THE NORTHEASTERN CHUKCHI SEA: A COMPLEX HIGH-LATITUDE ECOSYSTEM

Robert H. Day and the CSESP Team

ACKNOWLEDGMENTS

ConocoPhillips
Statoil
Olgoonik Fairweather LLC
RPS Evans-Hamilton
ABR inc. environmental research & services
JASCO APPLIED SCIENCES
oasis ENVIRONMENTAL
TigerNav
NRC NATURAL RESOURCES CONSULTANTS, INC.
SALA Remote Medics
Resource Data Inc. PEOPLE • TECHNOLOGY • RESULTS
UAF UNIVERSITY OF ALASKA FAIRBANKS
University of Alaska Fairbanks Institute of Marine Science Founded 1960
ASL Environmental Sciences
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AOS ALDRICH OFFSHORE SERVICES LLC

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CHUKCHI SEA ENVIRONMENTAL STUDIES PROGRAM

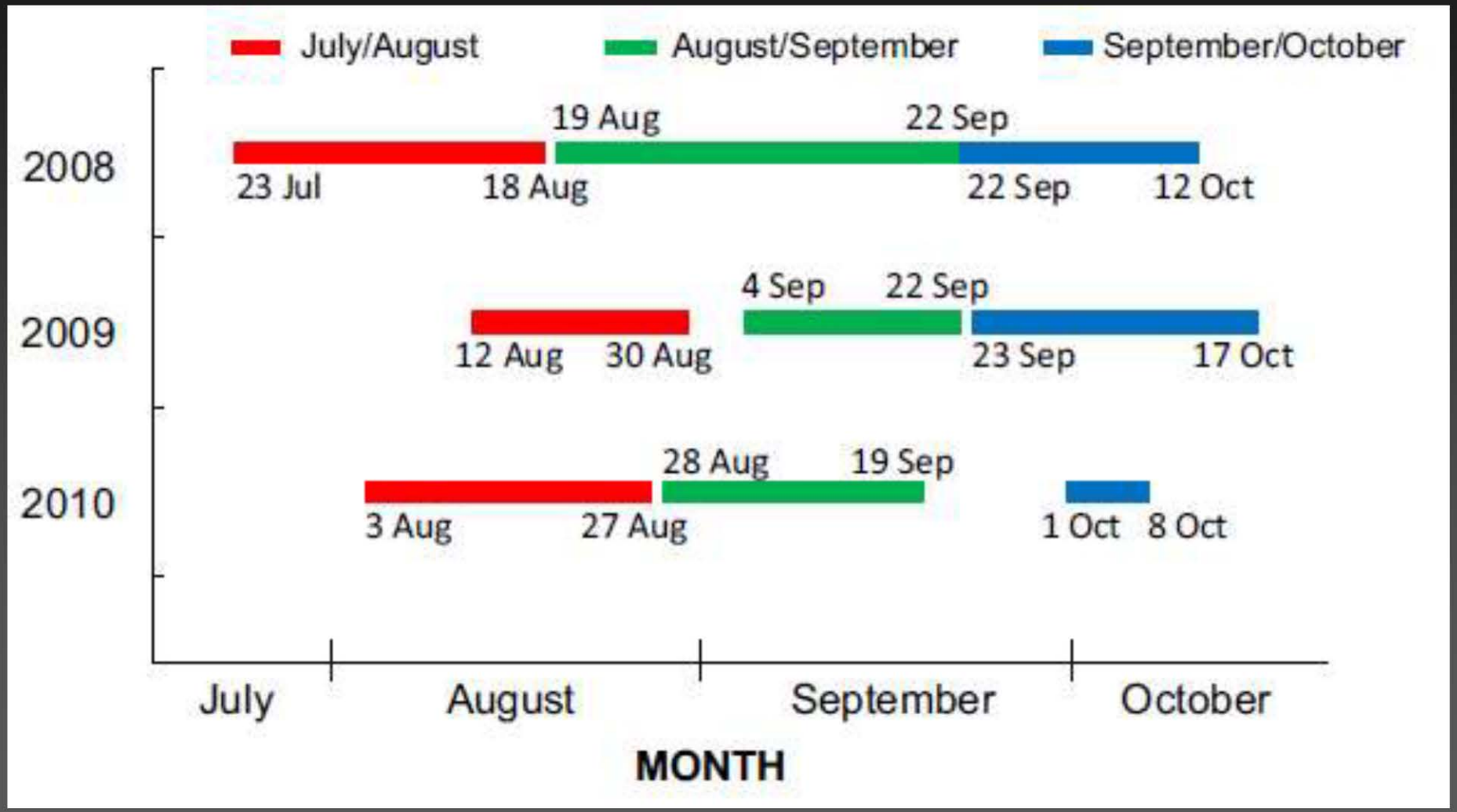
- Multiyear, multidisciplinary oceanographic study prior to oil exploration—data for
  - permit applications
  - NEPA documents
  - baseline data to assess potential environmental effects of oil and gas exploration, development
  - input into planning future operations, mitigation

- Surveys in open-water season 2008–2010

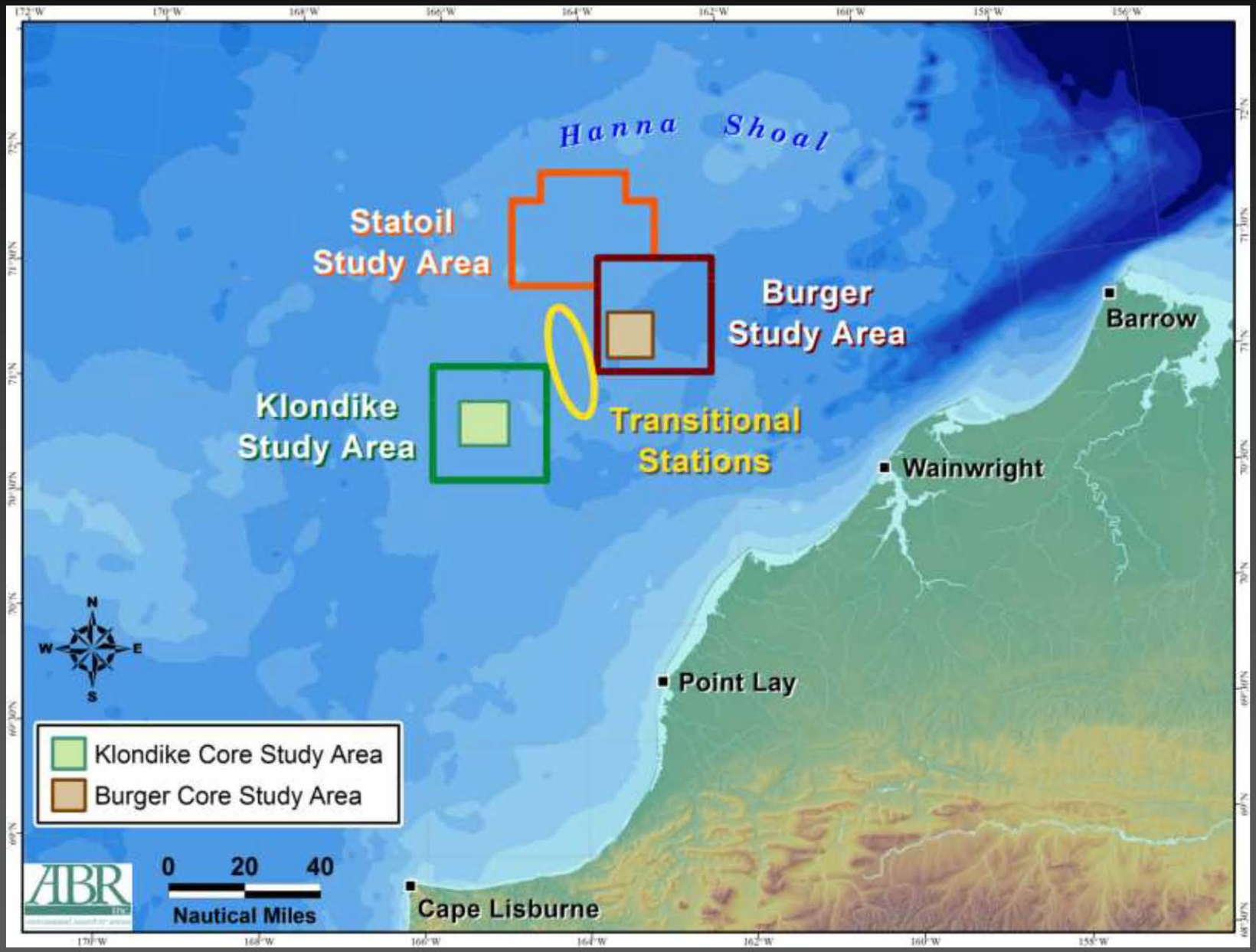
SCIENTIFIC DISCIPLINES

- Physical oceanography
- Nutrients/phytoplankton
- Zooplankton
- Ocean acidification
- Baseline chemistry
- Benthic ecology
- Fisheries ecology
- Seabird ecology
- Marine-mammal ecology
- Passive acoustics

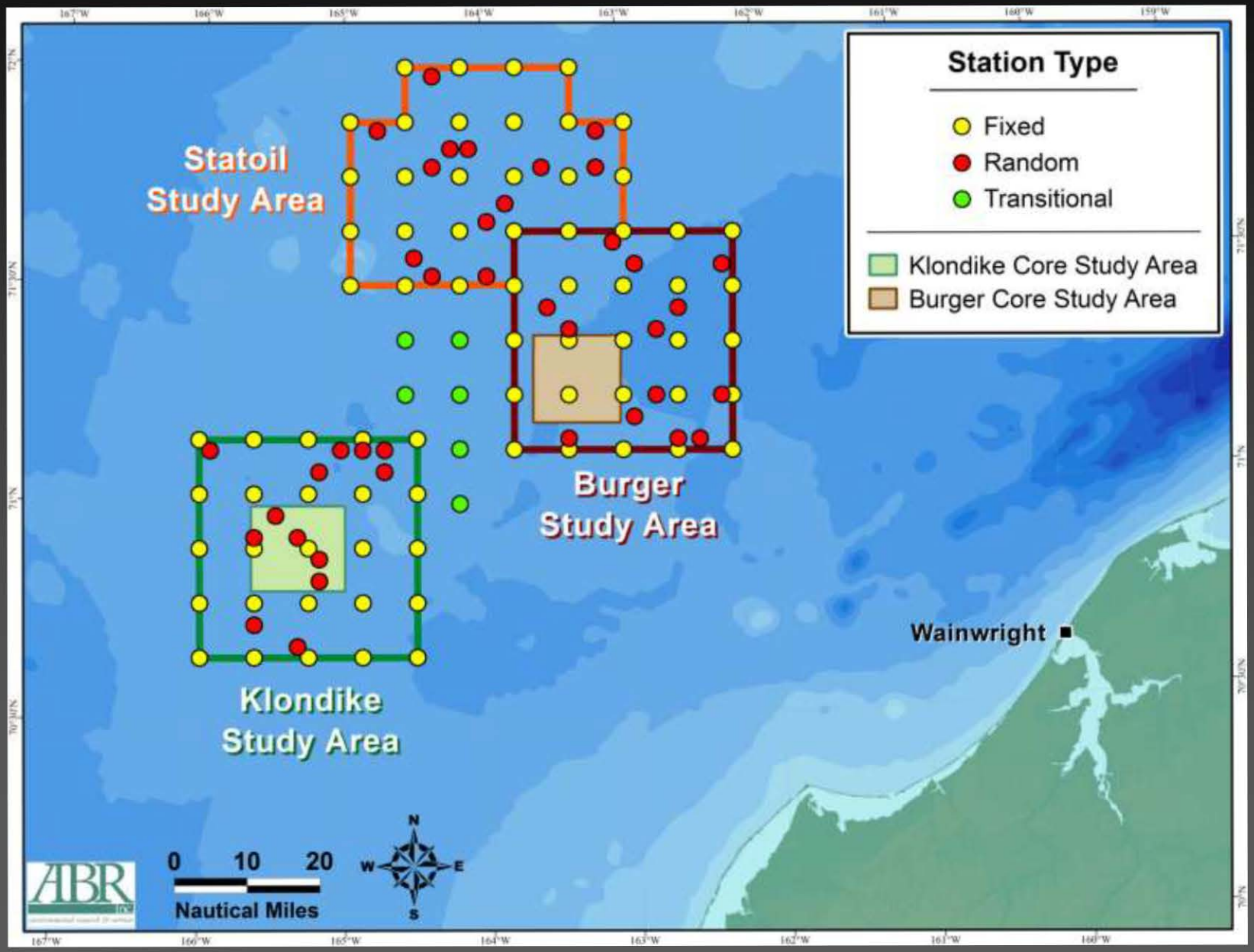
3 CRUISES/YEAR



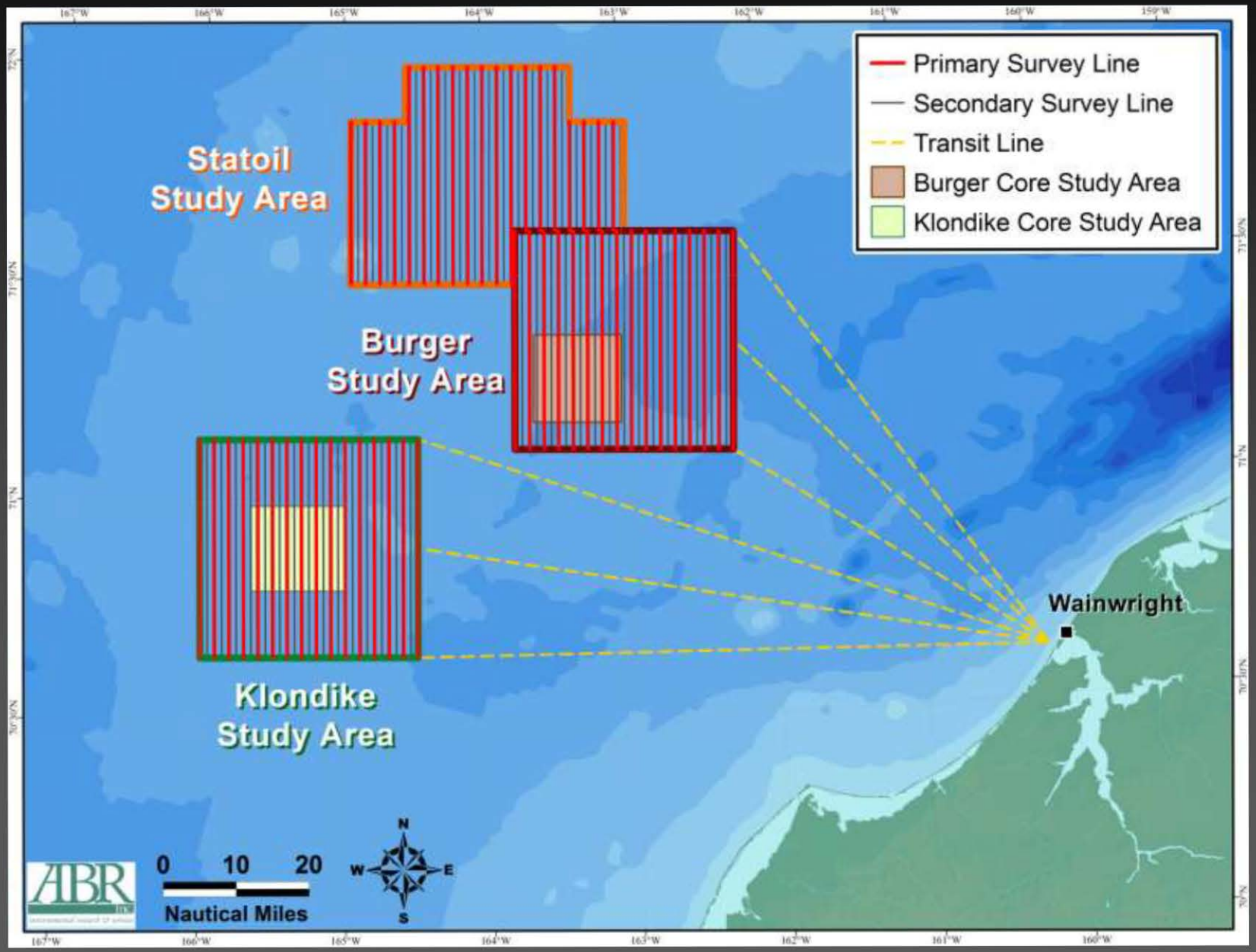
STUDY AREAS (2008–2010*)



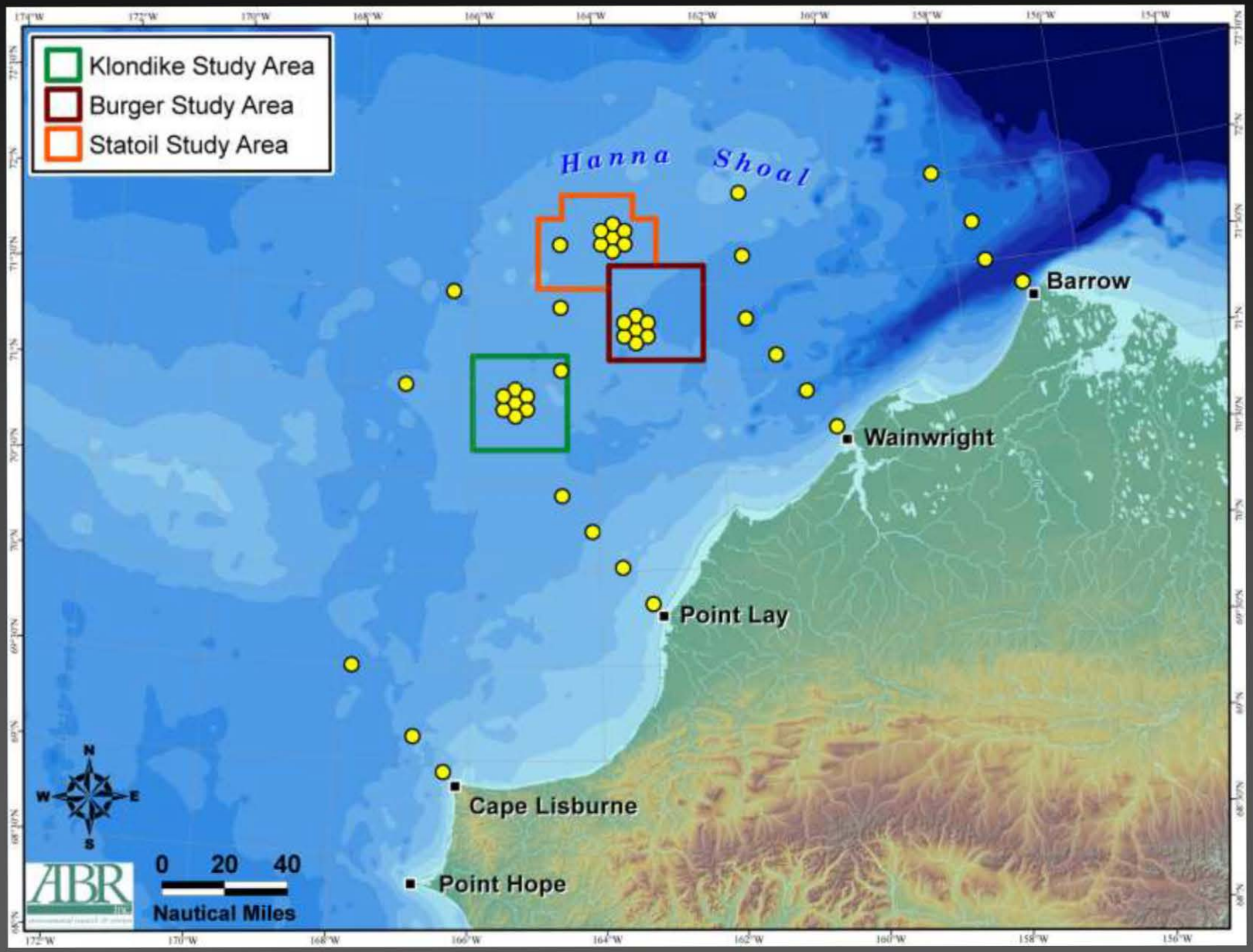
OCEANOGRAPHIC STATIONS



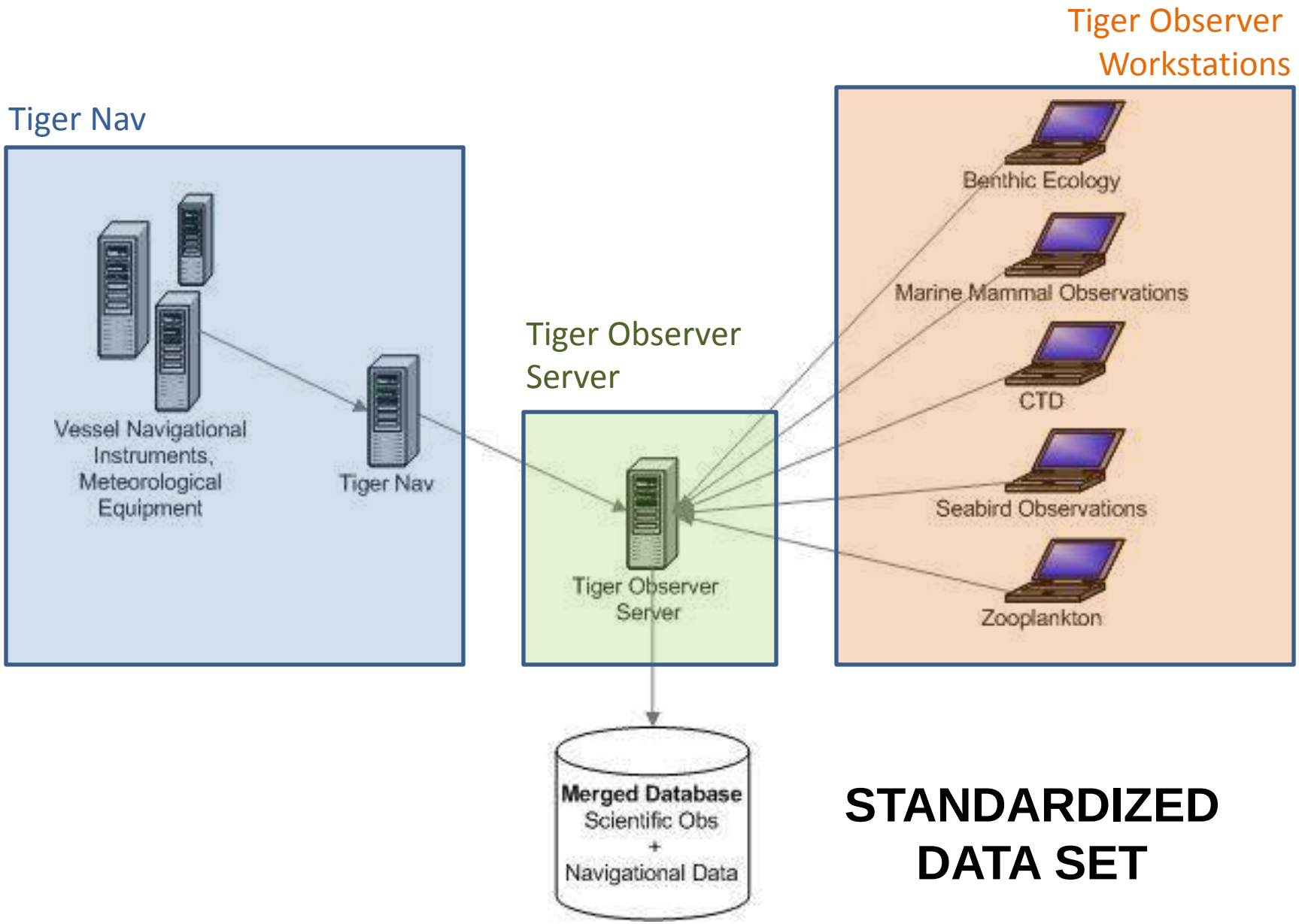
BIRD/MAMMAL LINES



ACOUSTIC MOORINGS

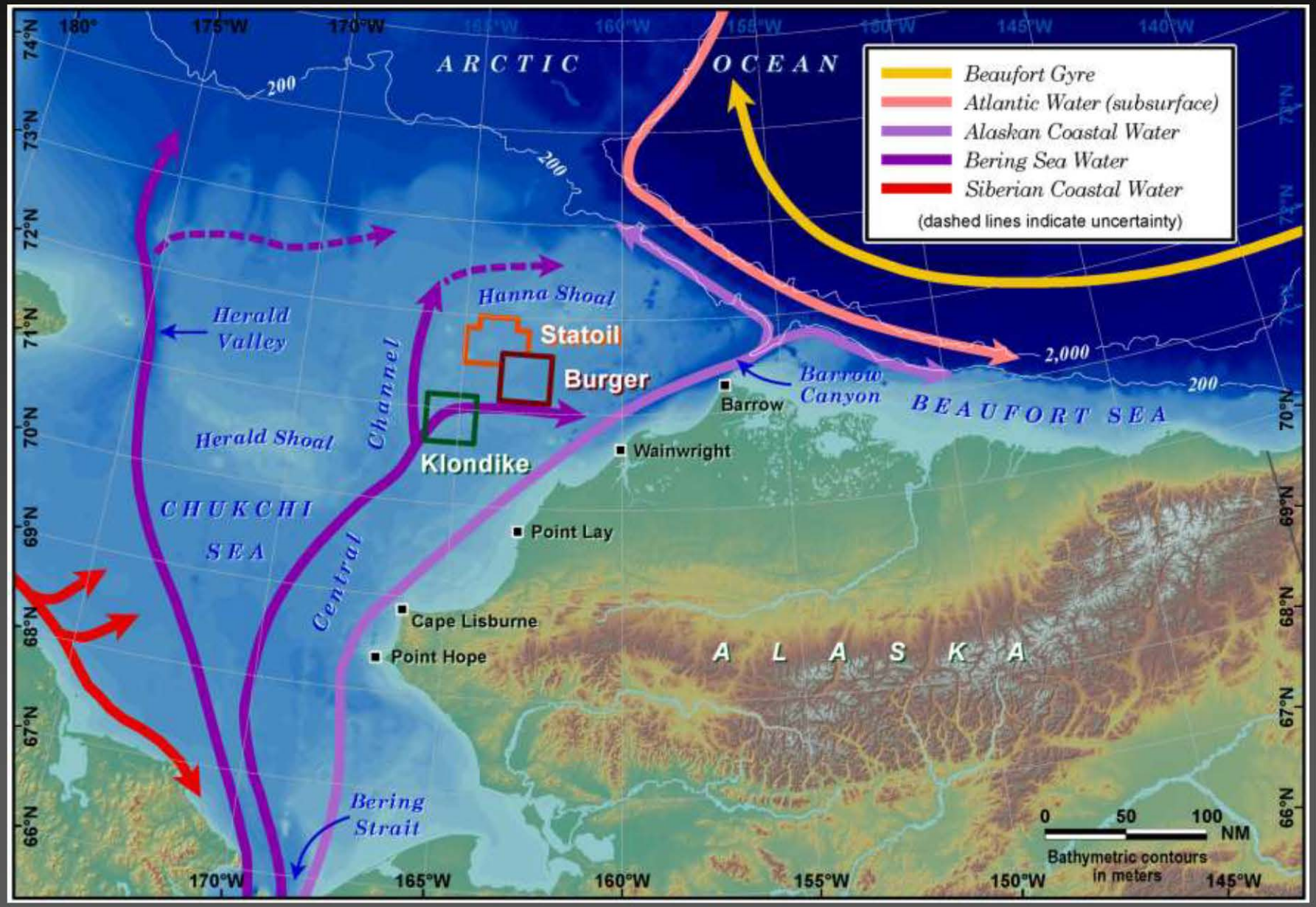


TIGERSOFT DATA SYSTEM



STANDARDIZED DATA SET

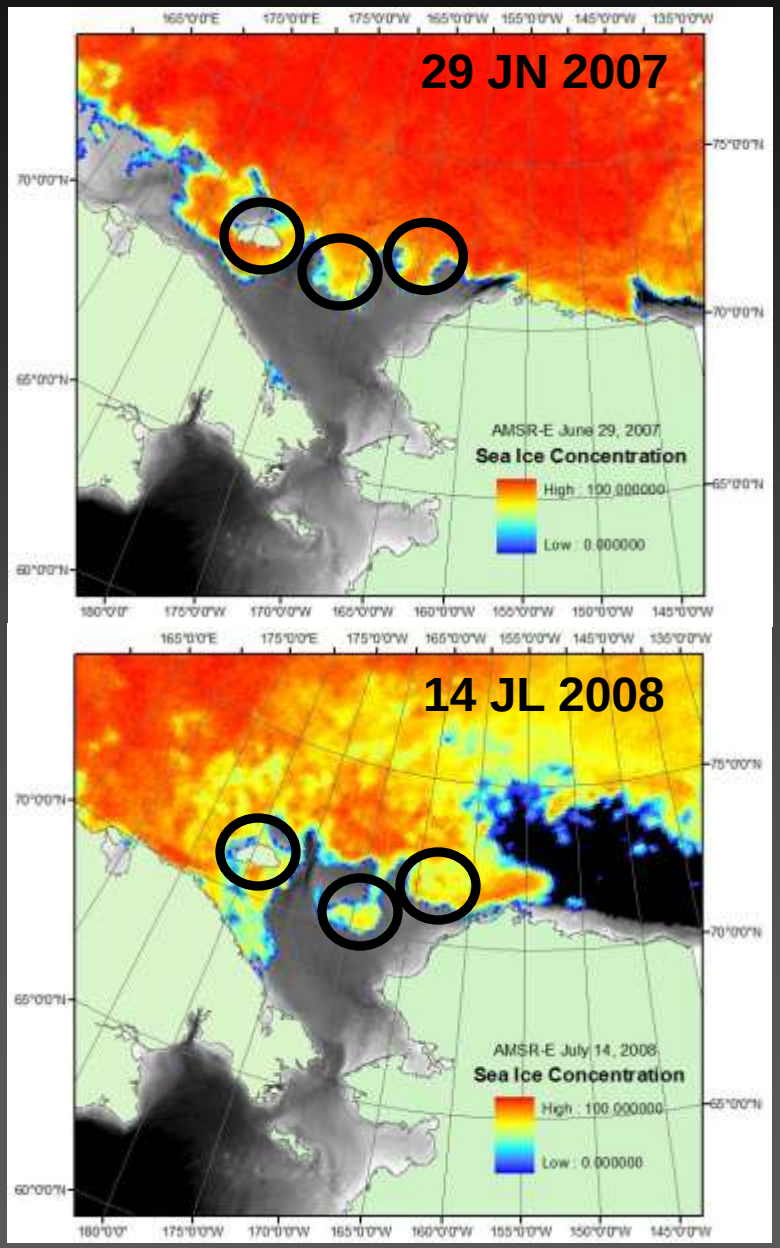
CURRENTS, BATHYMETRY



PHYSICAL OCEANOGRAPHY

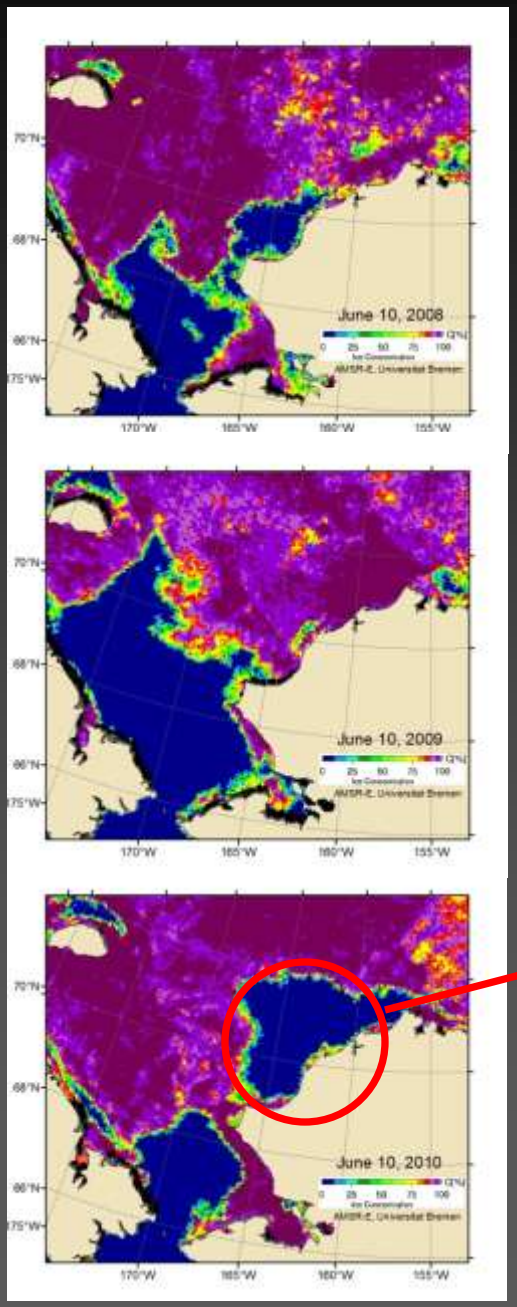
- Water from S of Bering Strait
  - Brings heat, nutrients, plankton, fishes into system, affect production in Chukchi
- Currents, winds affect ice melt-off and movement patterns, timing of blooms
  - Advect warm water from S, melt ice
  - Easterly winds advect ice out of study area
- Two surface water-masses in our area
  - Bering Sea Water
  - Meltwater

CURRENTS AFFECT ICE RETREAT



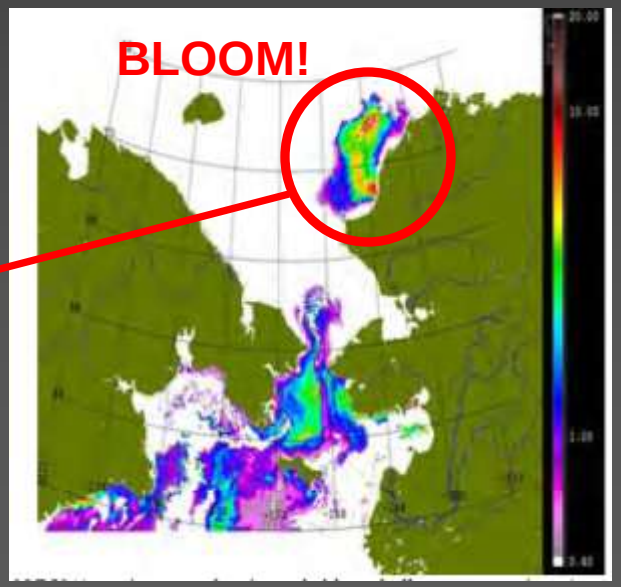
- Currents transport heat
- Ice retreats earliest in channels and latest over shoals—implications for marine mammals
- Much variability among years
- Northeasterly winds retard flow, eastward winds do not

WINDS ALSO AFFECT ICE RETREAT AND BLOOM



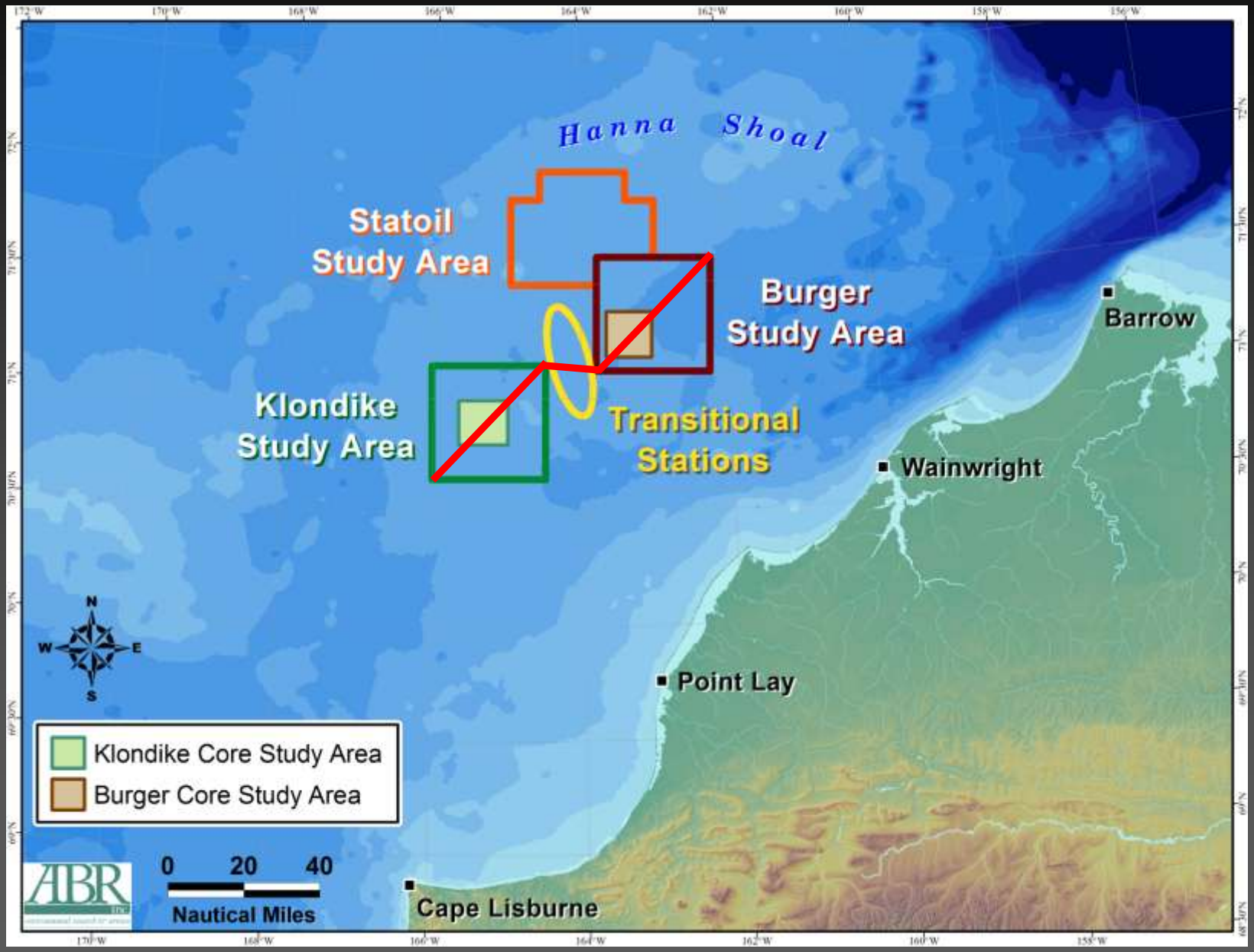
10 JUNE 2008-2010

MODIS
29 MAY 2010

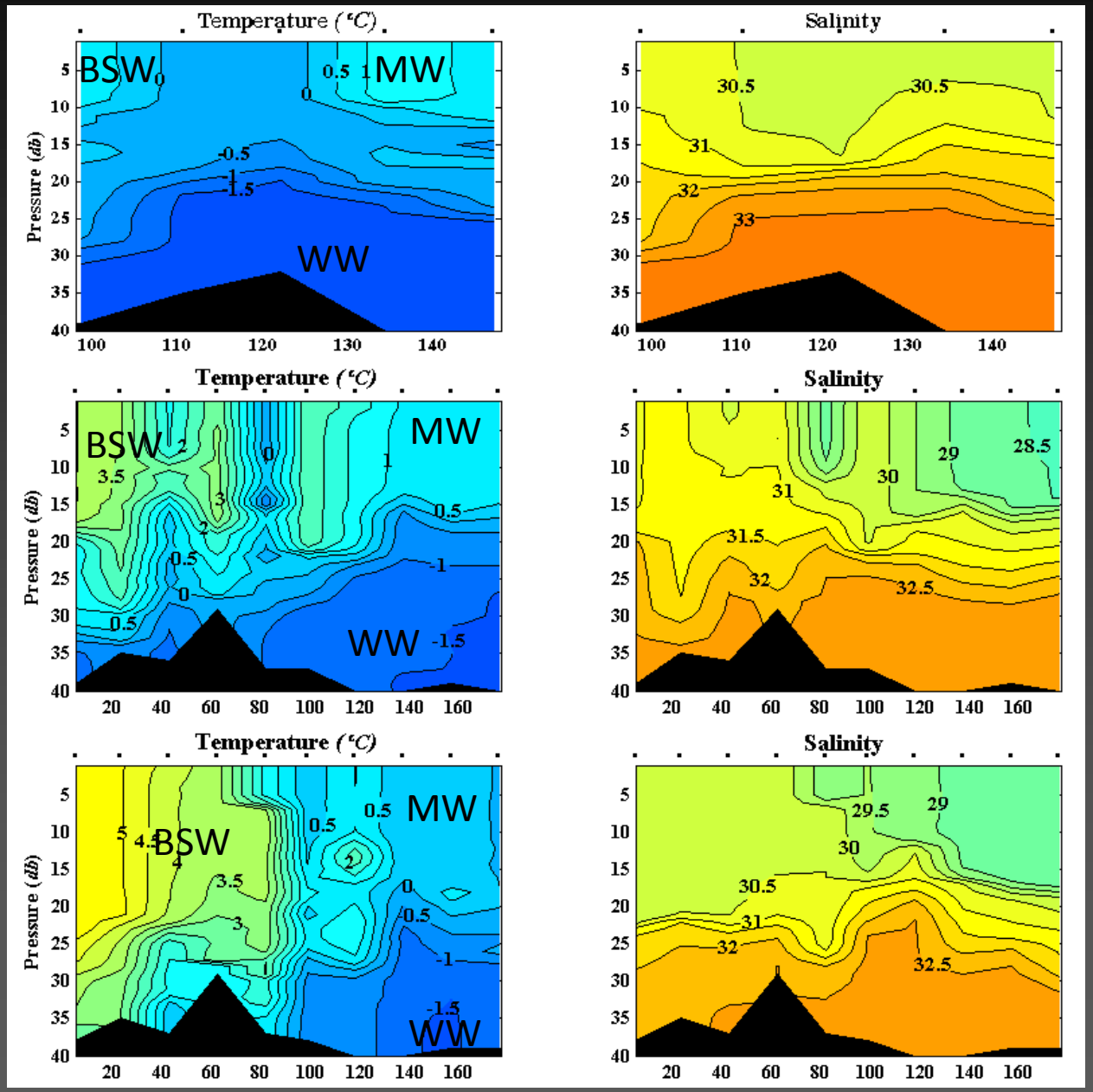


- Consistent easterly winds may push ice to west
- May open area for early spring bloom
- Much variability among years

WATER-COLUMN STRUCTURE

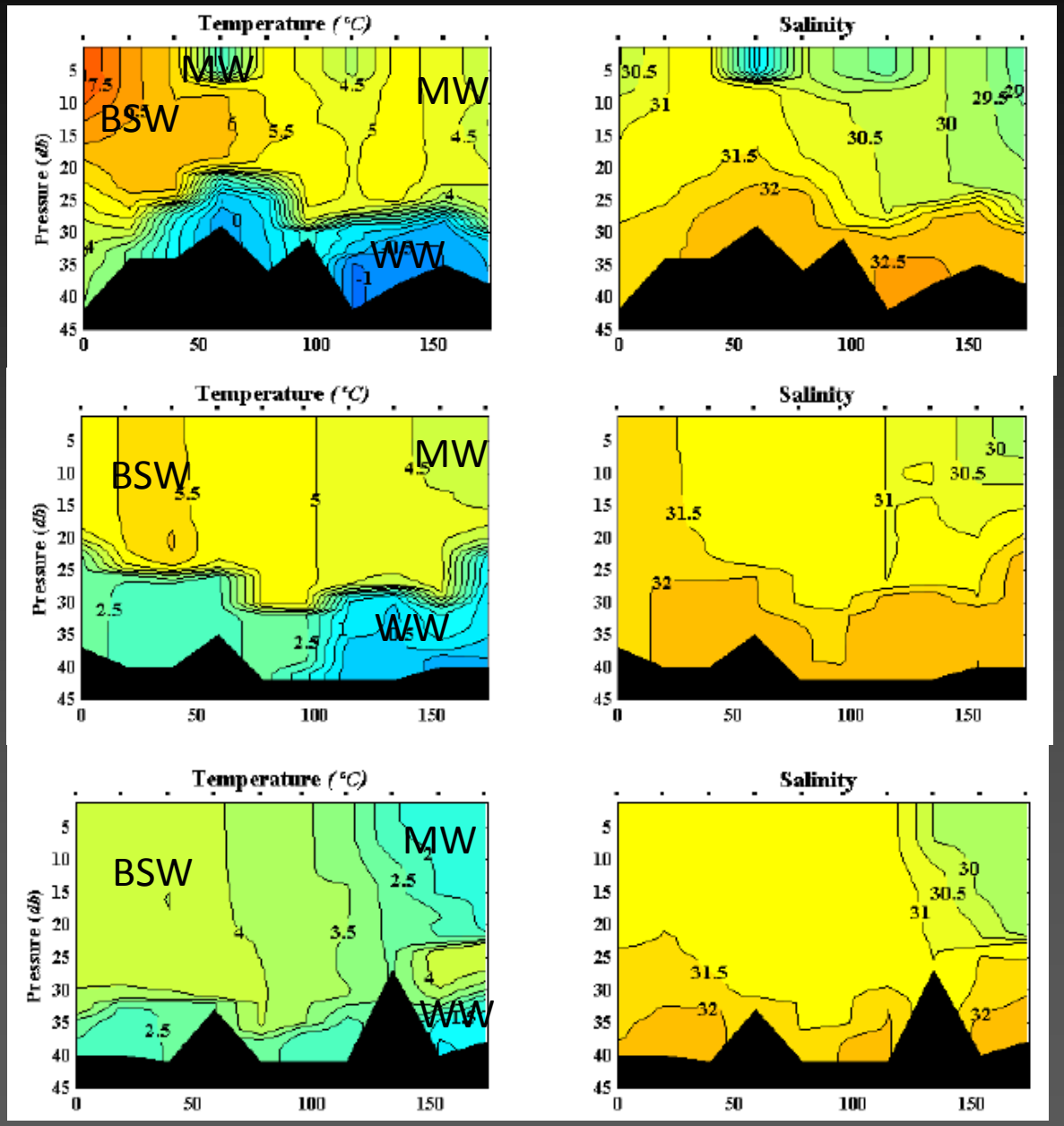


VERTICAL SECTIONS (2008)



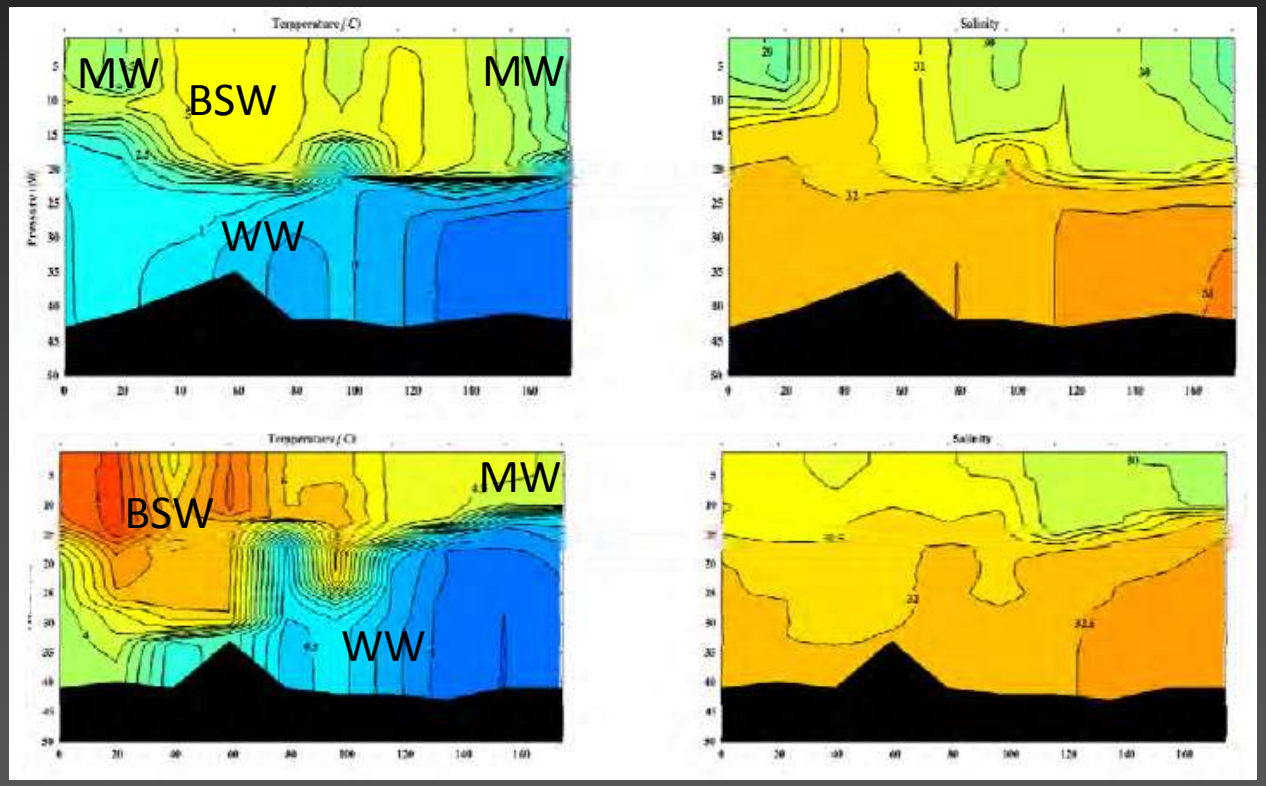
- Water is getting warmer through time
- WW is gradually displaced northeastward through time
- MW is always at the surface (retreats to NE over time)
- BSW penetrates northeastward with time (flow increases)

VERTICAL SECTIONS (2009)



- Water over entire area is BSW
- WW is gradually displaced northeastward through time
- MW is always at the surface (sometimes retreats to NE)
- BSW penetrates northeastward with time (flow increases)

VERTICAL SECTIONS (2010)



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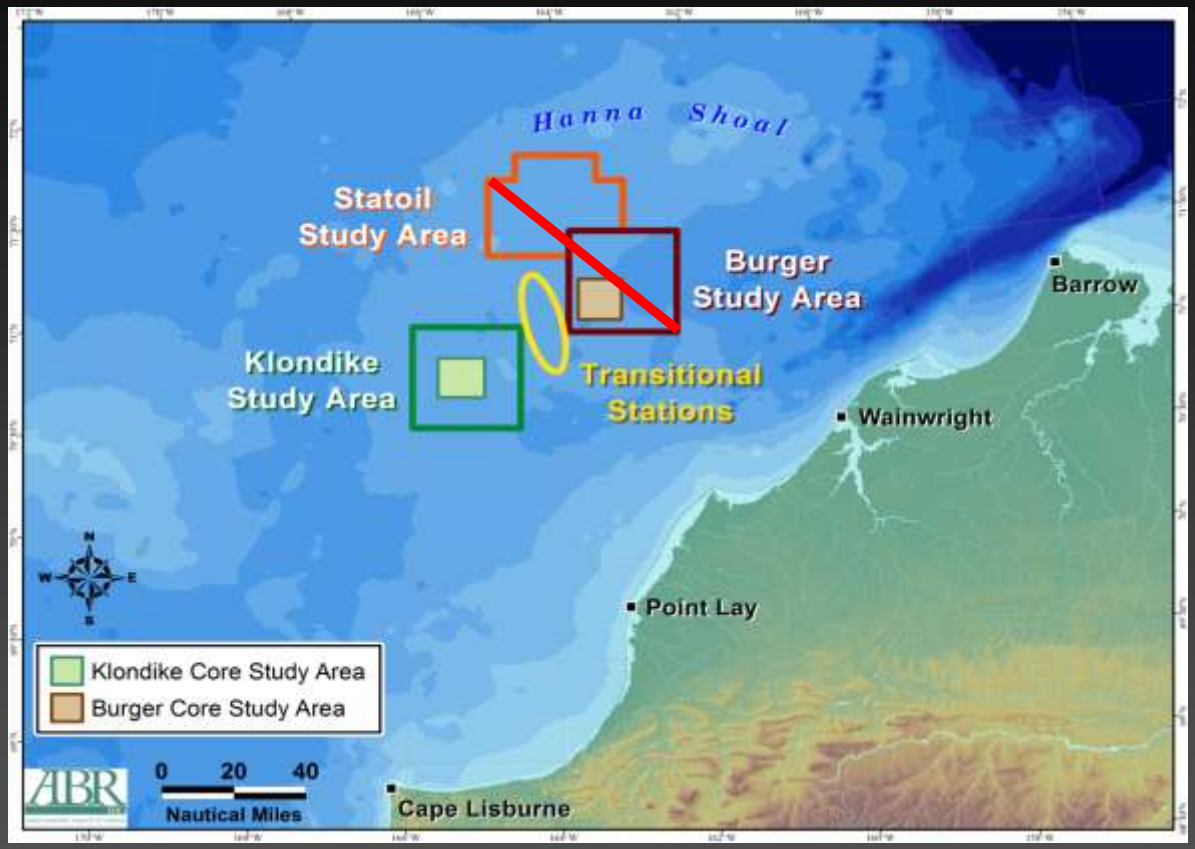
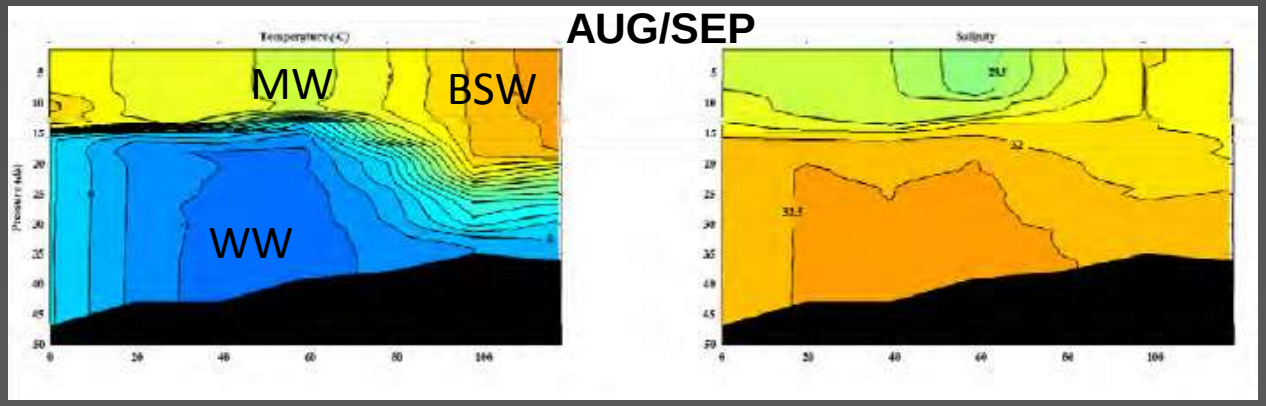
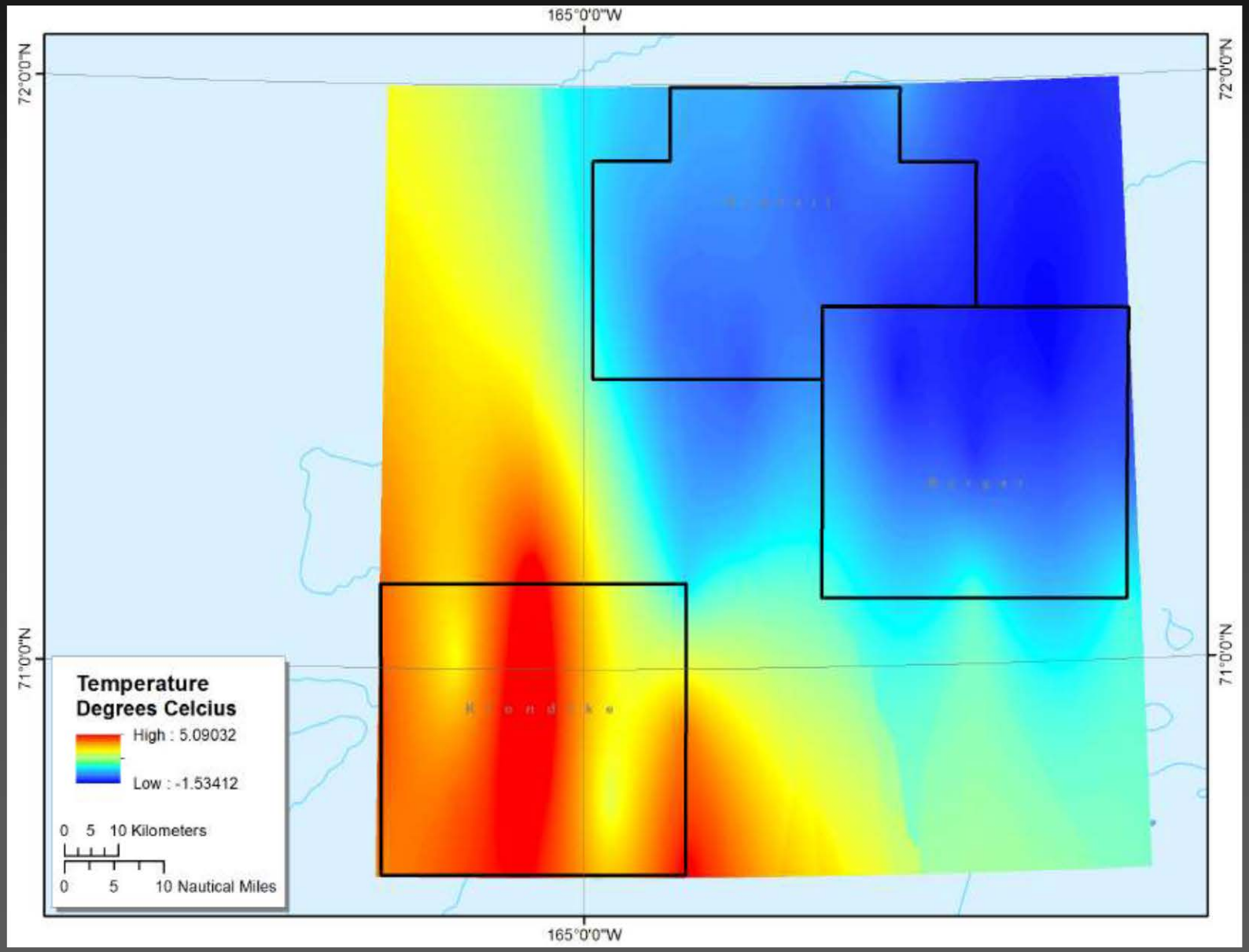
STATOIL SECTION (2010)





BOTTOM TEMPS (2010)



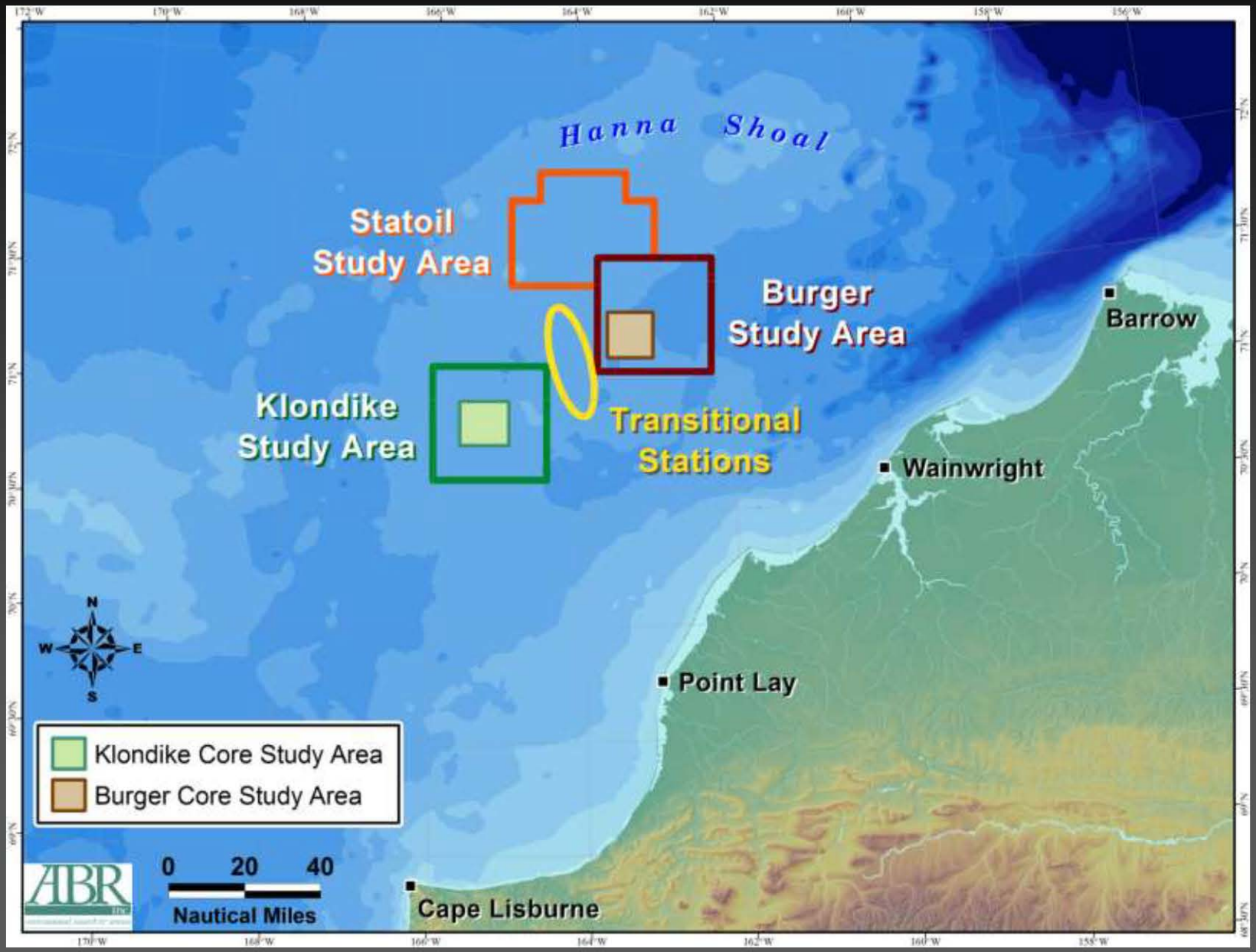
INTERANNUAL VARIABILITY

YEAR	CHARACTERISTIC	ICE	BERING SEA WATER
2008	COLD	MUCH, PERSISTENT	KLONDIKE
2009	VERY WARM (EARLY)	NONE	EVERYWHERE
2010	INTERMEDIATE (WARM LATER IN YEAR)	LITTLE (GONE QUICKLY)	EVERYWHERE

CHLOROPHYLL AND NUTRIENTS

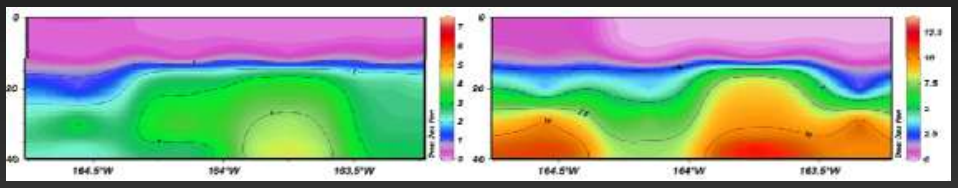
- Nutrients generally stripped from upper part of water-column by the time we arrive—bloom is over (caught tail end in 2008)
- Chl-a generally at/below pycnocline—relies on regeneration of nutrients
- In general, bloom generally (but not always) occurs before open-water season
- Spring bloom may occur either in ice or in open water

STUDY AREAS

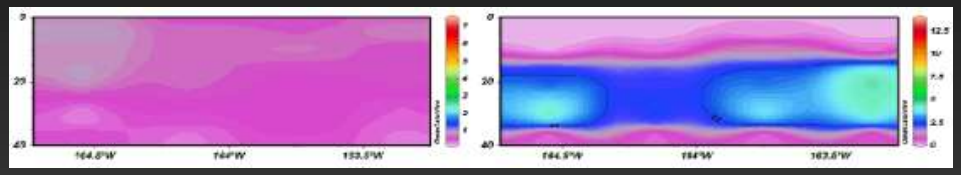

Hanna Shoal
Statoil Study Area
Burger Study Area
Klondike Study Area
Transitional Stations
Barrow
Wainwright
Point Lay
Cape Lisburne
N
W
E
S
Klondike Core Study Area
Burger Core Study Area
0 20 40
Nautical Miles
ABR

SOUTH VS. NORTH (2010)

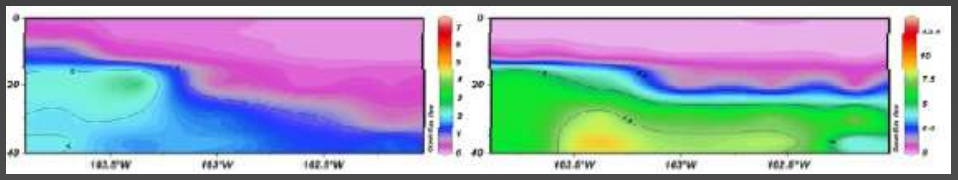
N. STATOIL JUL/AUG 2010



N. STATOIL AUG/SEP 2010



N. BURGER JUL/AUG 2010



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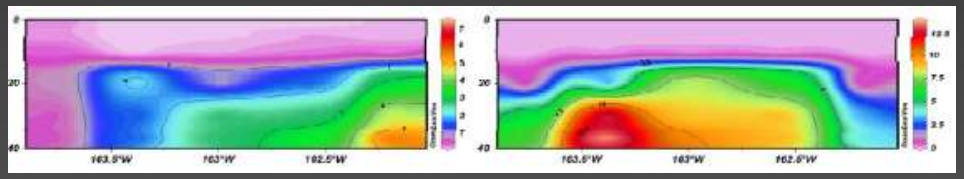
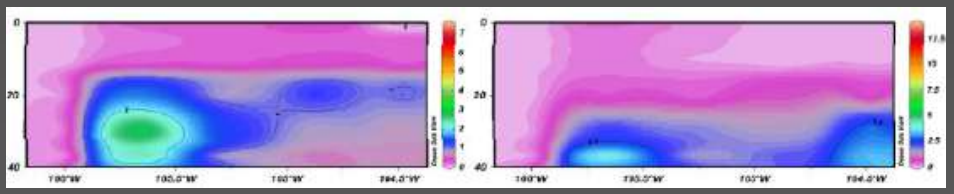
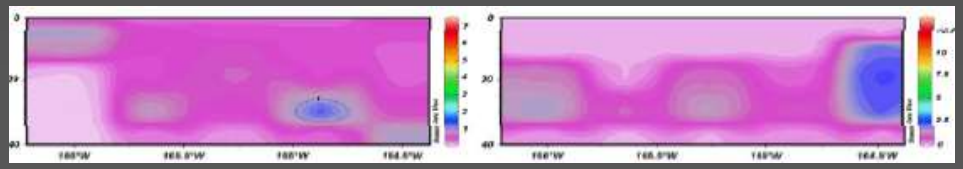


N. KLONDIKE JUL/AUG 2010



N. KLONDIKE AUG/SEP 2010

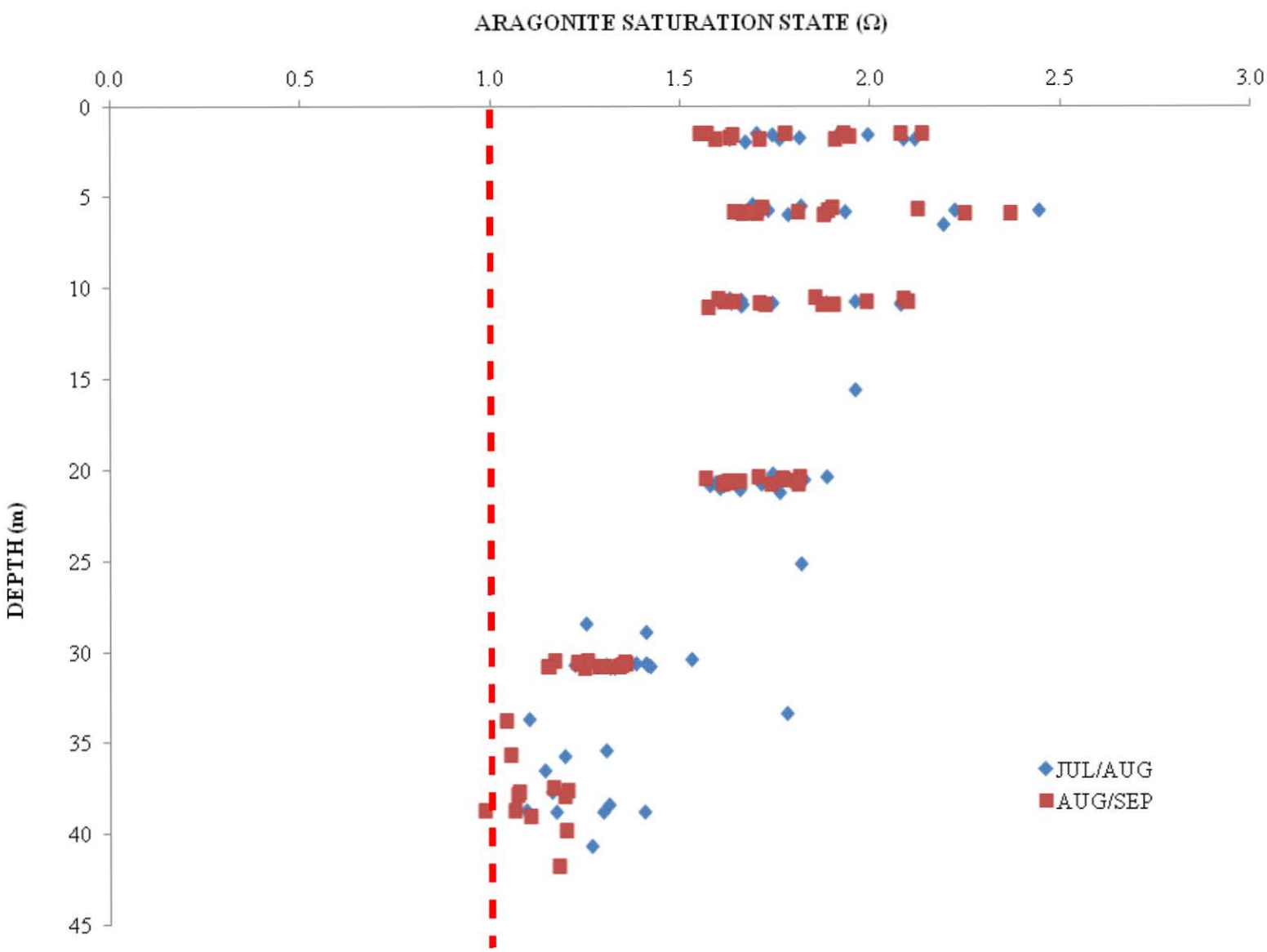


CHLOROPHYLL NITRATE CHLOROPHYLL NITRATE

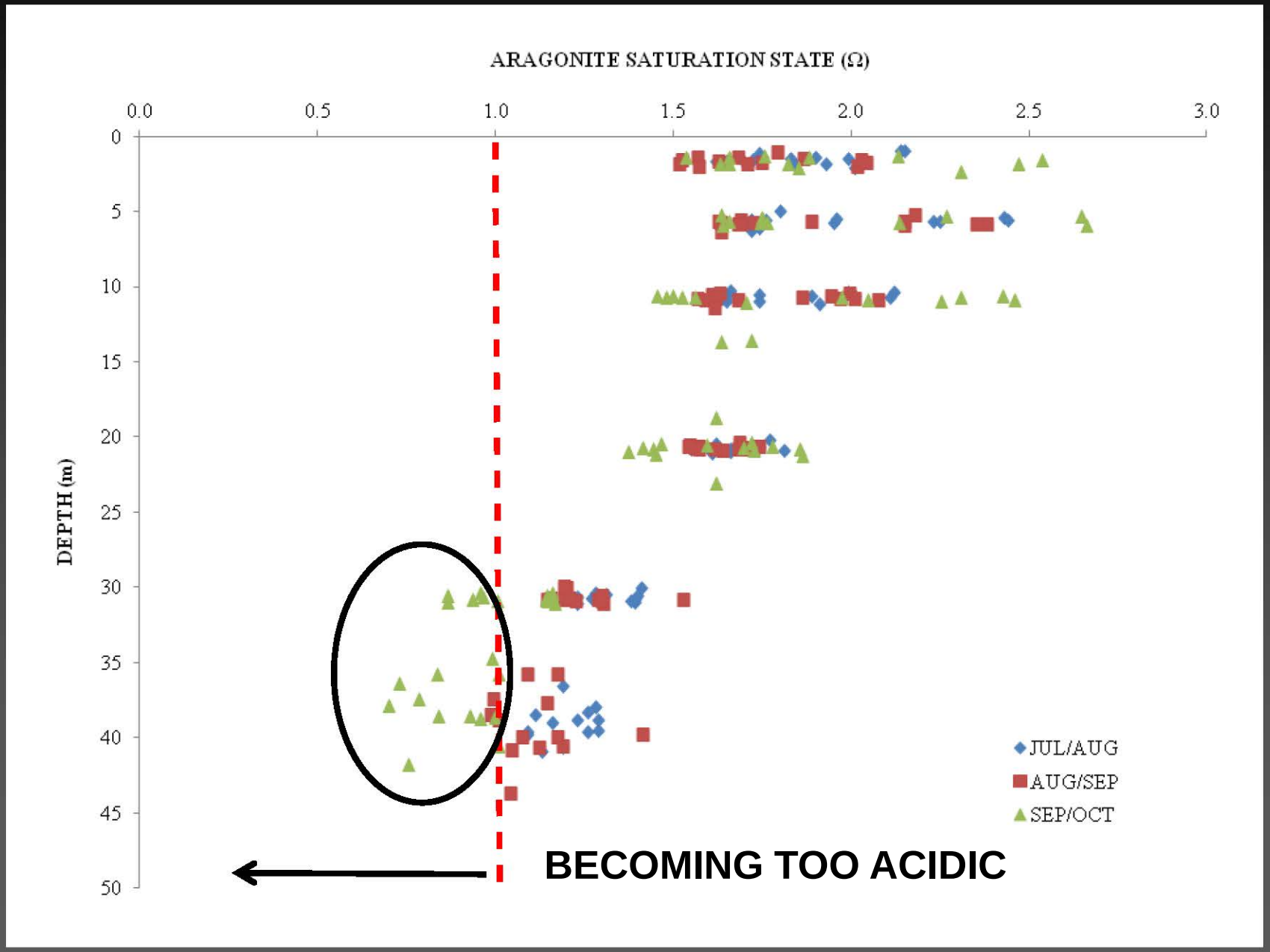
ACIDIFICATION

- Acidification results from high solubility of CO_2 in cold water at high latitudes
- Increases seasonally because of sinking of primary productivity to the benthos—results from decomposition of phytoplankton at depth
- Affects metabolism of both Aragonite and Calcite forms of $CaCO_3$; seems to affect Aragonite more than Calcite

KLONDIKE, STATOIL SIMILAR

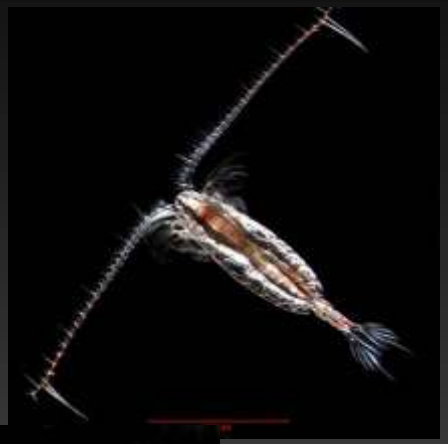


BURGER DIFFERENT



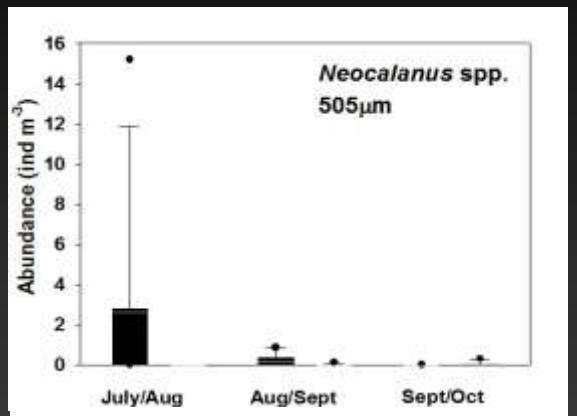
ZOOPLANKTON

- Generally oceanic faunas and neritic faunas—but many species are both to some extent
- Seasonal onset conditions vary among years
- Seasonal evolution of plankton community
- These factors complicate interpretations

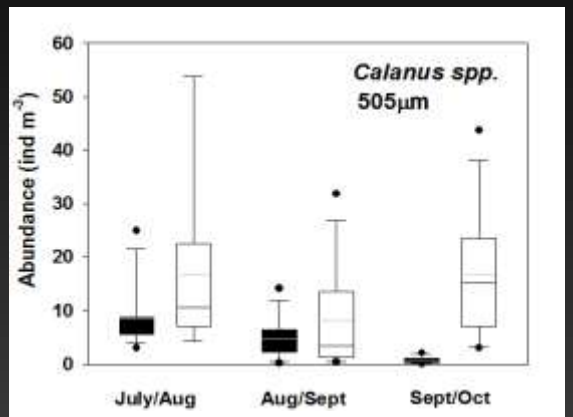


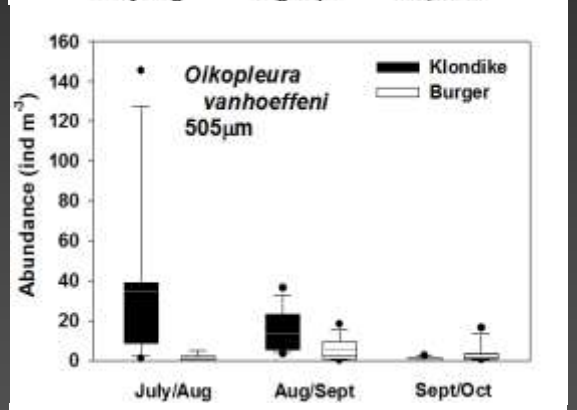
HABITAT DIFFERENCES

LARGE ZOOPS

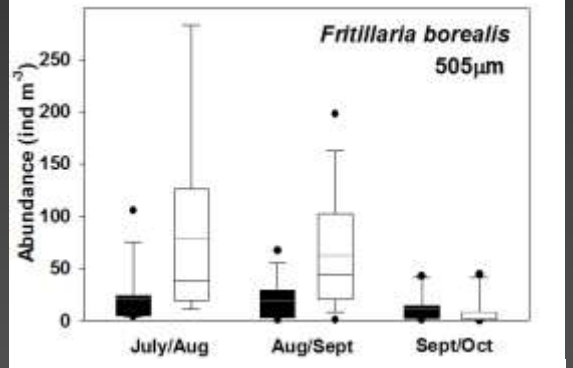


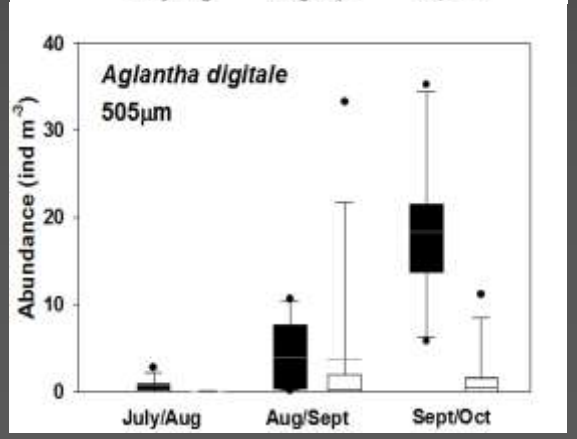
LARGE COPEPODS





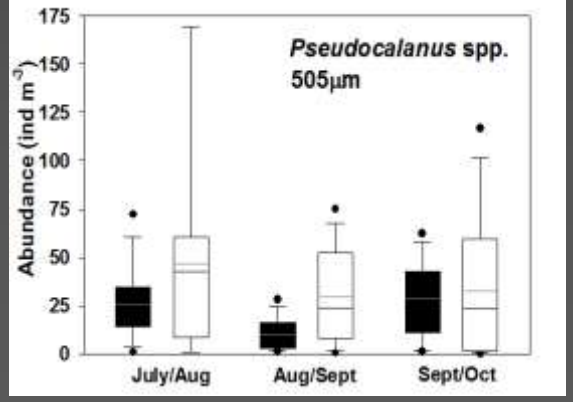
APPENDICULARIANS





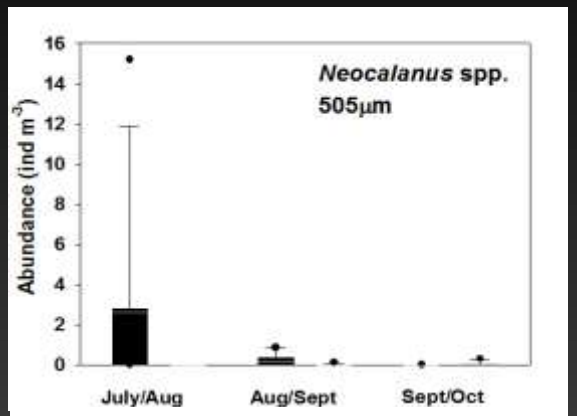
MEDUSA

SMALL COPEPOD



INTERANNUAL (2008 VS. 2010)

LARGE ZOOPS



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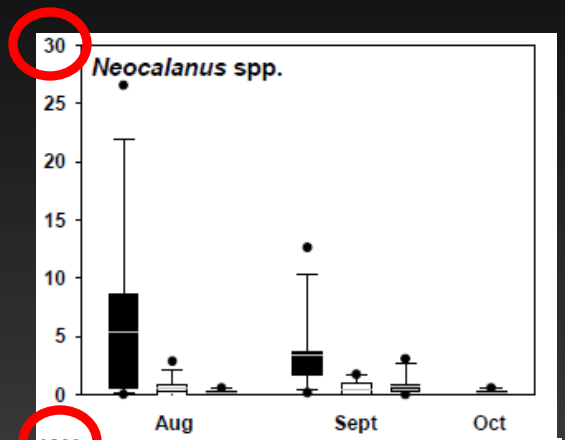
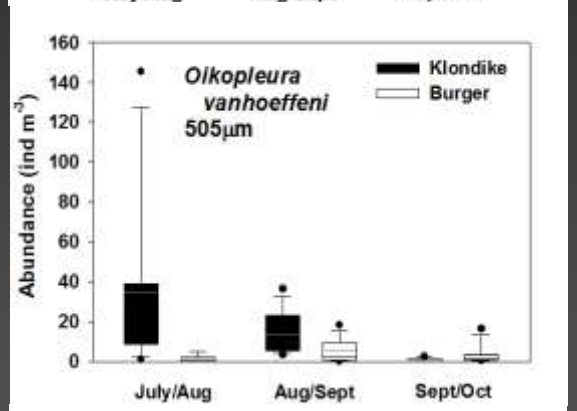
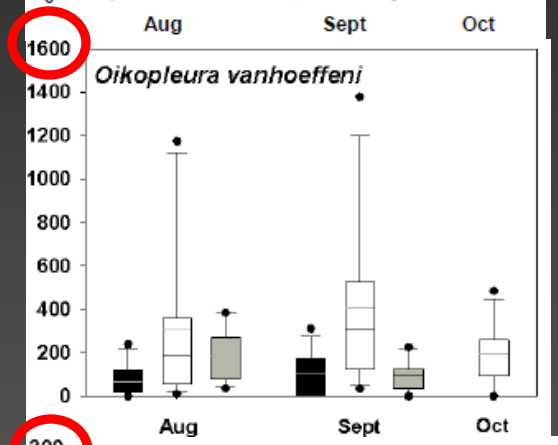
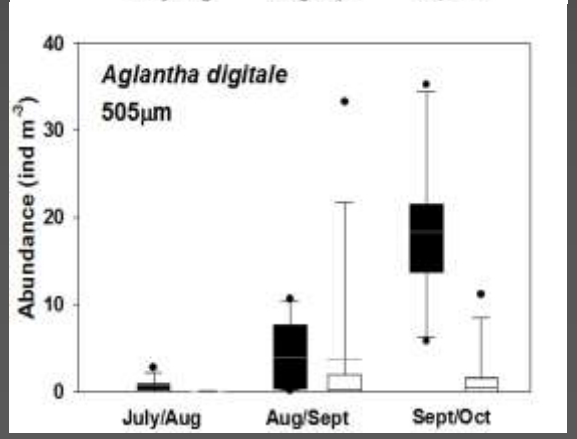


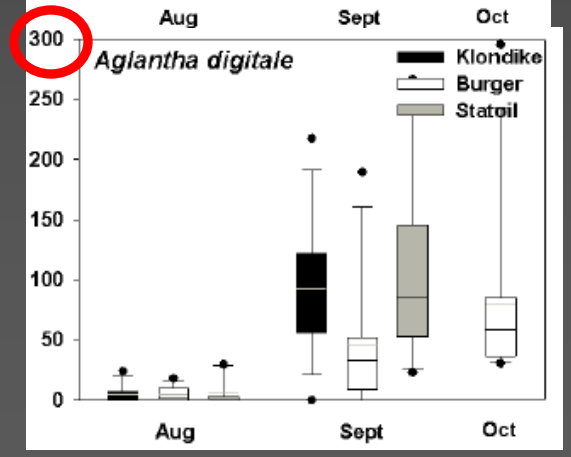


APPENDICULARIAN

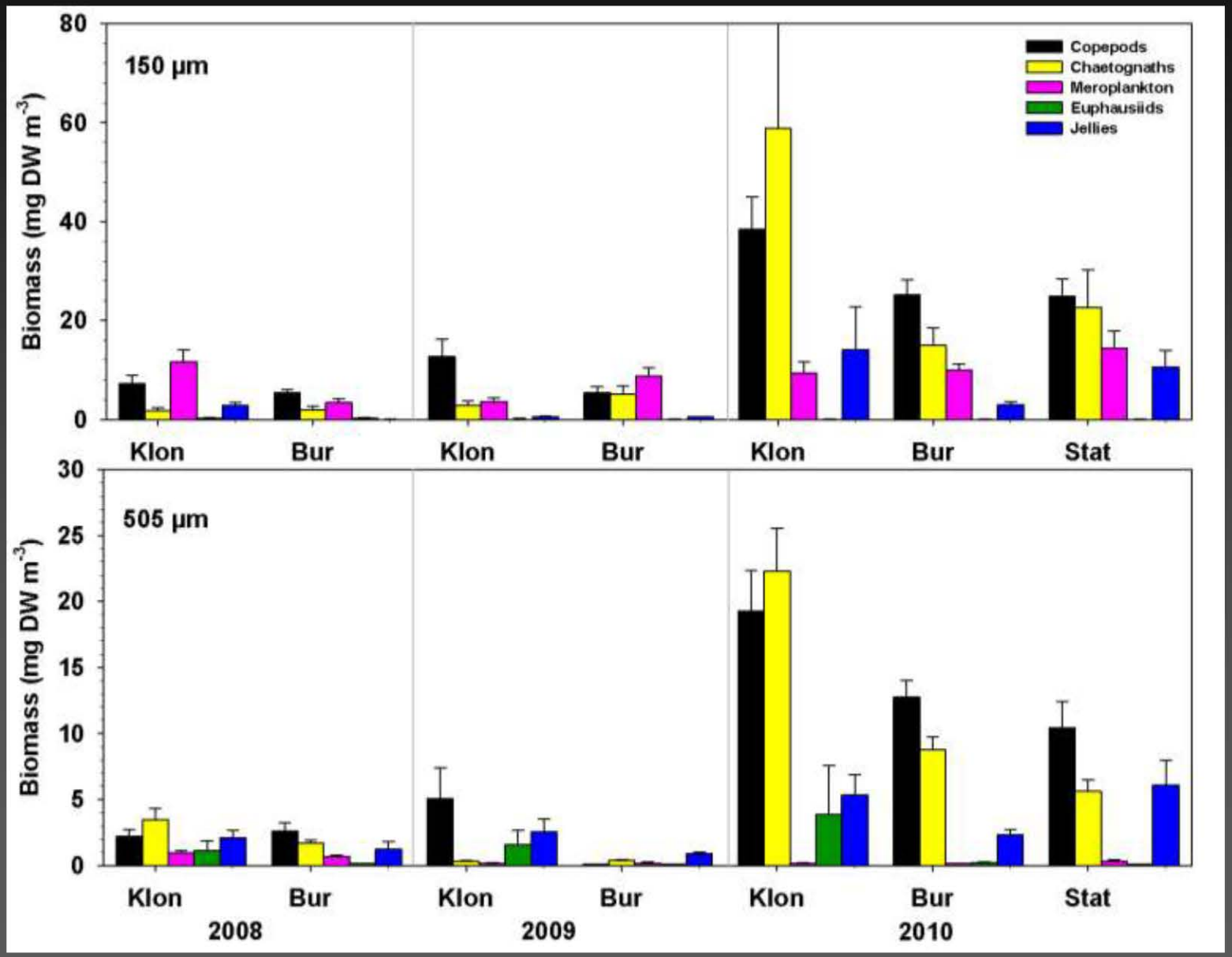




MEDUSA



OVERALL PATTERNS

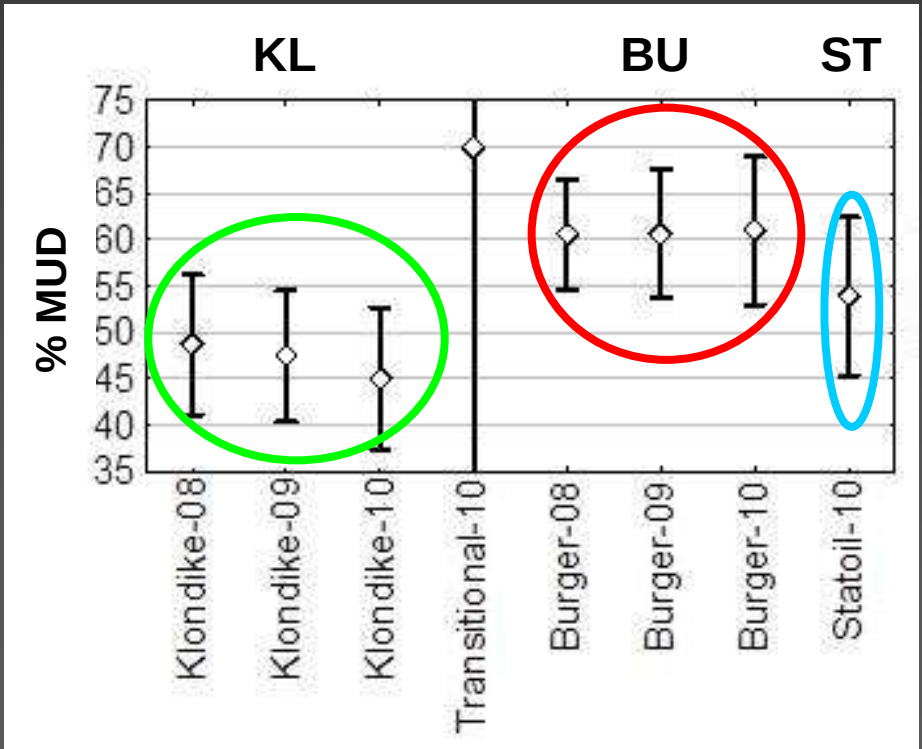


BENTHIC DIFFERENCES

- Klondike warmer and less saline than Burger—differences in circulation
- More mud, less sand at Burger—depositional environment
- Statoil intermediate

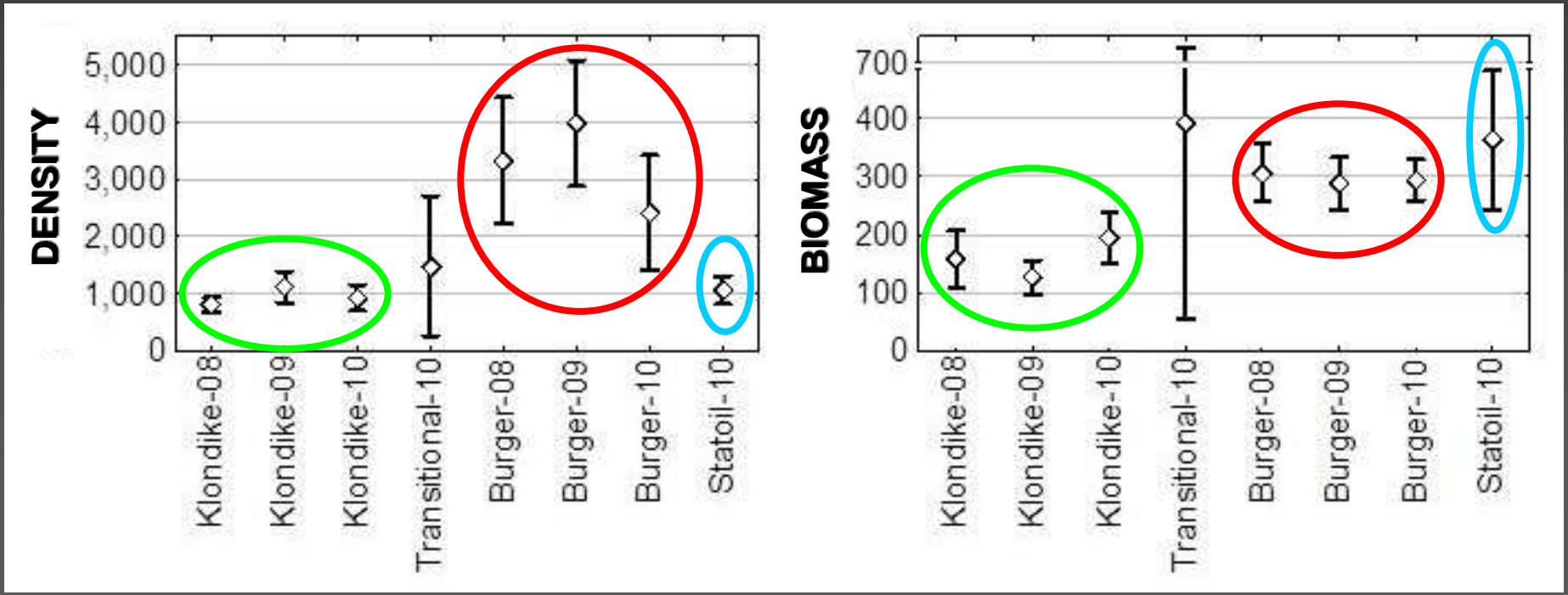
KLONDIKE, BURGER 2008–2010

STATOIL 2010

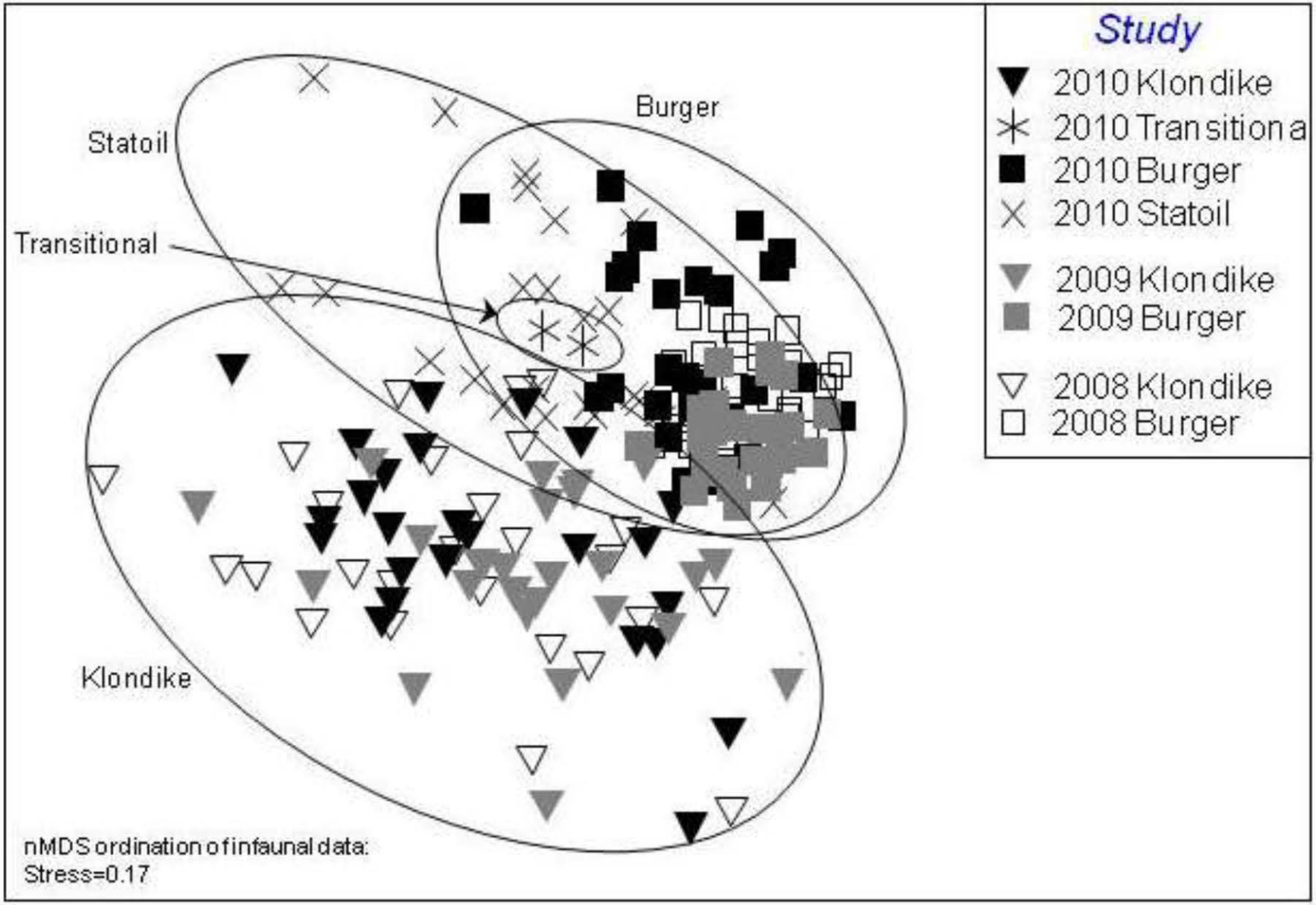


INFAUNA (2008–2010)

- Same species found in both areas
- At Burger, density ~3X and biomass ~2X that at Klondike
- Statoil a mixture (1X, 2.5X that at Klondike)

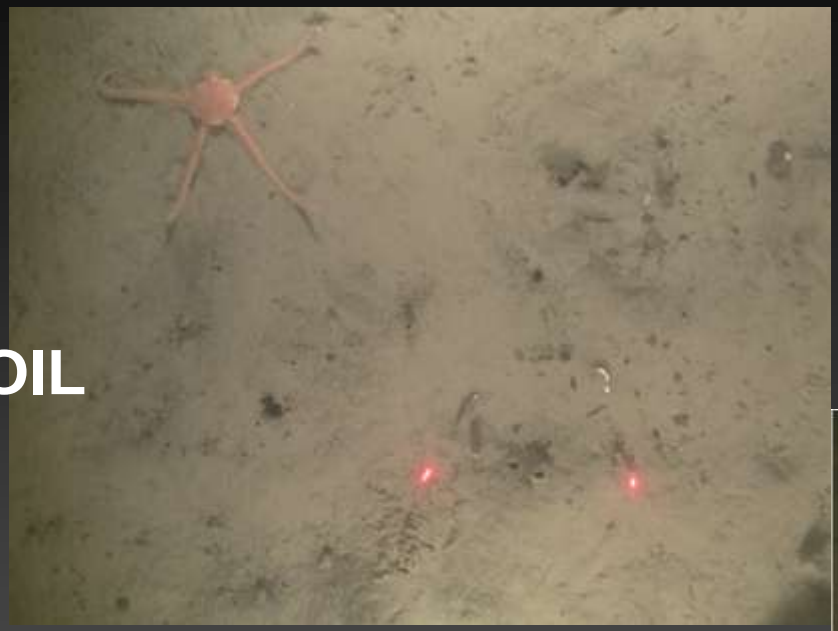


INFAUNAL AREA DIFFERENCES



INFAUNAL AREA DIFFERENCES

STATOIL

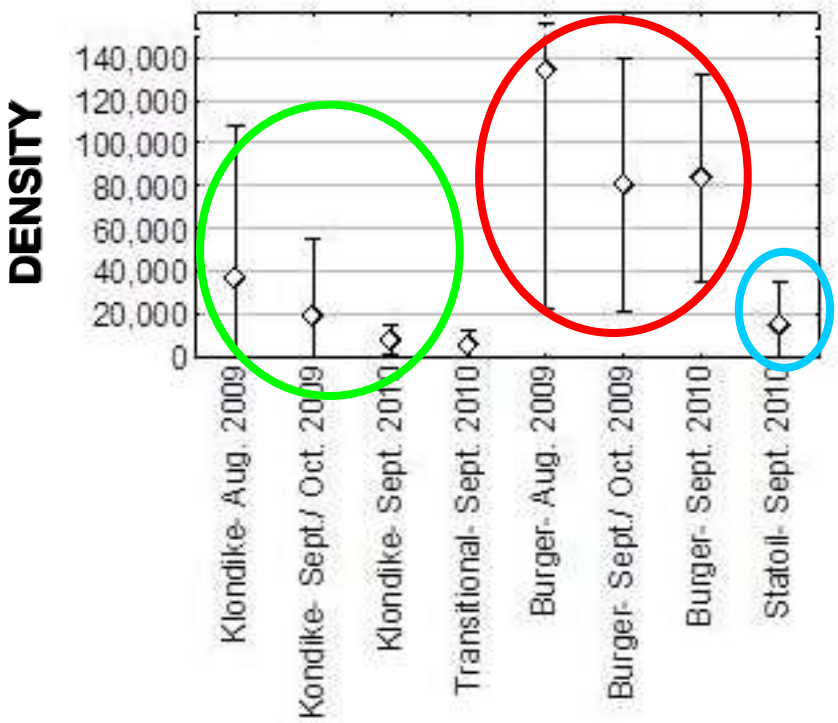


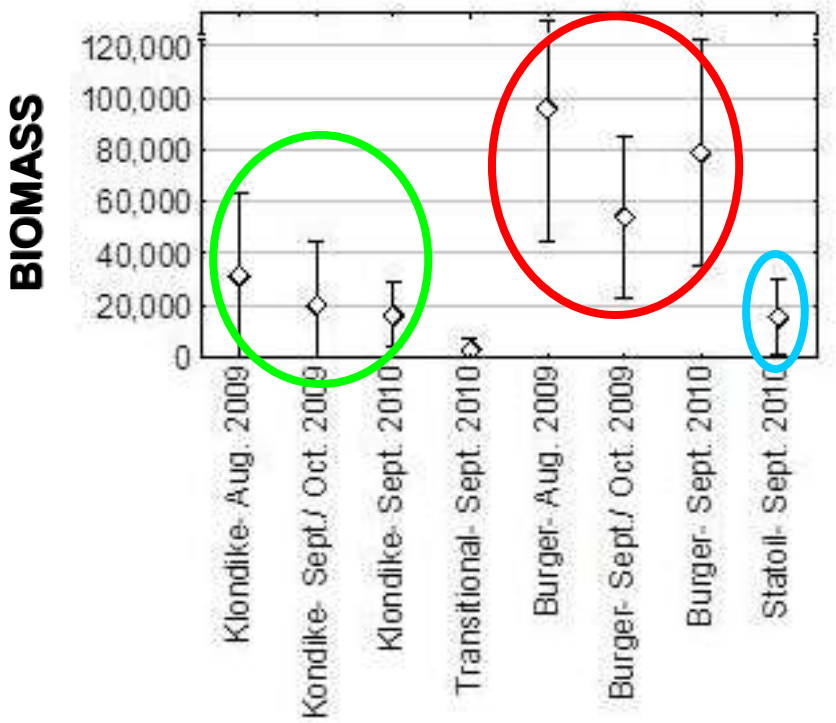
BURGER

KLONDIKE

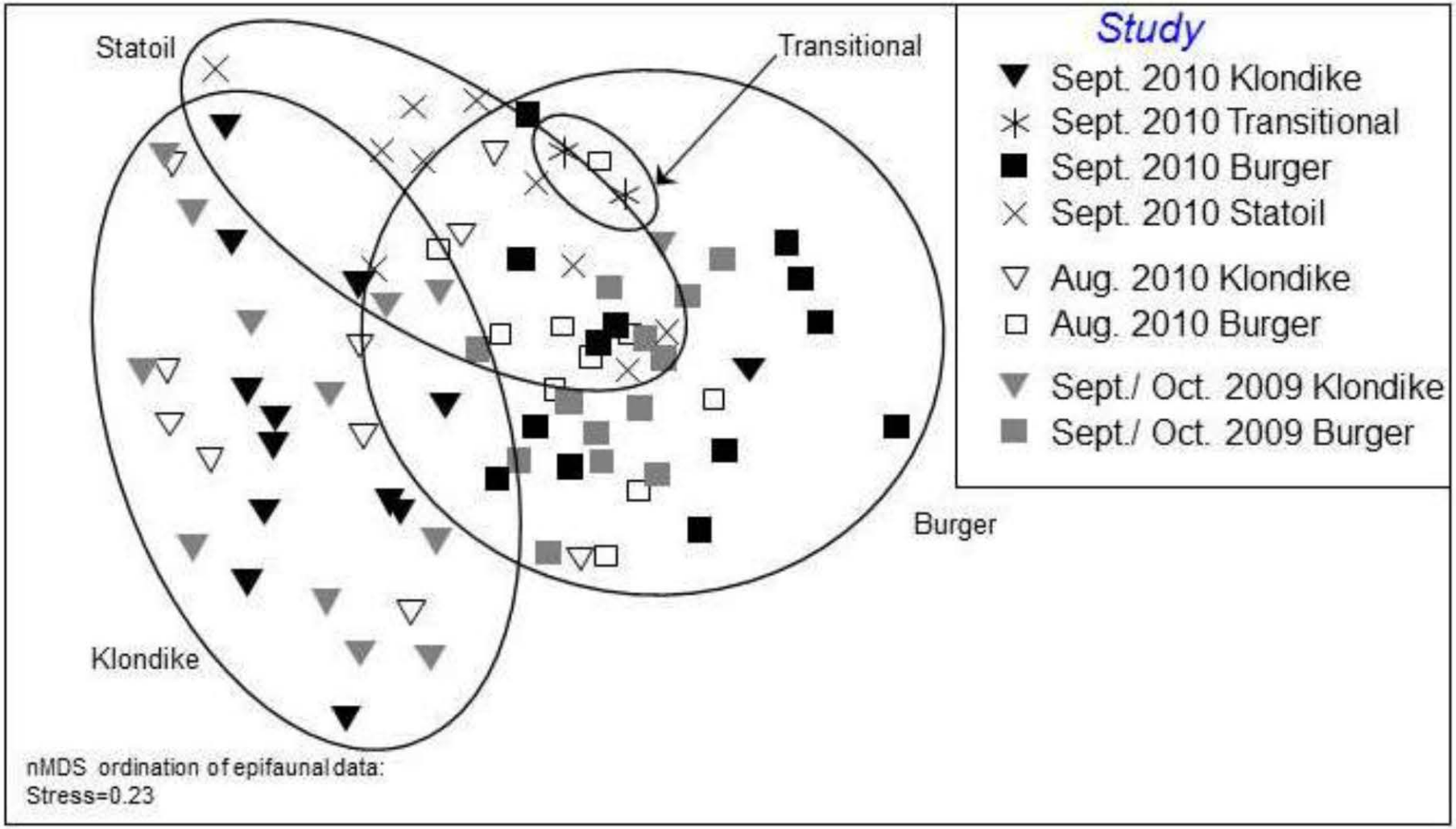
EPIFAUNA (2009–2010)

- Same species found in both areas
- At Burger, density and biomass ~4X that at Klondike
- Statoil similar to Klondike





EPIFAUNAL AREA DIFFERENCES



EPIFAUNAL AREA DIFFERENCES

KLONDIKE

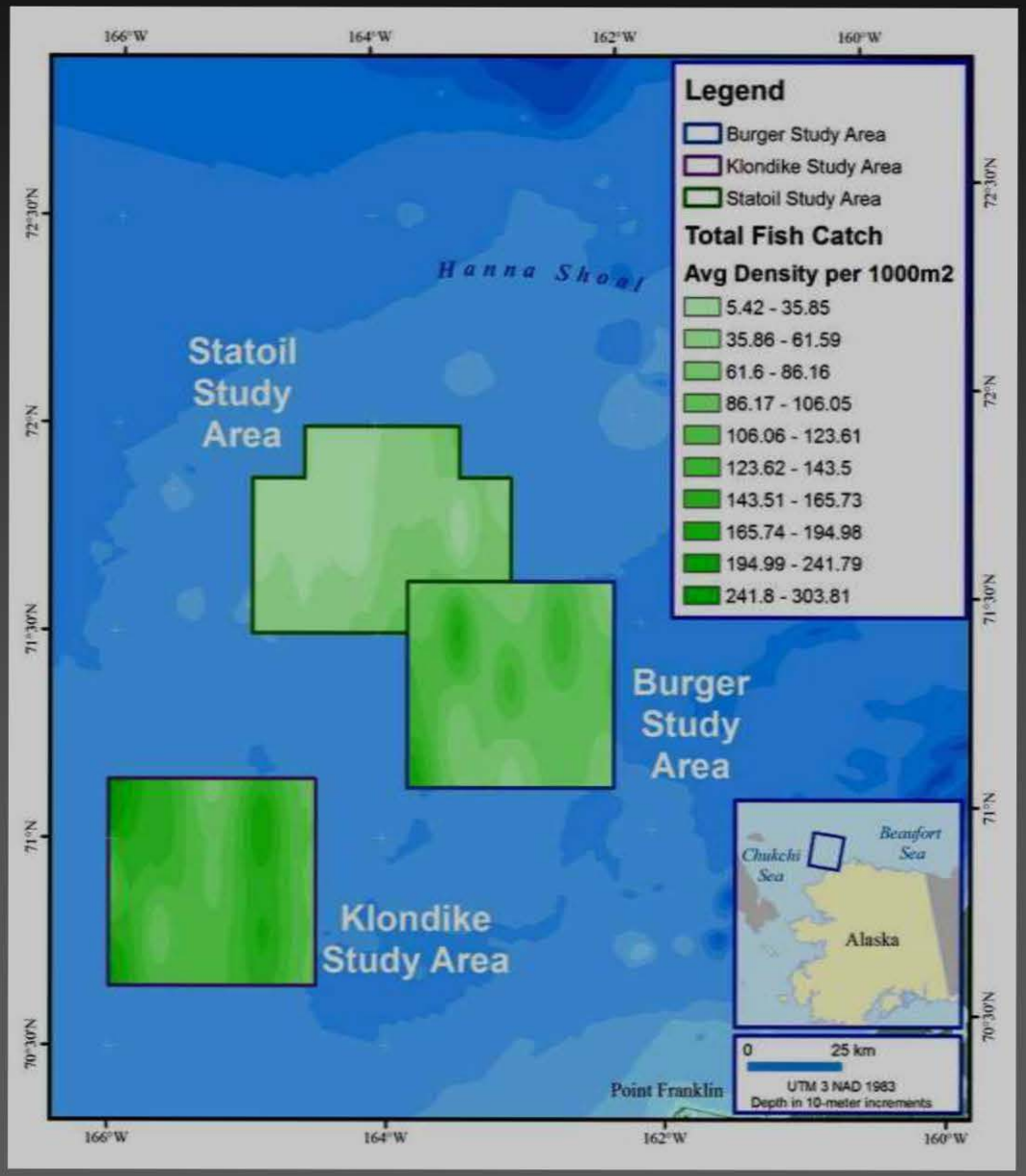
BURGER

FISHES

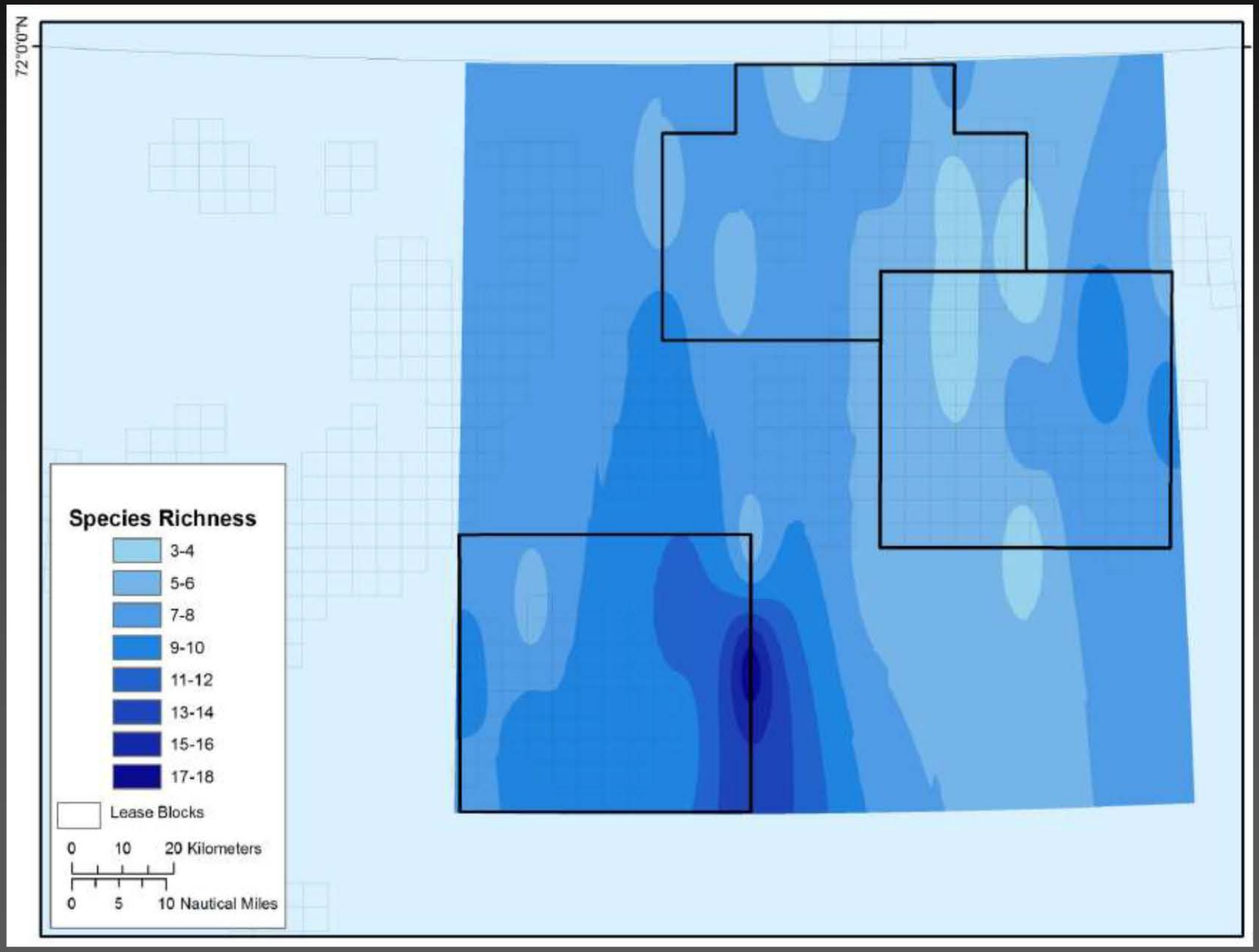
- Midwater and demersal communities
- Fish communities are benthic-based invertebrate-feeders—few piscivorous fishes
- Primarily demersal species (arctic cod, sculpins)
- Dominated by arctic cod—a generalist and both mid-water and demersal
- Few fishes in general, small (25–100 mm)
- Fish abundance greater in Klondike than in Burger, Statoil

FISH TRAWL FROM CHUKCHI SEA

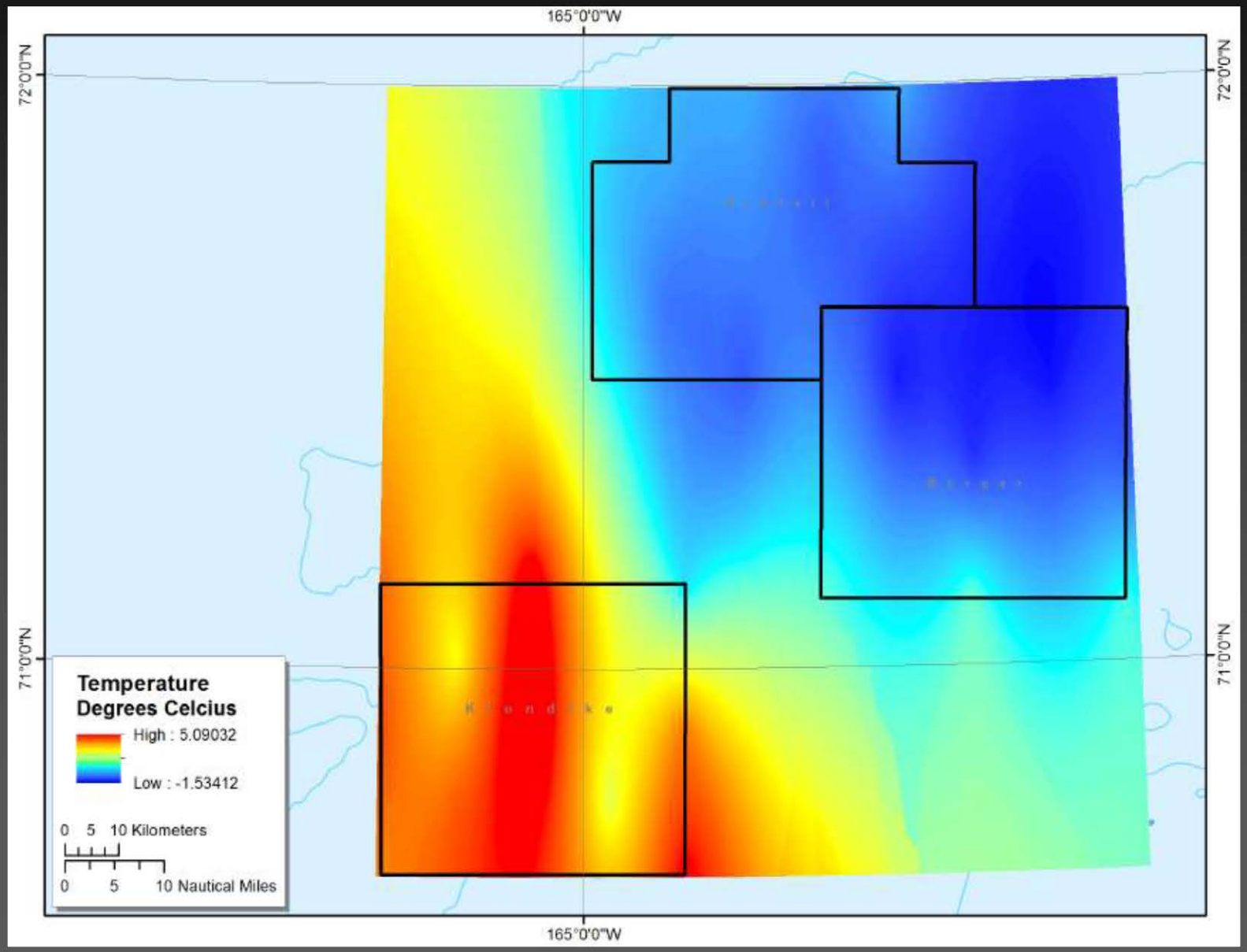
FISH ABUNDANCE (2009-2010)



FISH SPECIES-RICHNESS (2010)

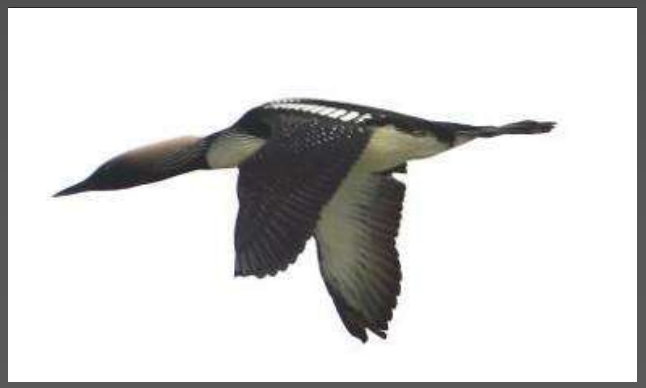


BOTTOM TEMPS (2010)

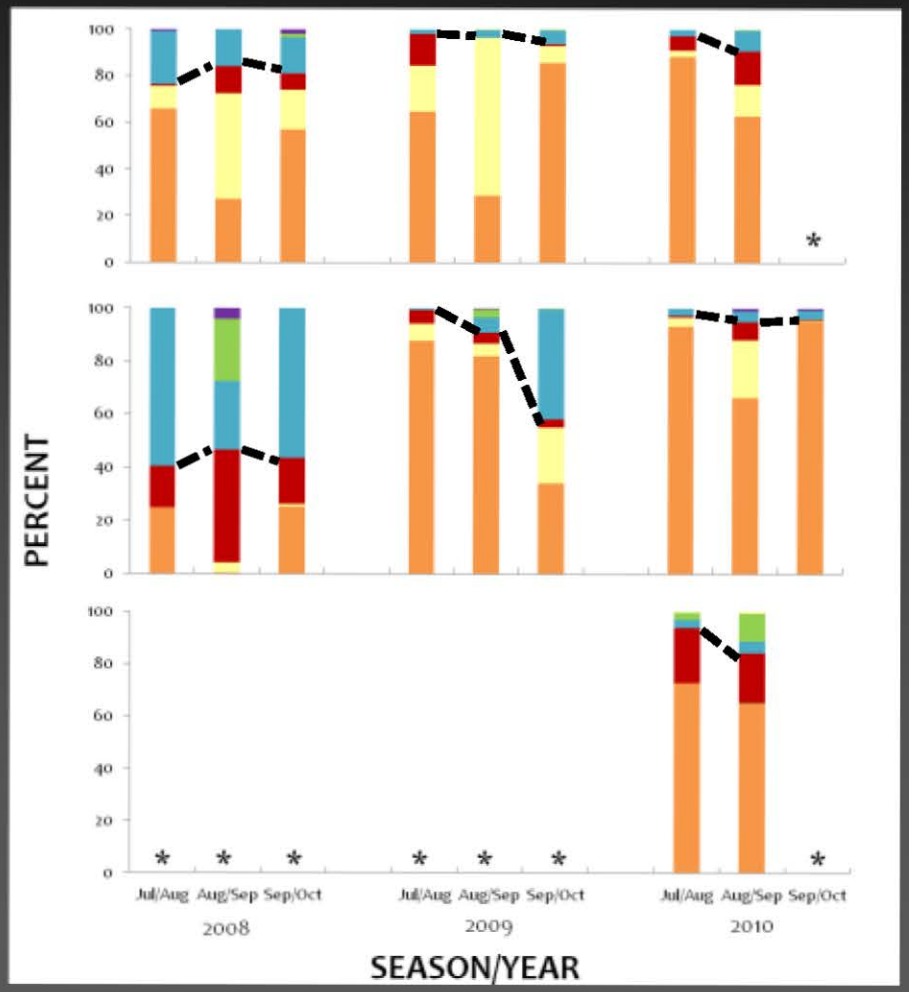


SEABIRDS

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

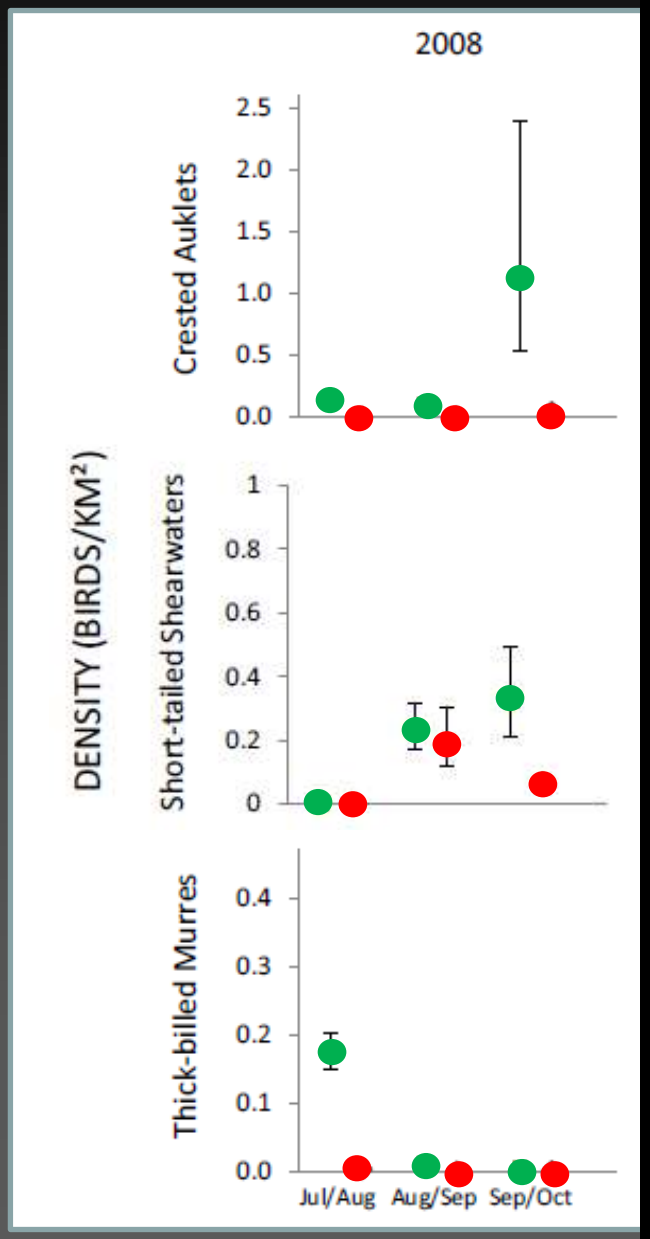


SYSTEM IS DOMINATED BY ZOOP-FEEDERS



- Alcids
- Larids
- Tubenoses
- Phalaropes
- Loons
- Waterfowl

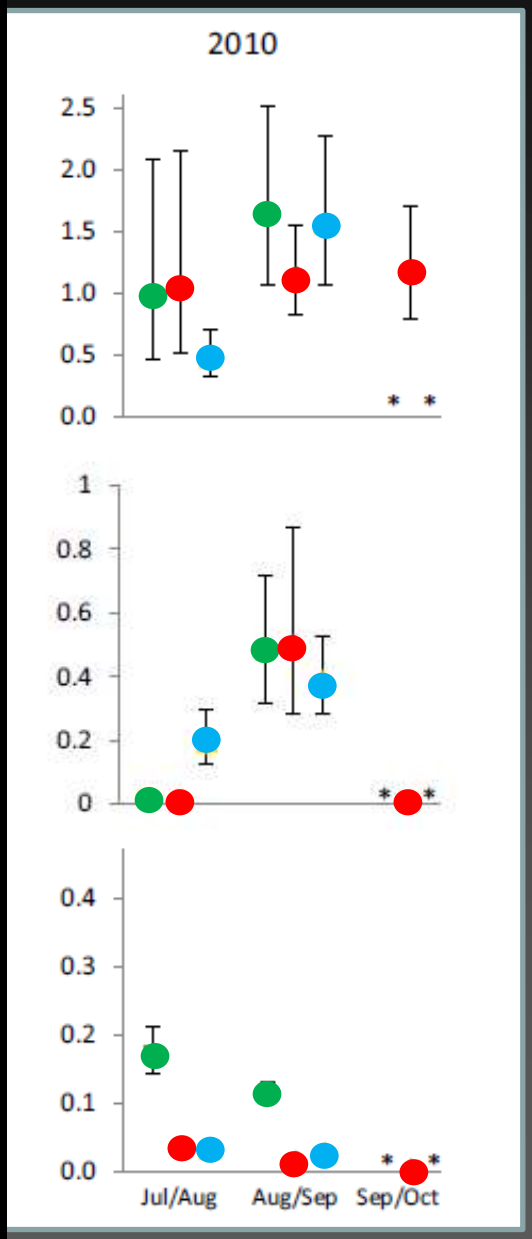
BIRDS FOLLOW OCEANOGRAPHY



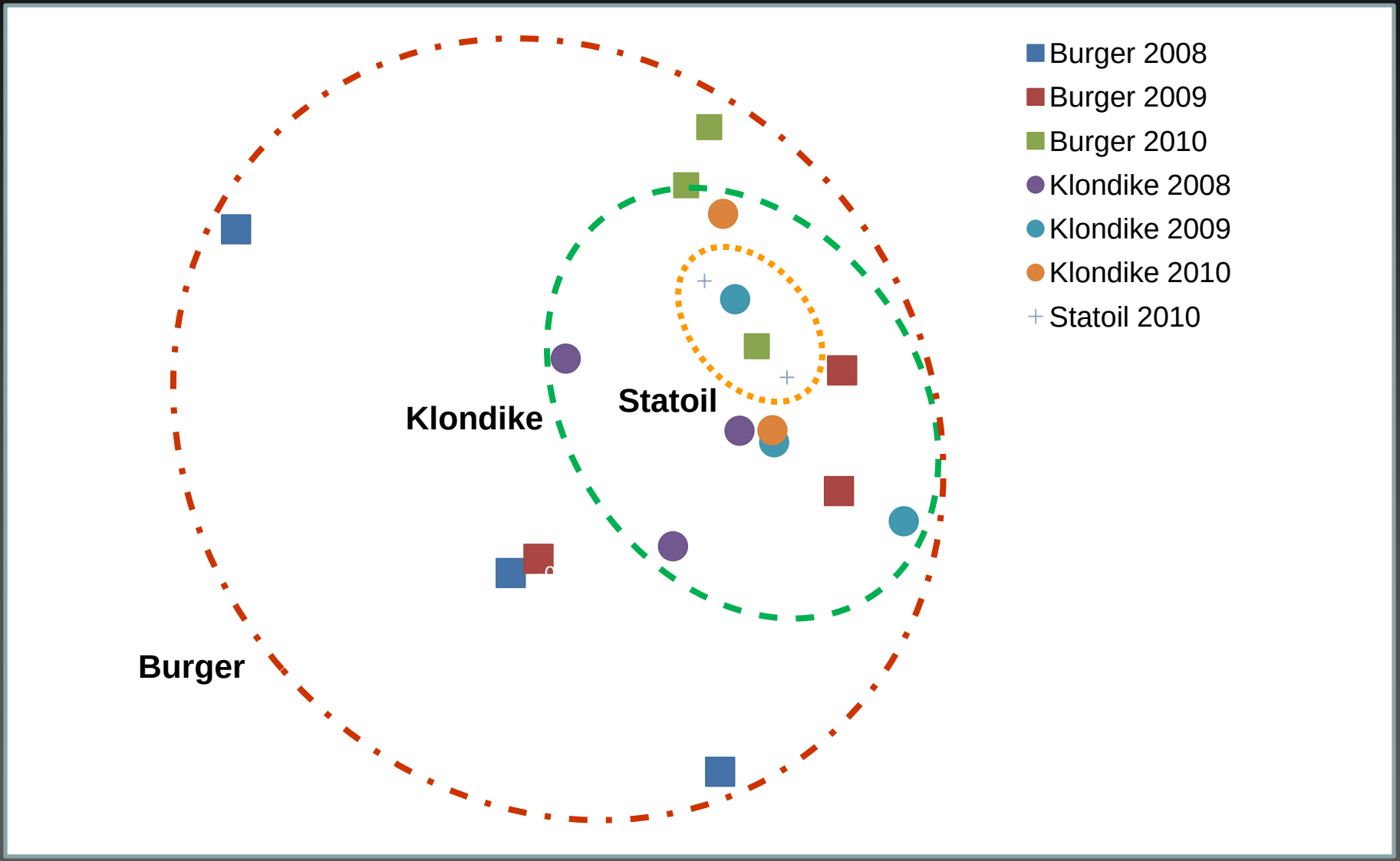
CRESTED AUKLET
(OCEANIC COPEPODS)

SHORT-TAILED
SHEARWATER
(EUPHAUSIIDS)

THICK-BILLED MURRE
(FISHES)



SEABIRD AREA DIFFERENCES



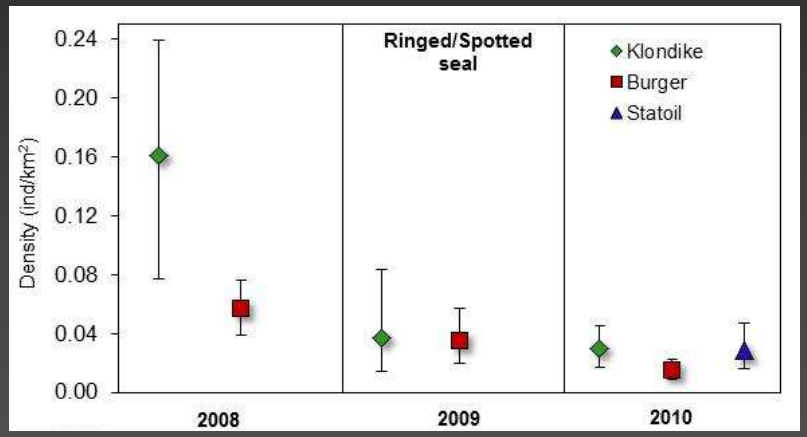
MARINE MAMMALS

- Dominated during OW season by seals and Walruses
- Two ecological groups
  - pelagic-feeders (Ringed, Ribbon, Spotted seals)
  - benthic-feeders (Bearded Seal, Walrus)

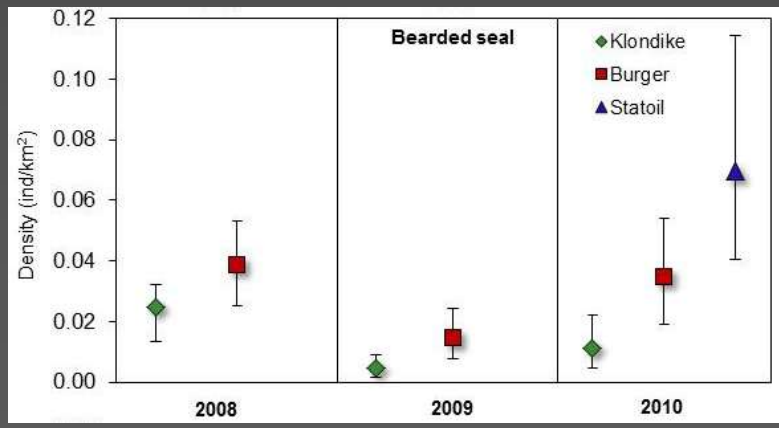
SEALS FOLLOW OCEANOGRAPHY

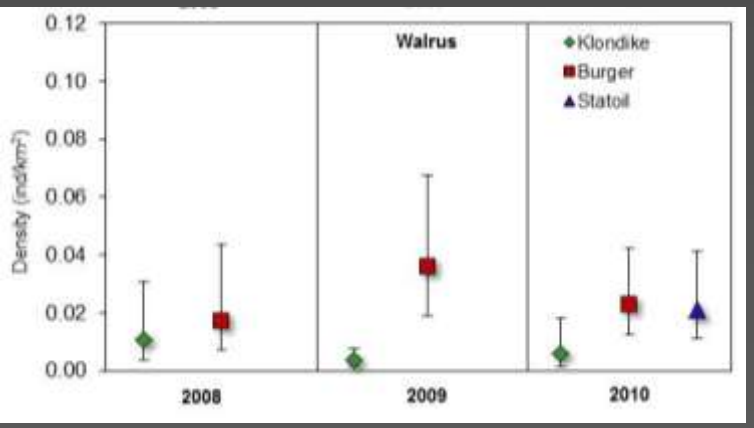
- Effect of ice on abundance
- Pelagic-feeders in Klondike
- Benthic-feeders in Burger

PELAGIC-FEEDERS



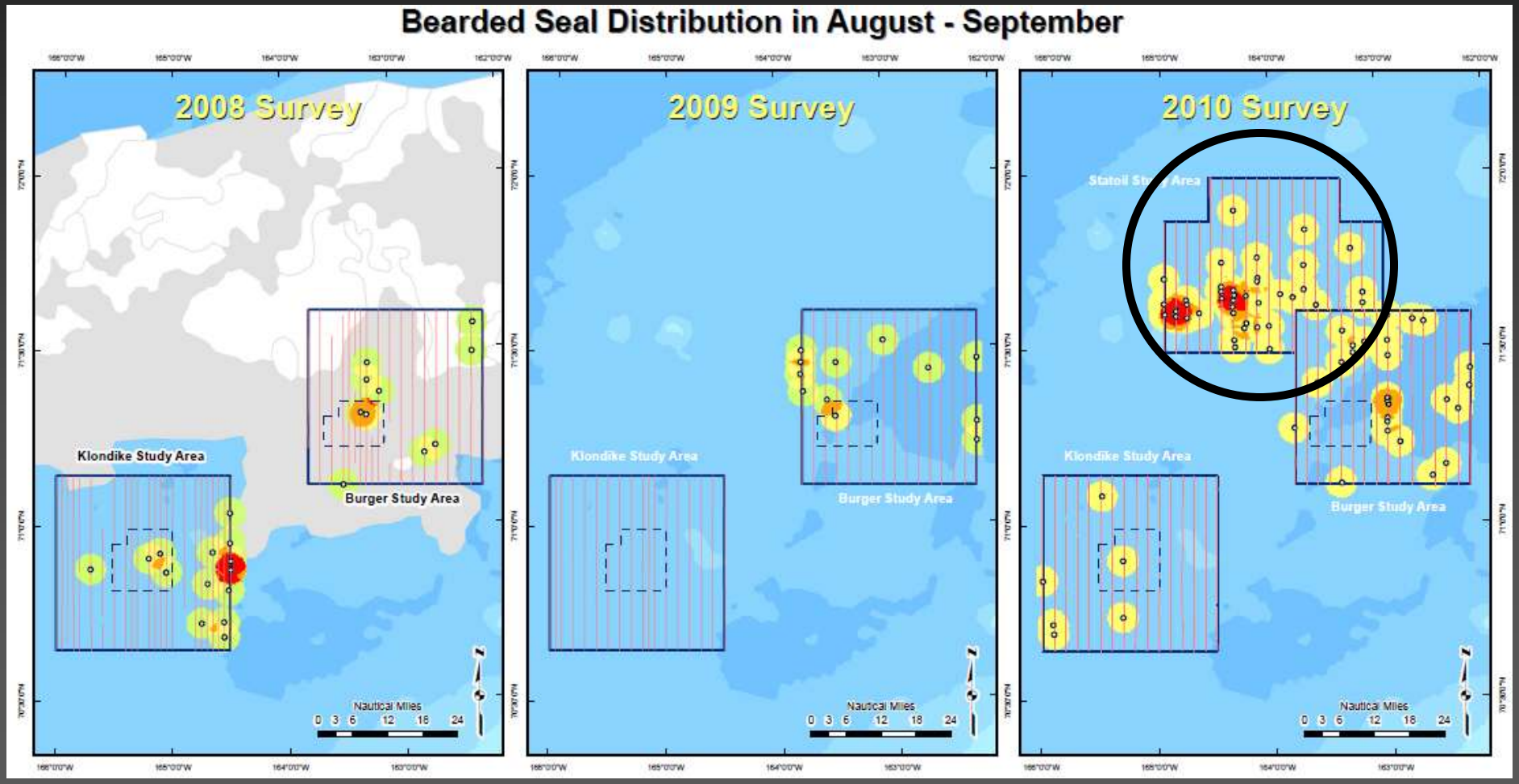
BENTHIC-FEEDERS





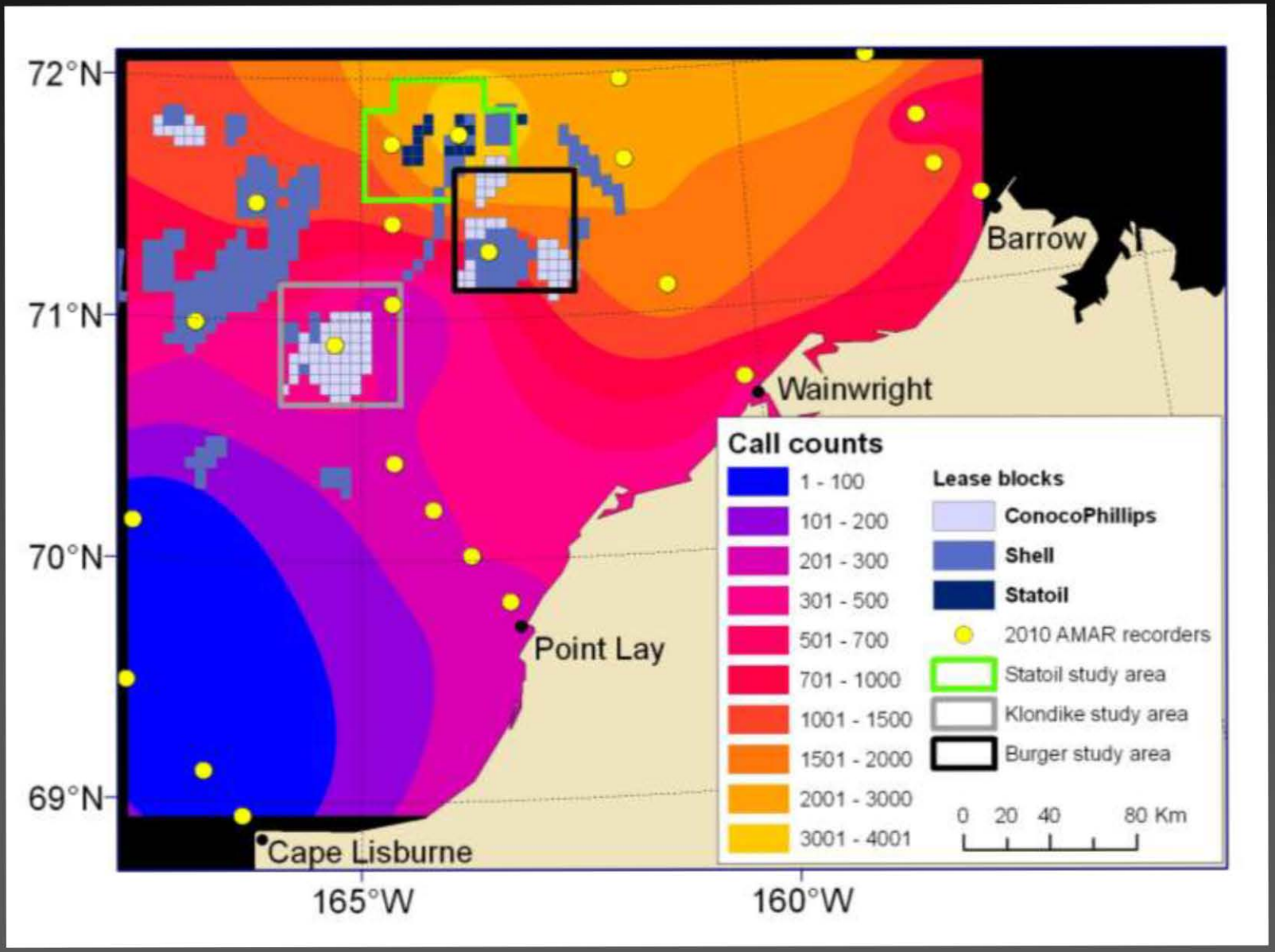
BEARDED SEALS IN BURGER, STATOIL

AT-SEA SURVEYS



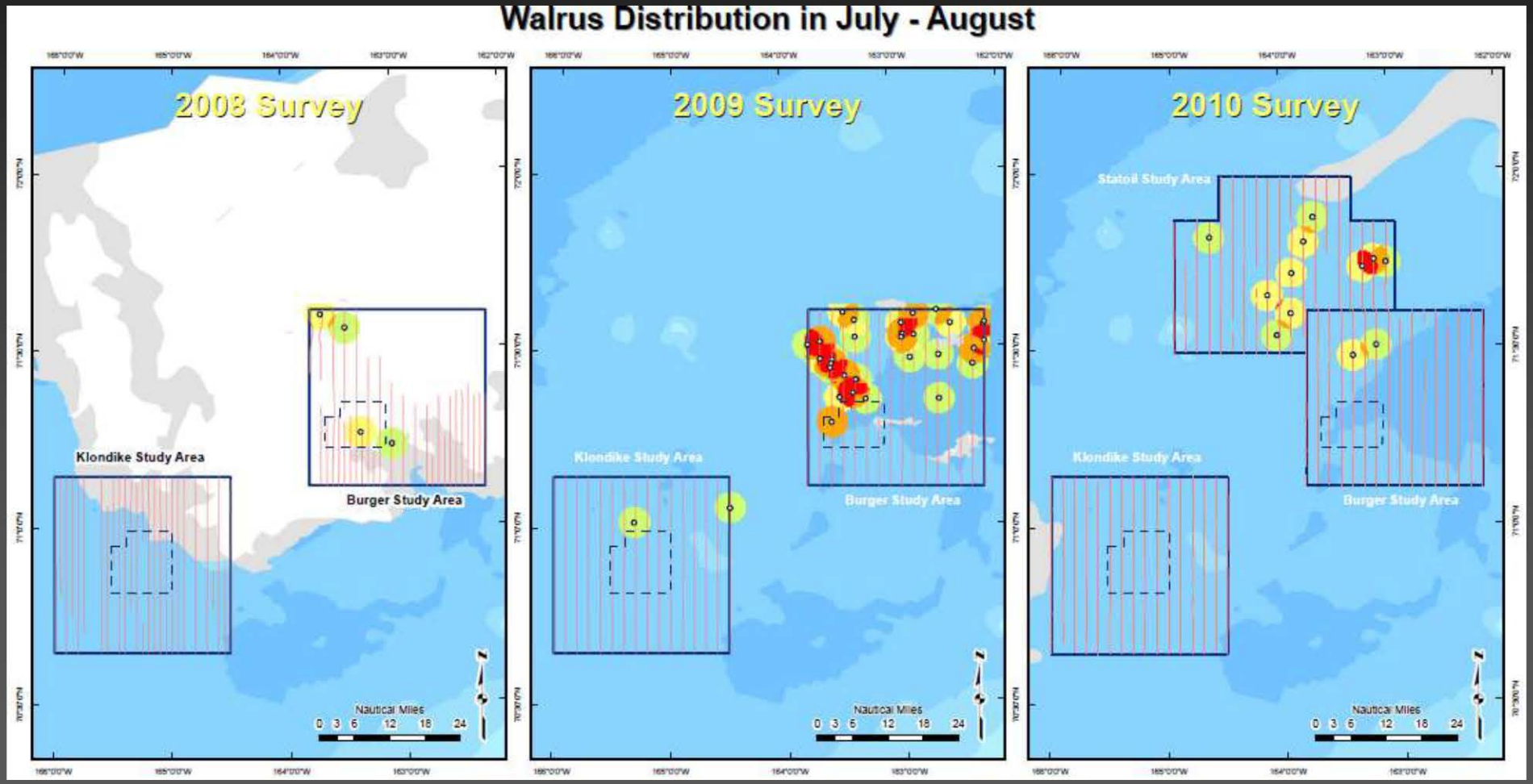
BEARDED SEALS (2010)

ACOUSTIC MONITORING



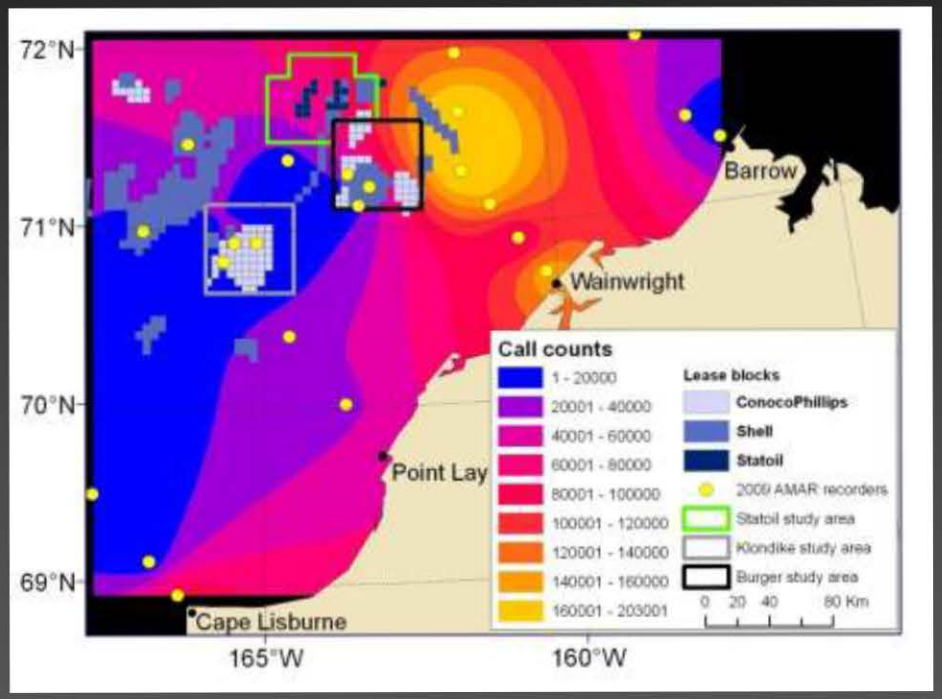
WALRUSES IN BURGER, STATOIL

AT-SEA SURVEYS

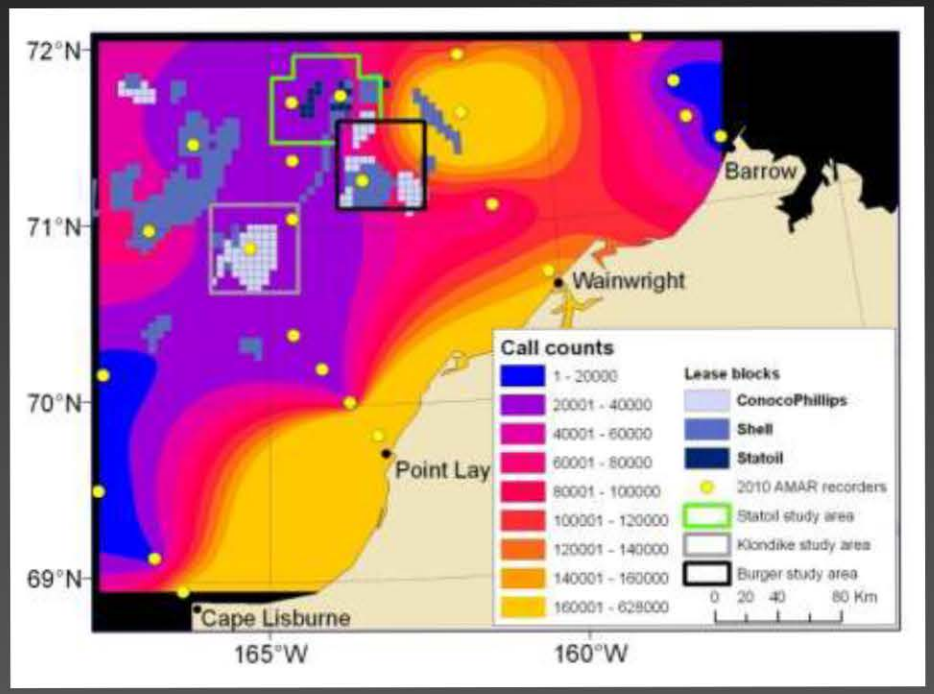


WALRUSES

ACOUSTIC MONITORING



2009

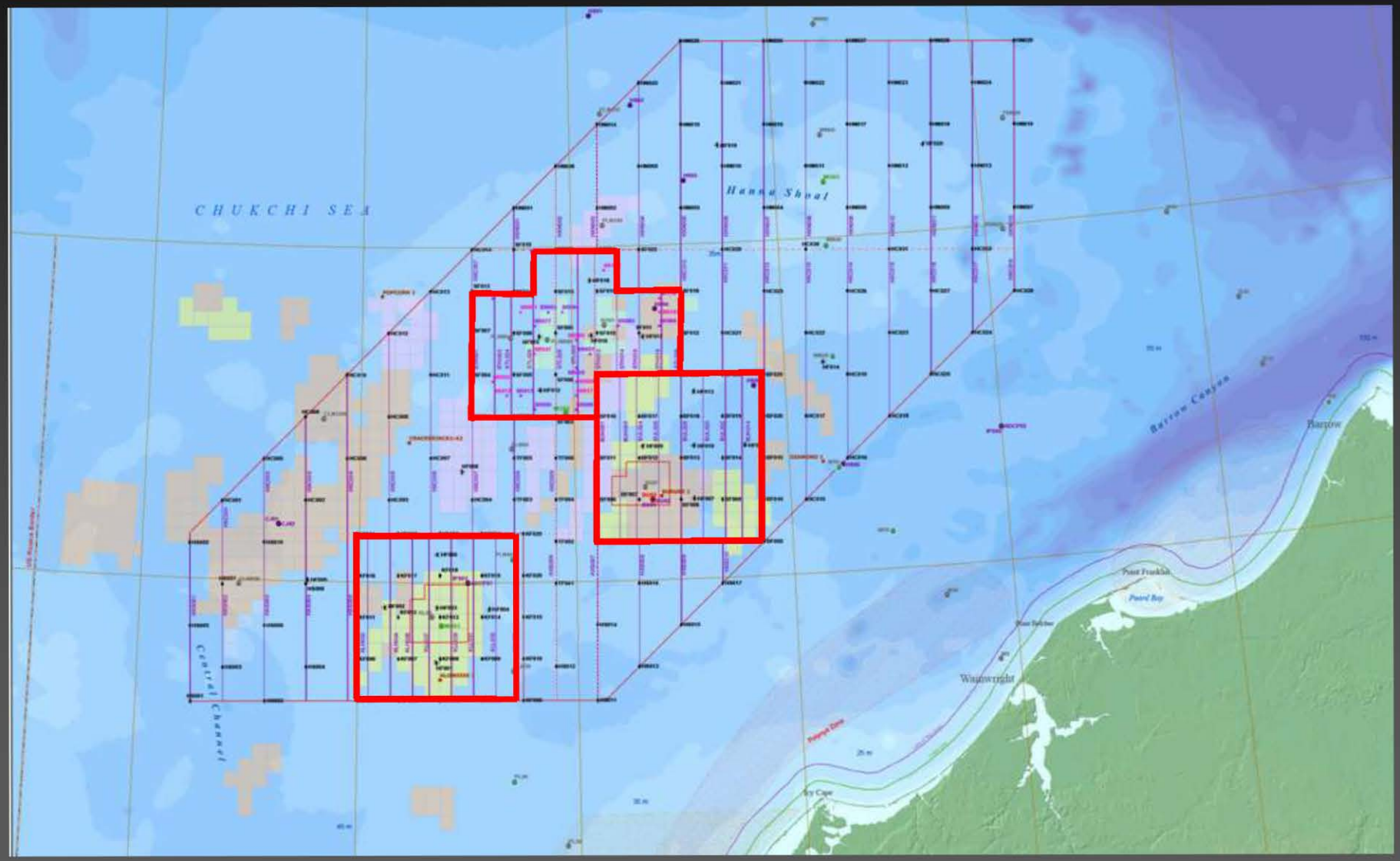


2010

SUMMARY

- Klondike more like a pelagic system, although imperfectly:
  - more pelagic-feeding seabirds & seals
  - flow-through system
  - most nutrients already stripped out farther south, so not as productive as it could be
- Burger operates more like a benthic system:
  - most carbon flowing to benthos
  - greater benthic communities
  - more benthic-feeding pinnipeds & whales

SUMMARY

- Statoil appears to follow Burger pattern, although western end similar to Klondike
  - western end catches edge of CC Current, so like Klondike
  - Central/eastern part more like Burger
- Odd ecosystem attributes
  - occasional fall bloom (rare in the Arctic)
  - few large fishes anywhere
  - few fishes in Burger, Statoil
  - few benthic-feeding seabirds anywhere

2011 AND ONWARD