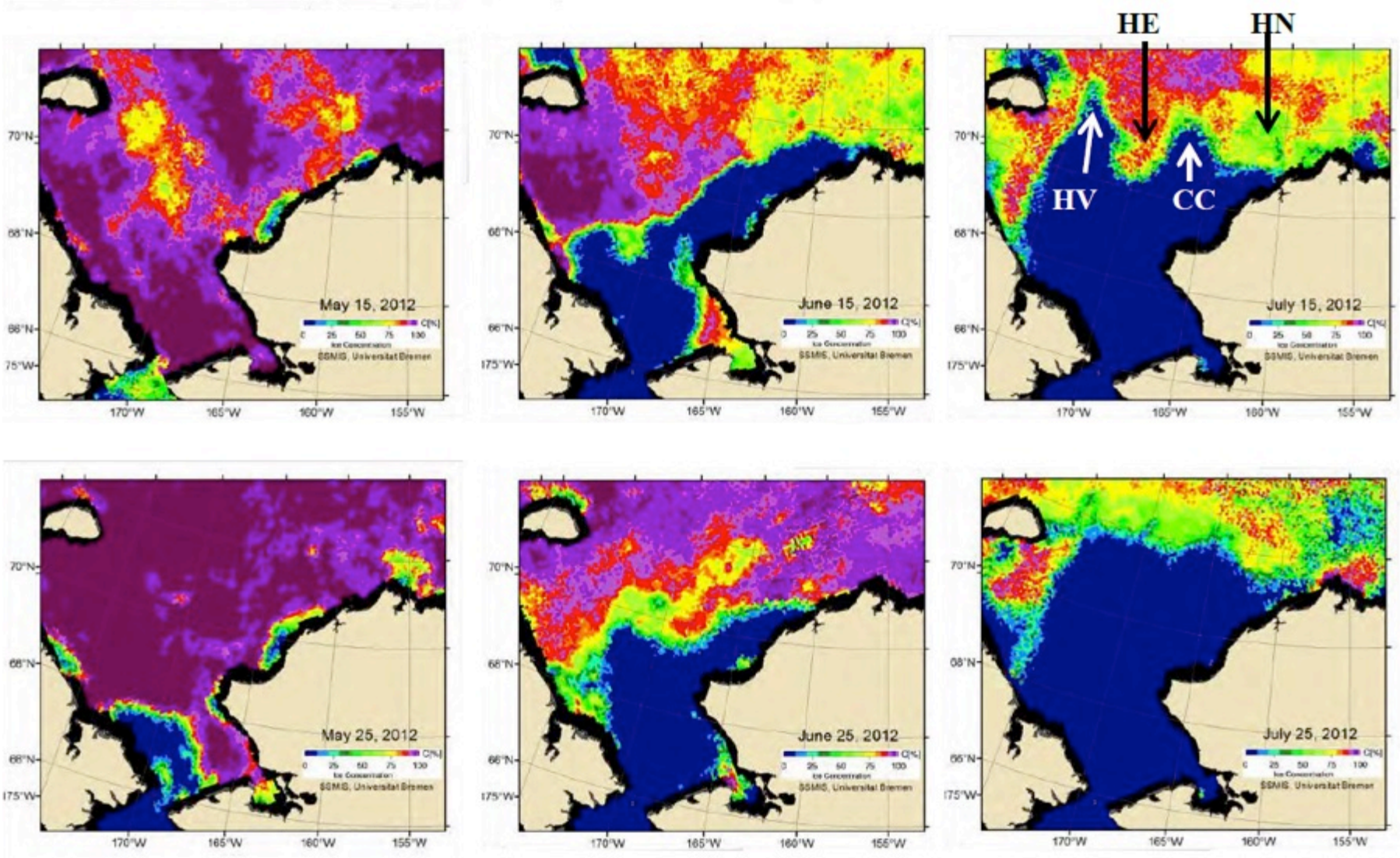
- In relation to the study area(s)
  - Klondike is most affected by the central channel current
  - Water moves from the central channel and around Hanna Shoal to Barrow canyon before exiting the Chukchi
  - Burger and Statoil are relatively slack in terms of oceanic currents



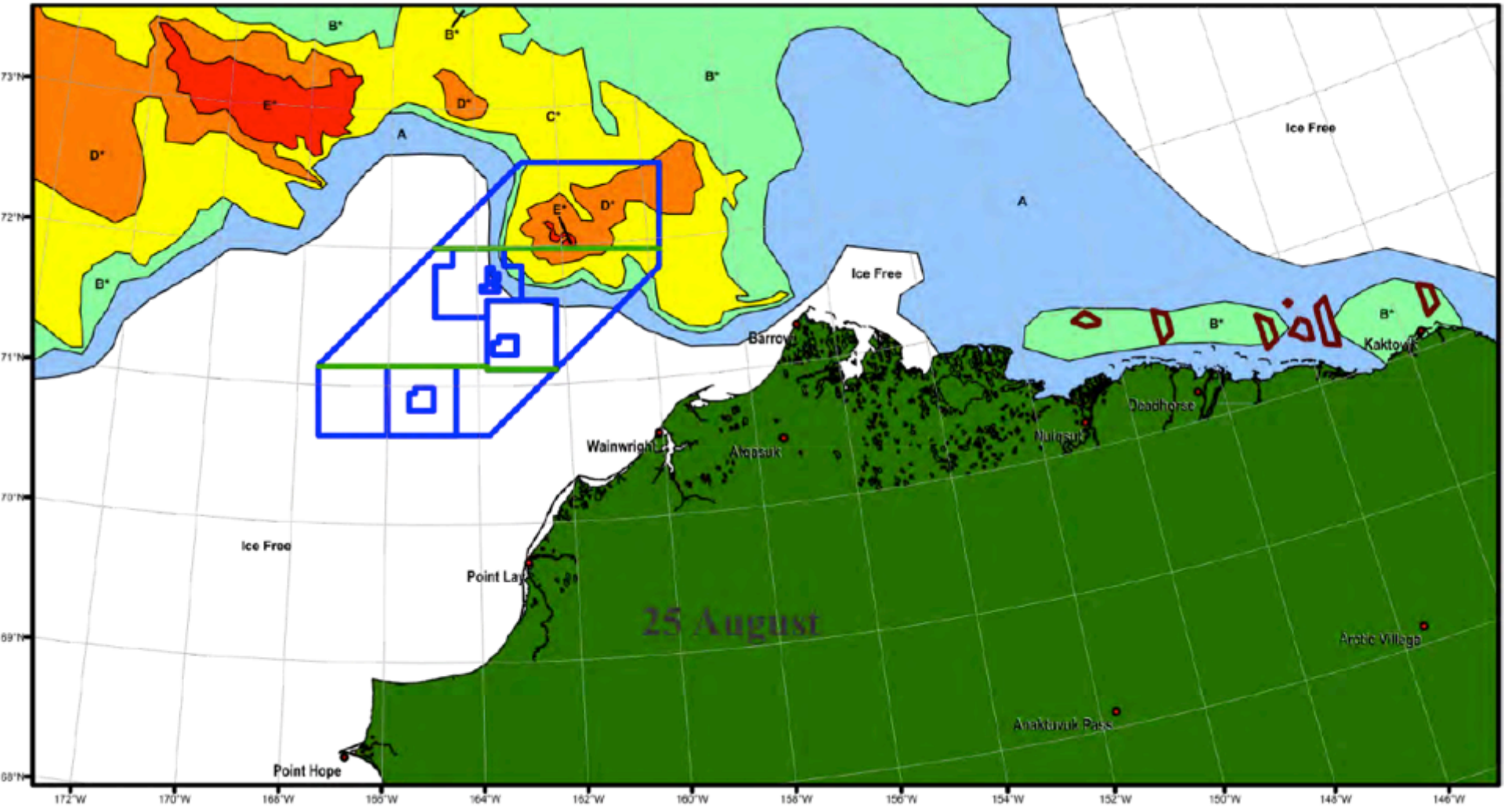
Oceanography varies spatially

- **Water from south of the Bering Strait**
  - Brings heat, nutrients, plankton, fishes into the system
  - Affects production in the Chukchi
- **Currents, winds affect ice melt-off and movement patters, timing of blooms**
  - Advects warm water from south, melt ice
  - Easterly winds advect ice out of the study area
- **Two main surface water masses**
  - Bering Sea water – warm moderate salinity
  - Meltwater – cold low salinity

Impact on Ice Dynamics



Impact on Ice Dynamics

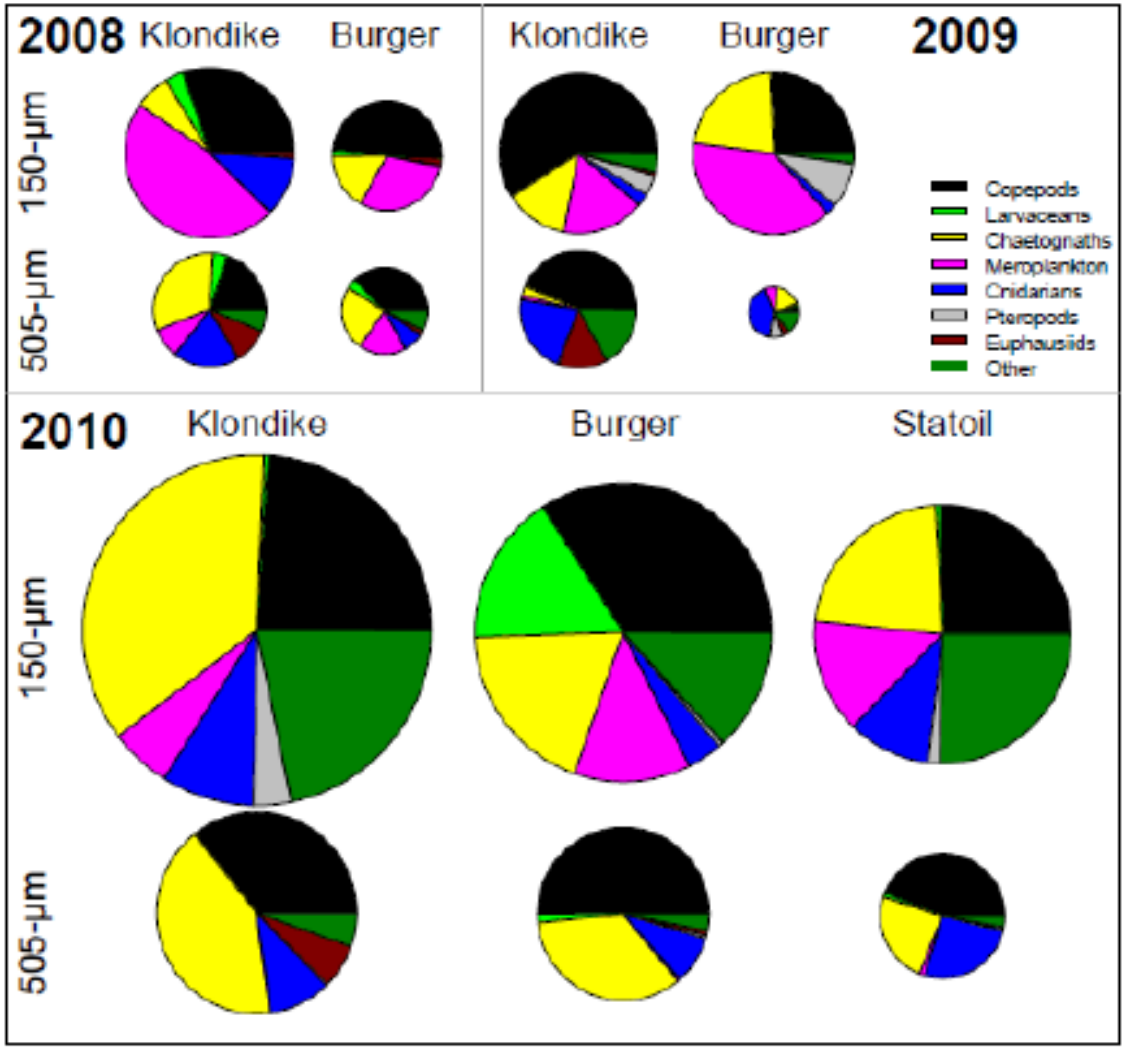


Inter-annual variability

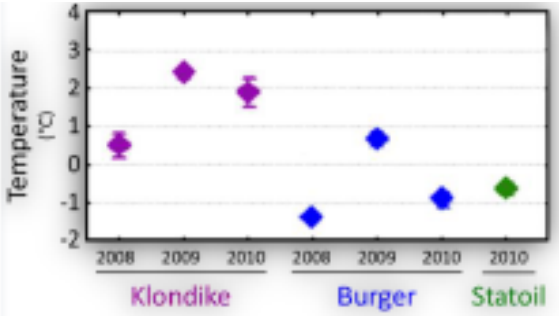
YEAR	CHARACTERISTIC	ICE	BERING SEA WATER	MELTWATER
2008*	Cold	Much, Persistent	Klondike	Burger
2009*	Very Warm (Early)	None	Everywhere	NE Burger
2010	Very Warm (But Later In Year)	Little (Gone Quickly)	Everywhere	NE Burger/ NE Statoil

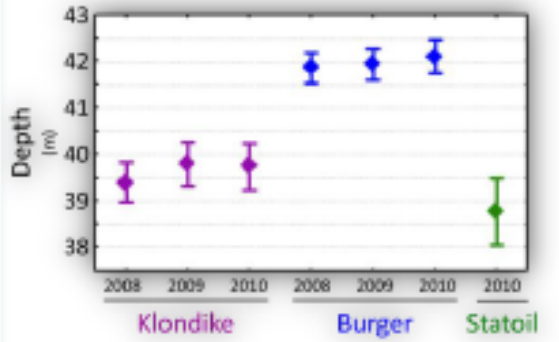
Zooplankton Ecology

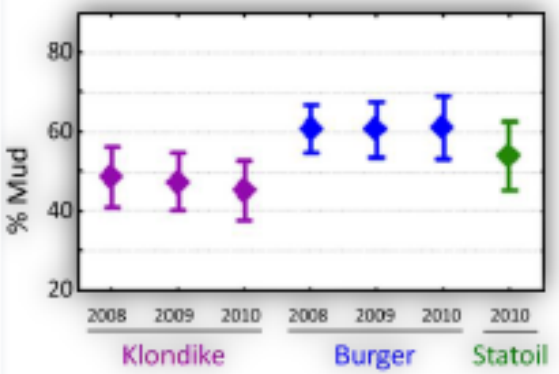
- Klondike the highest biomass for larger zooplankton
- Klondike nearly always highest for smaller zooplankton
- Inter-annual variability across all areas in terms of biomass and abundance
  - Areas and years of early melt back result in higher biomass and abundance of zooplankton



Benthic ecology







Klondike ⟷ Statoil ⟷ Burger

warmer
shallower
sandier

Dynamic Environment

colder
deeper
muddier

Depositional Environment

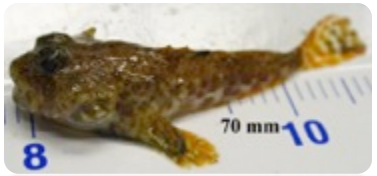
Fish Ecology

- Fish communities are benthic-based, invertebrate feeders

- Primarily demersal species (arctic cod, sculpins)
- Few fishes in general, small in size (25-100mm)

Arctic cod

Hamecon

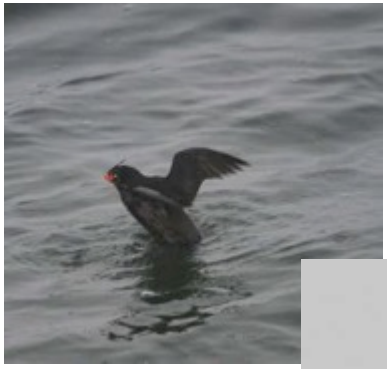


Polar eelpout

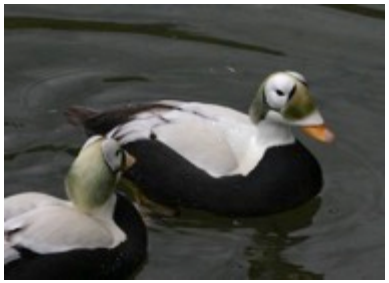
Stout eelblenny

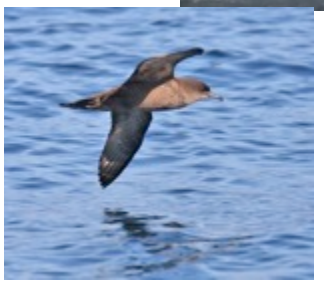
Seabird Ecology

- Primarily ~8-10 species (diving feeders, surface feeders)
- Dominated by zooplankton feeders (auklets, shearwaters)
- Few fish eaters (murres)
- Generally higher densities in Klondike that Burger or Statoil







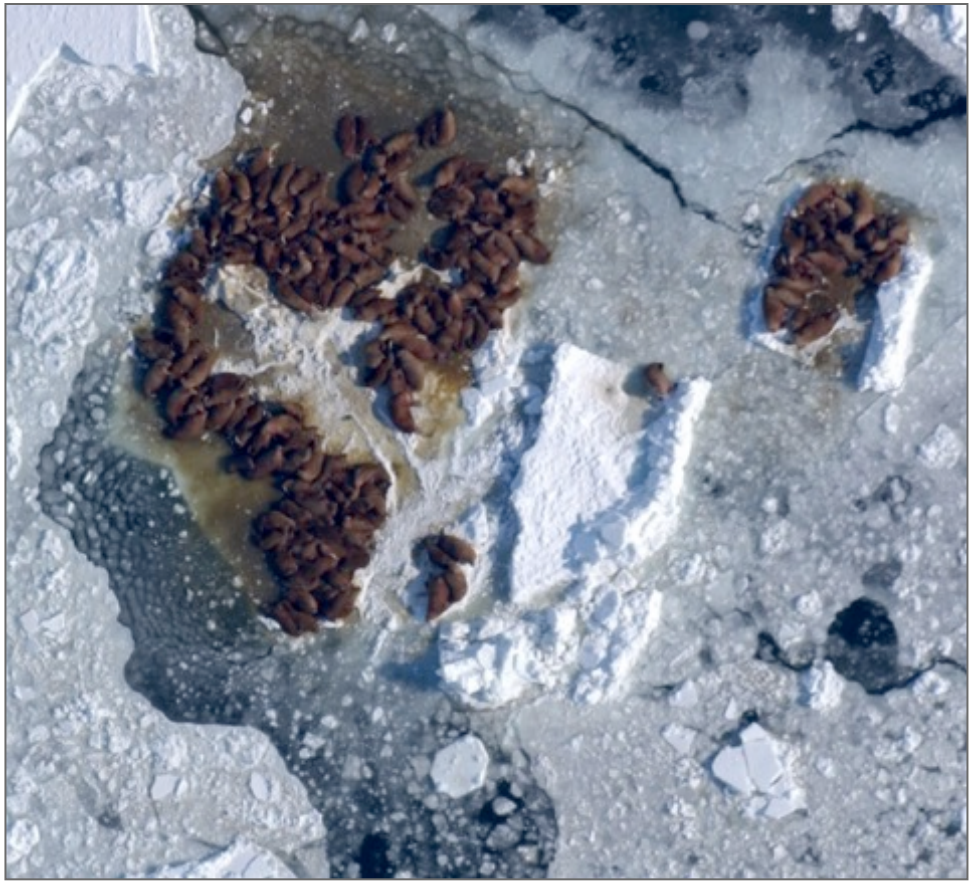


Marine Mammal Ecology

- Bowhead whales most common in Sept/Oct in all years and at Burger
- Beluga whales generally not present in the study area during the study period
- Gray whales observed nearshore and east of Burger
- Klondike dominated by pelagic feeders (ringed, ribbon, spotted seals)
- Burger dominated by benthic feeders (bearded seals, walruses

Case Study - The Ecosystem – a walrus perspective

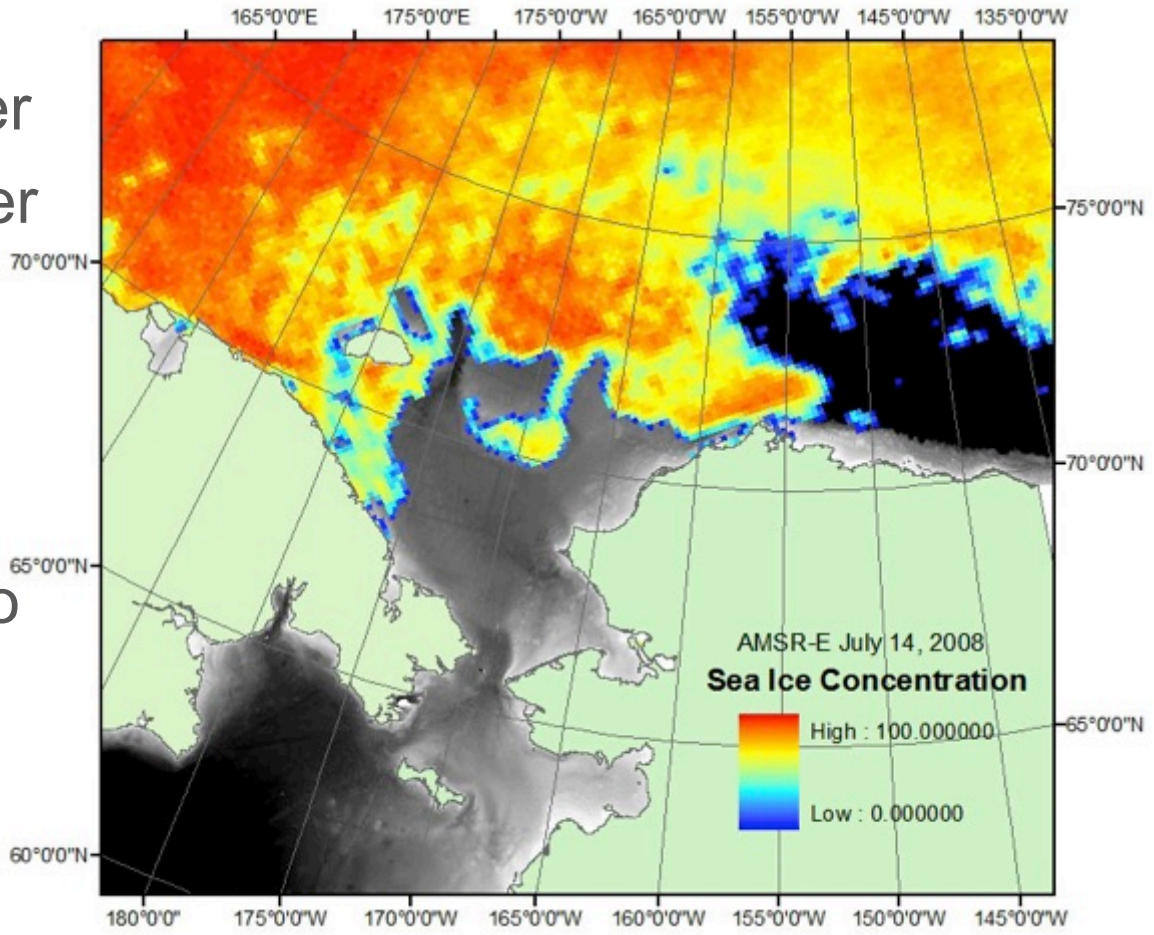
- Pacific walruses utilize relatively shallow continental shelf habitats
- Feed on benthic invertebrates at depths <100 m
- Spend time between foraging dives hauled out on ice, when available, or on land
- Distribution of concentrations of walruses is not uniform



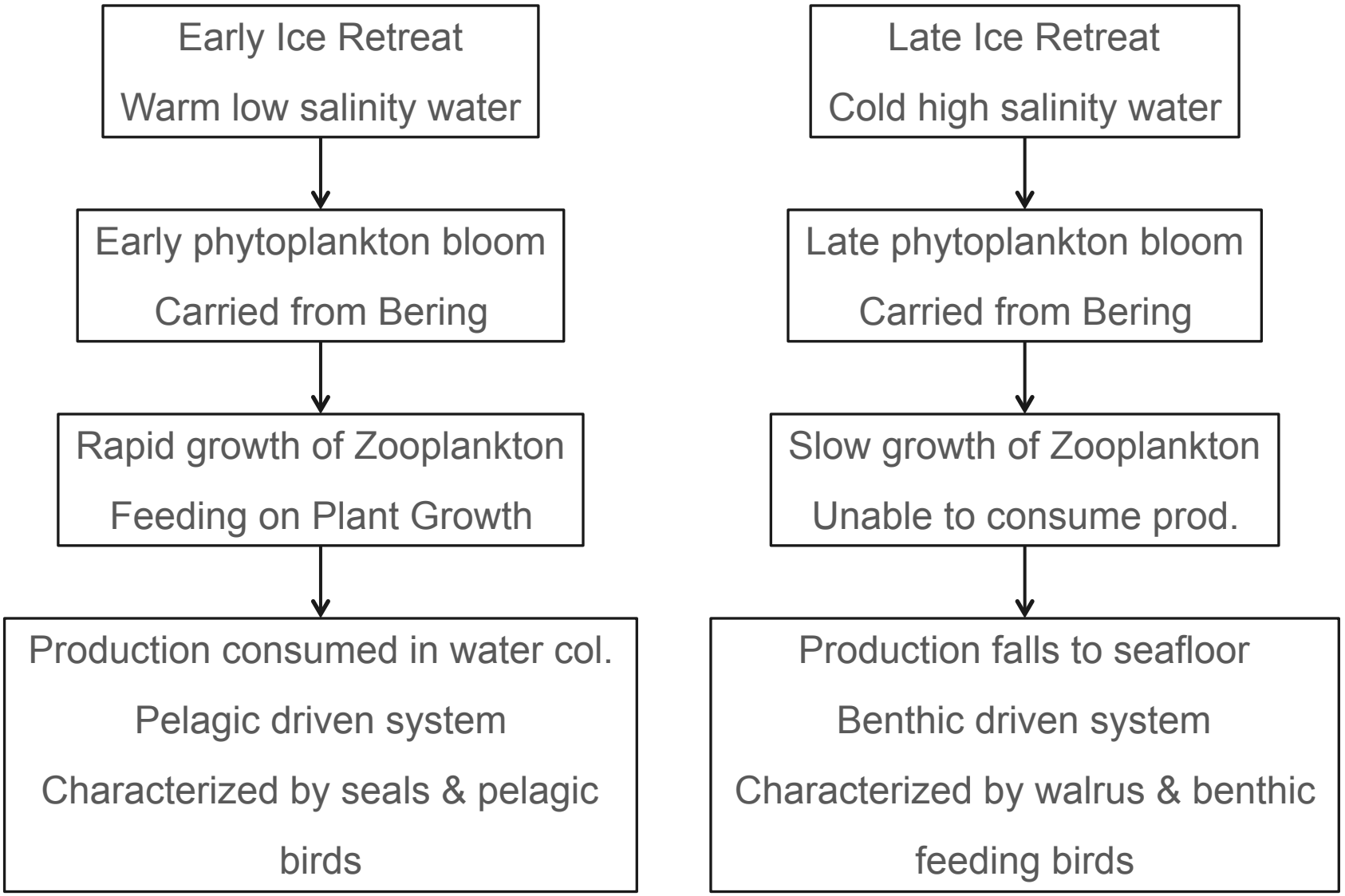
Case Study - The Ecosystem – a walrus perspective

Currents Effect Ice Retreat

- Ice retreats earliest over channels and latest over shoals
- Ice over Hanna Shoal tends to persist late into the season due to slow melting and grounding of multi-year ice



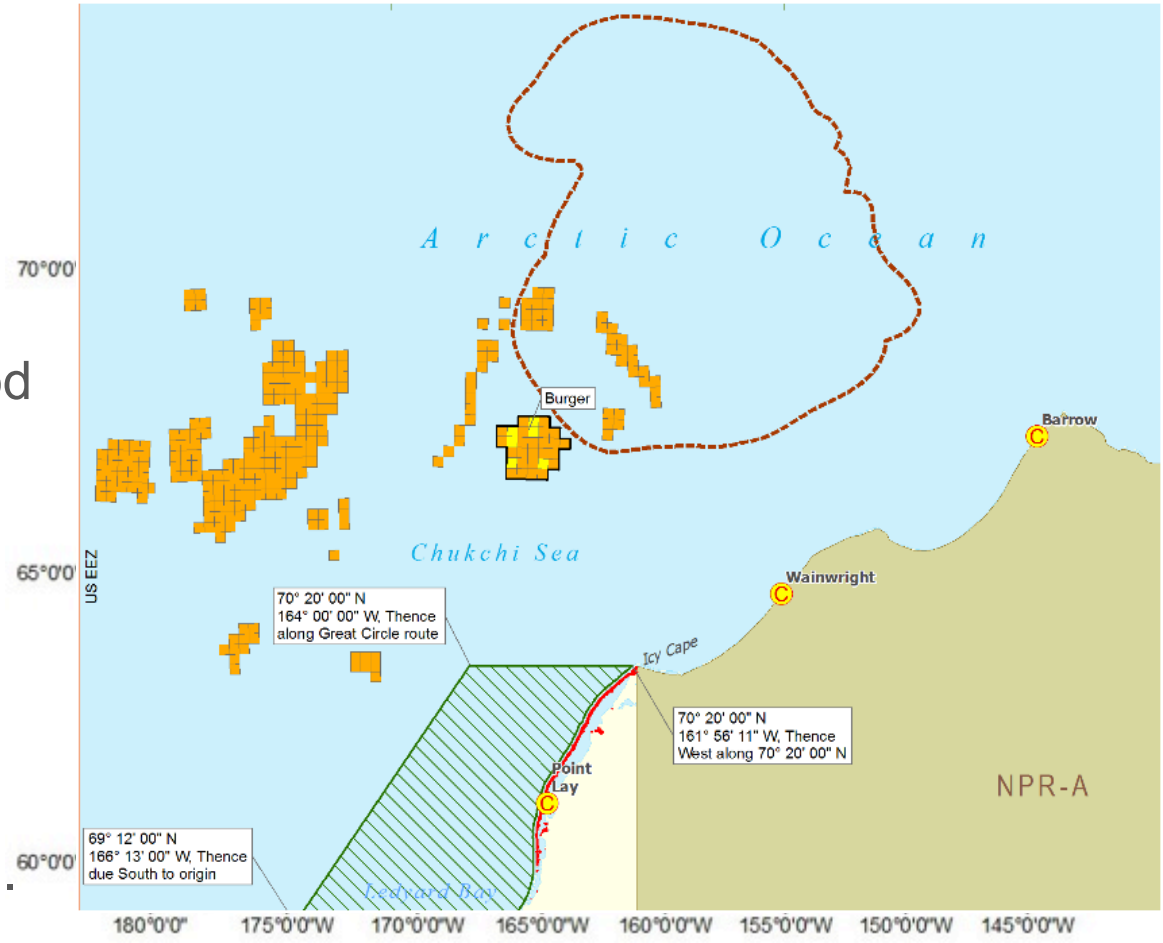
Case Study - The Ecosystem – a walrus perspective



Case Study - The Ecosystem – a walrus perspective

Currents Effect Ice Retreat

- Currents influence ice melt pattern
- Areas of cold water determine areas of high food availability for walruses
- This explains not only that the Hanna Shoal area is important to walruses, but mechanistically why as well.



Summary

- NE Chukchi not homogeneous & ***highly variable*** spatially (small scales), seasonally, inter-annually

- Sea ice retreat varies
  - Affects when/where/how much of spring bloom occurs
  - Affects nutrients within water column or on seafloor
    - Water temperatures varies
  - Affects zooplankton – how “old” and big
  - Influences distribution of animals feeding on zooplankton

- Highly Productive and Resilient

Data and Publications

- All the data collected during this program are available on line through the website for the Alaska Ocean Observing System-NOAA Data Sharing Agreement
  - http://www.aoos.org/industry-arctic-data/

- A dedicated volume of Continental Shelf Research has been published in 2013.
  - Papers from this dedicated volume are available at no cost and can be downloaded at: http://www.sciencedirect.com/science/journal/02784343/67

- Additional information on the CSESP, including presentations and annual report documents can be found at:
  - http://www.Chukchiscience.com

CSESP Strengths

- Ecosystem-based
- “Long-term”
- Collaborative with scientific community (DBO, PAG, ASAMM, AMBON)
- Cooperation/Coordination among industry

Questions?