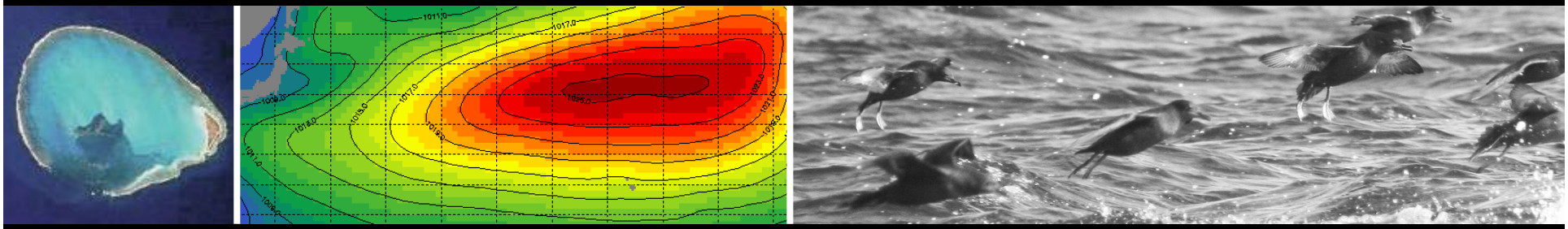

Seabirds and their marine environments: movements, dynamic habitats, and change

Josh Adams & John Y. Takekawa

USGS Western Ecological Research Center, SF Bay Estuary Field Station, Vallejo, California & Moss Landing Marine Laboratories, Moss Landing, California

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CLIMATE CHANGE, NATURAL RESOURCES AND COASTAL MANAGEMENT

A WORKSHOP ON THE COASTAL ECOSYSTEMS OF CALIFORNIA, OREGON AND WASHINGTON

January 29-30, 2008, San Francisco, California
Sponsored by: U.S. Fish and Wildlife Service & U.S. Geological Survey

Acknowledgments

- USGS Western Ecological Research Center, Land-Sea Interface Program, Climate Change Program
- Minerals Management Service, Pacific OCS Region
- FWS Ecological Services
- Humboldt State University, Moss Landing Marine Labs
- U. S. Navy
- Dep. Fish and Game, Oiled Wildlife Care Network, Oil Spill Prevention and Response
- National Park Service
- National Marine Sanctuaries

Shifting base-lines and the rise of slime in a brave new ocean

"Synergistic effects of habitat destruction, overfishing, introduced species, warming, acidification, toxins, and massive runoff of nutrients are transforming once complex ecosystems like coral reefs and kelp forests into monotonous level bottoms, transforming clear and productive coastal seas into anoxic dead zones, and transforming complex food webs topped by big animals into simplified, microbially dominated ecosystems with boom and bust cycles of toxic dinoflagellate blooms, jellyfish, and disease."

– J. B. C. Jackson, Ecological extinction and evolution in a brave new ocean. PNAS 2008

“Something big is going on out there”: Seabirds indicate anomalous ecosystem responses

The krill is gone: Strange weather shakes Pacific Coast ecosystems

Food shortage leads to more dead birds along Monterey Bay

SAN FRANCISCO — Marine biologists are spotting ominous signs all along the Pacific Coast this year: higher nearshore ocean temperatures, plummeting catches of groundfish, an explosion of dead birds on coastal beaches and, perhaps most disturbing, very few plankton — the tiny critters that form the basis of the ocean's intricate food web.

From California to British Columbia, unusual weather patterns have disrupted the marine ecosystem, scientists say. The normal northerly winds failed to show up this year, preventing the usual upwelling of colder water that contains the plankton, and in turn, many other species from anchovies to cormorants to whales.

Is this just a strange year, or is this what global warming looks like? Few scientists are willing to blame the plankton collapse on the worldwide rise in temperatures attributed to carbon dioxide and other gases believed to trap heat in the earth's atmosphere. Yet few are willing to rule it out.

See ECOSYSTEMS, page 6

Pacific krill are in shortage.

Hannah Nevins, beachcombers coordinator with the Moss Landing Marine Lab, looks over a dead Brandt's cormorant Thursday at Natural Bridges State Park in Santa Cruz.

AP, Register Pajaronian July 23, 2005

Warmer oceans may be killing West Coast marine life

“SOMETHING BIG IS GOING ON OUT THERE”

Cold water isn't rising from depths; scientists note increase in dead birds

BY CARINA STANTON
Seattle Times staff reporter

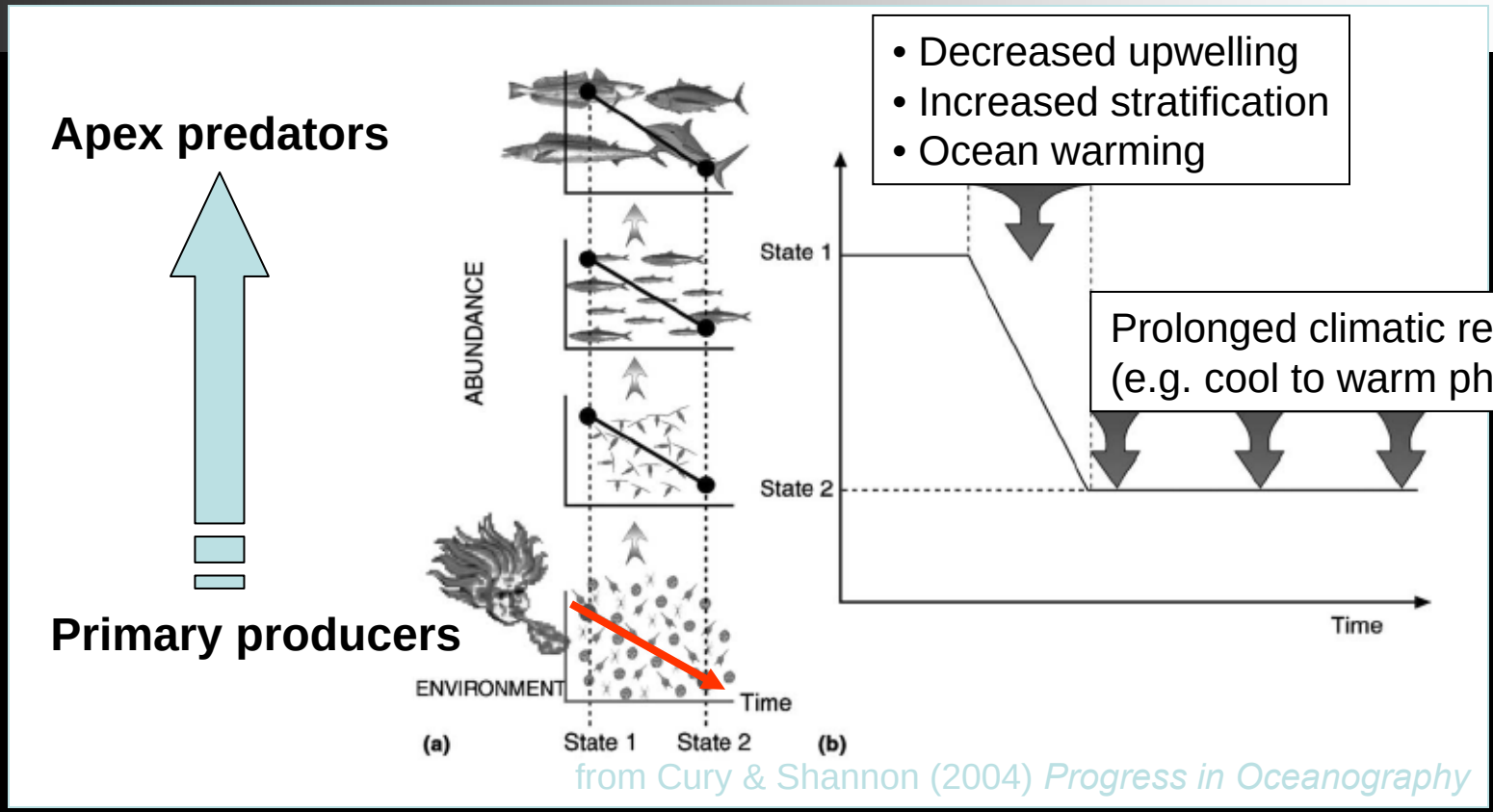
Scientists suspect that rising ocean temperatures and dwindling plankton populations are behind a growing number of seabird deaths, reports of fewer salmon and other anomalies along the West Coast.

Seattle Times July 13, 2005

How will climate change effect seabirds in the Pacific and CCS?

- Sea level rise, wave-height, & storm-surge
  - ASSP, CA Least Tern, millions of seabirds NW Hawaiian Islands, Pacific Islands National Monument (n = 8, 4.4 ± 0.8 m asl)
  - Beach erosion could alter winter habitat for scoters (loss of sandy beach / littoral habitats)
  - Altered kelp forest structure could effect foraging for Marbled Murrelets, Pigeon Guillemot, cormorants
- Wind-stress and upwelling – timing of events/productivity (Bakun 1990, Diffenbaugh et al. 2003, Snyder et al. 2003)
- Depth of the mixed layer (Palacios et al. 2004 , McGowan et al. 2003)
- SST affects productivity, metabolic rates, prey availability/composition, parasites & disease

Bottom-up control & regime shifts: “from wind to whales”



from Cury & Shannon (2004) *Progress in Oceanography*

“*A global change in upper-ocean heat content, accompanied by an increase in stratification and mixed-layer deepening relative to the critical depth for net production, could lead to a widespread decline in plankton abundance.*”
– McGowan et al. (2003)

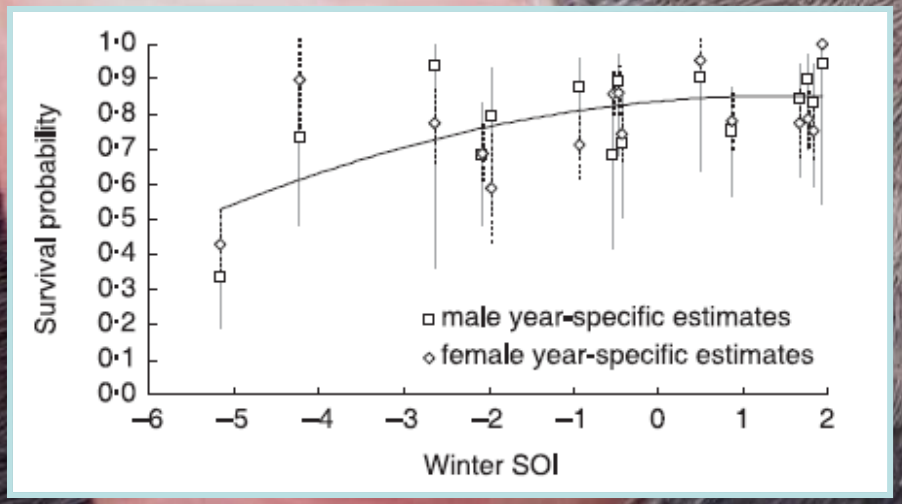
Three seabirds: revealing mechanisms to understand and predict responses to marine climate change

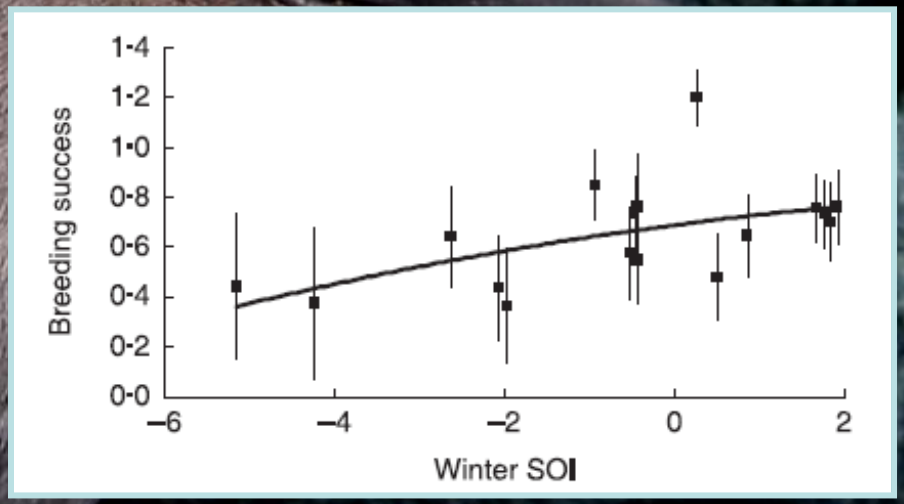
Predicted changes to the CCE: wind-stress, upwelling, thermal stratification, changes in zooplankton abundance/availability & community composition, seasonal phenology (timing of events)

1. Cassin's Auklet: an indicator of change to the upper mixed layer
2. Sooty Shearwater: integrator of mid-trophic-level marine productivity and dynamic response to upwelling habitats
3. Hawaiian Petrel: dependent on mega-scale wind patterns and productivity in the NPAC

Cassin's Auklet: an indicator of change to the upper mixed layer

- Demography linked to climate variability and SST 1986– 2002

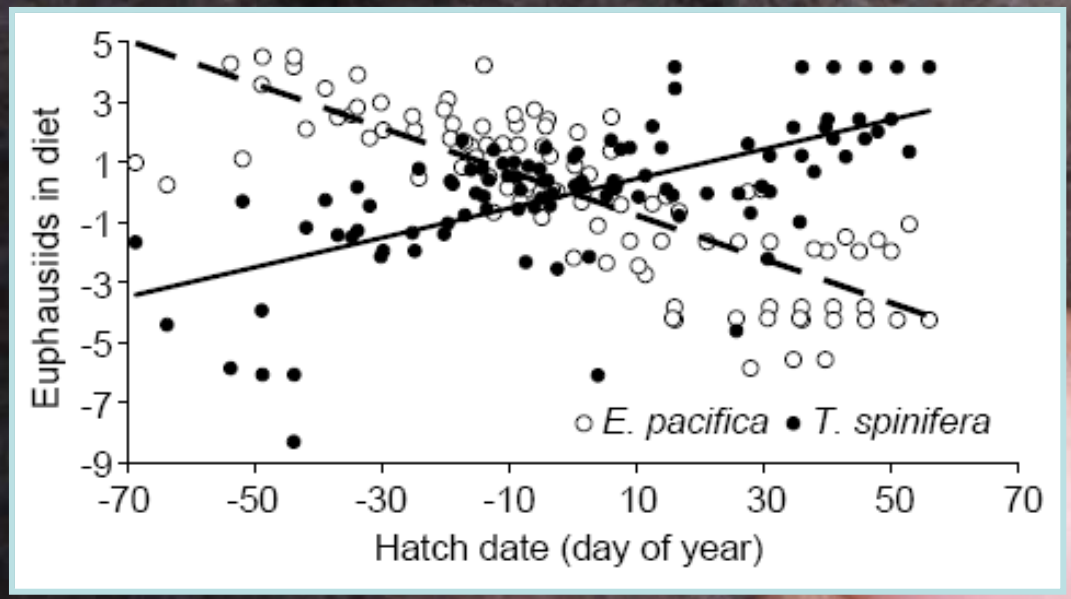


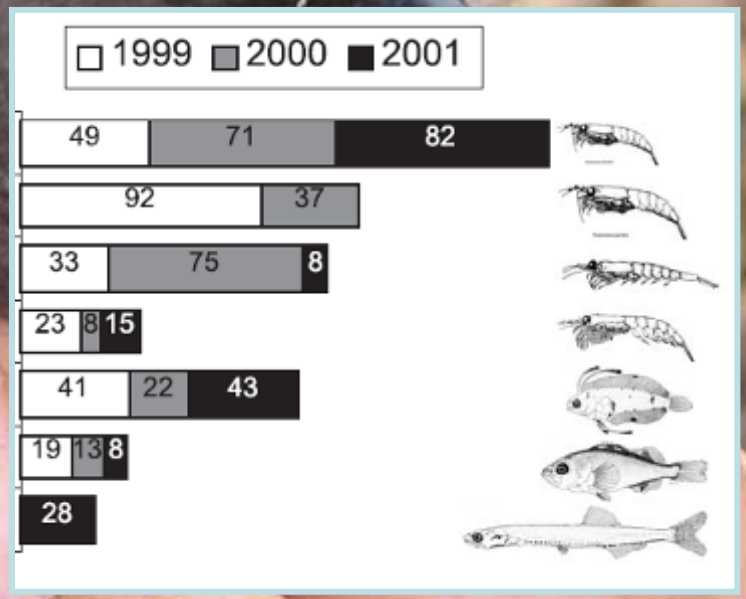


Lee et al. (2007) *Journal of Animal Ecology*

Cassin's Auklet: an indicator of change to the upper mixed layer

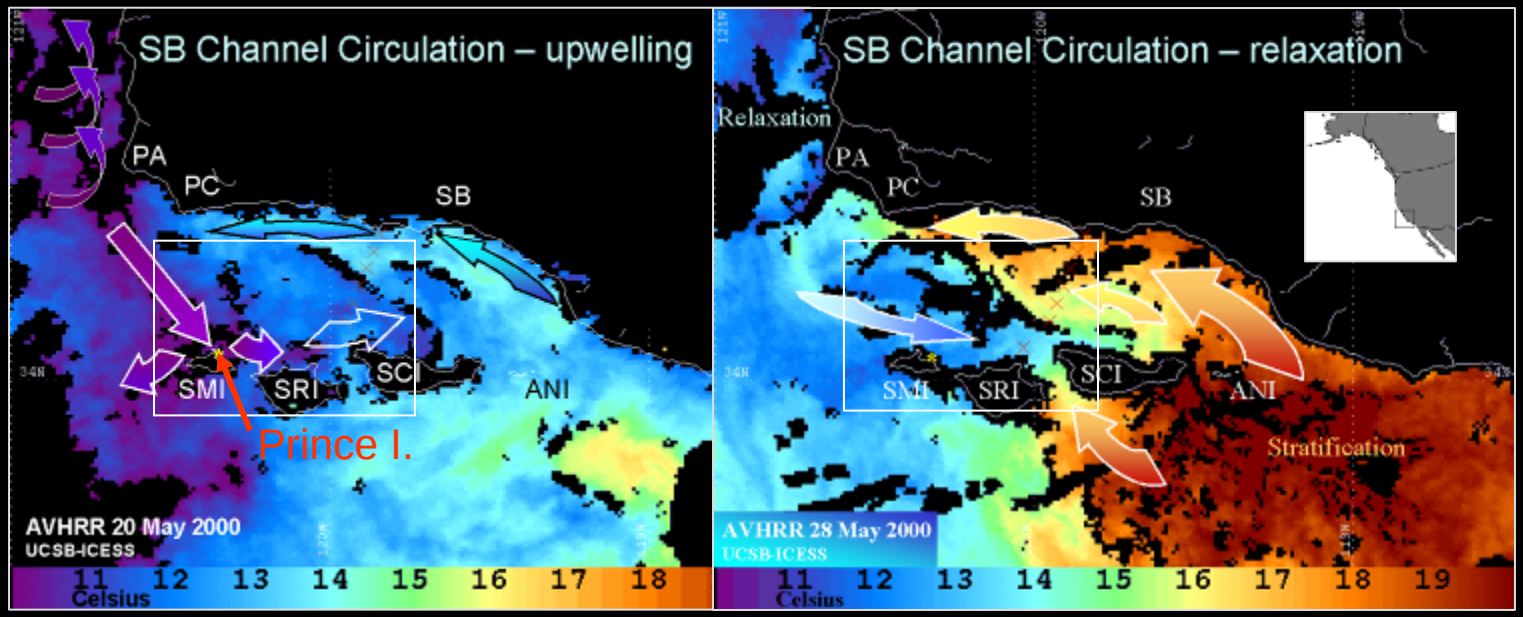
- Zooplankton diet, breeding phenology, and chick growth linked to climate variability and SST

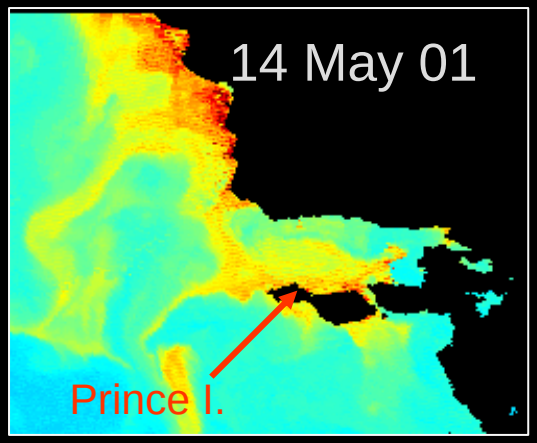


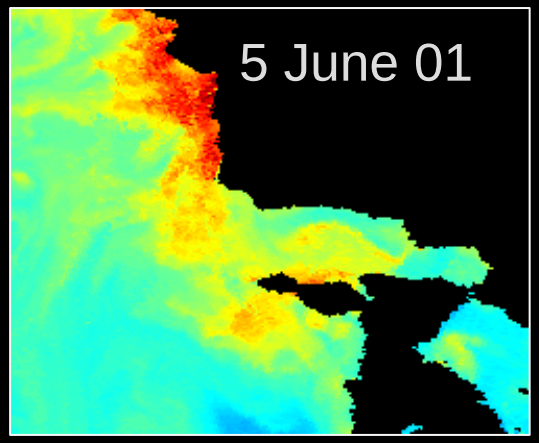


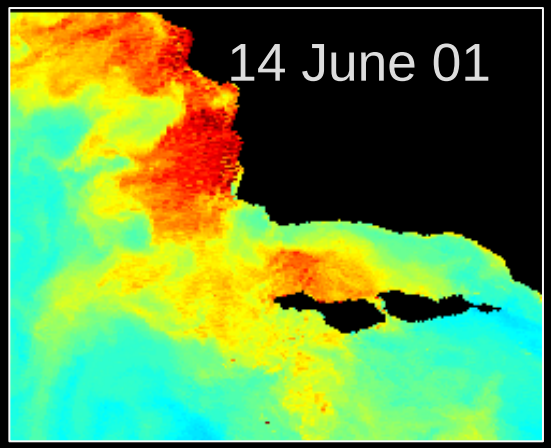
(Adams, Takekawa, and Carter (2004) *Can J Zoology;* Ainley *et al.* (1996) *Mar Ecol Prog Ser;* Abraham (2008) *J. Avian Biology;* Abraham and Sydeman (2006) *Mar Ecol Prog Ser*; Bertram et al. (2001) *Prog Ocean*)

Auklets in the SB Channel: a unique physical setting









Chlorophyll-a mg m^{-3}

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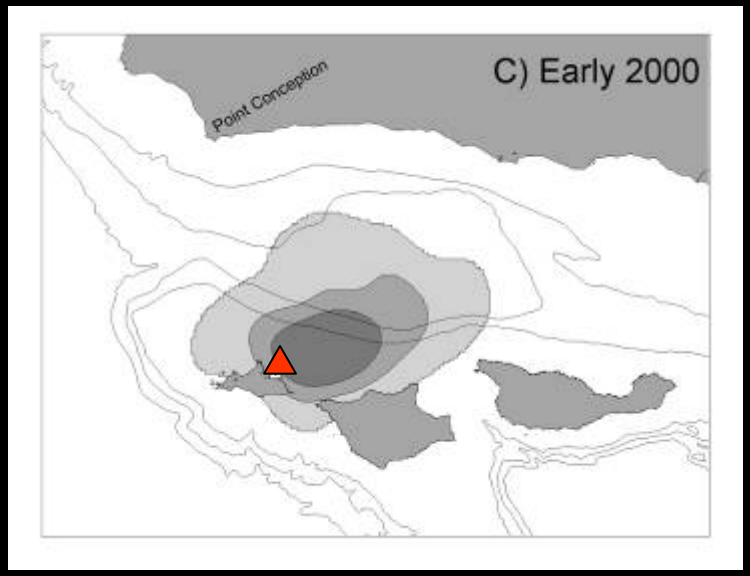
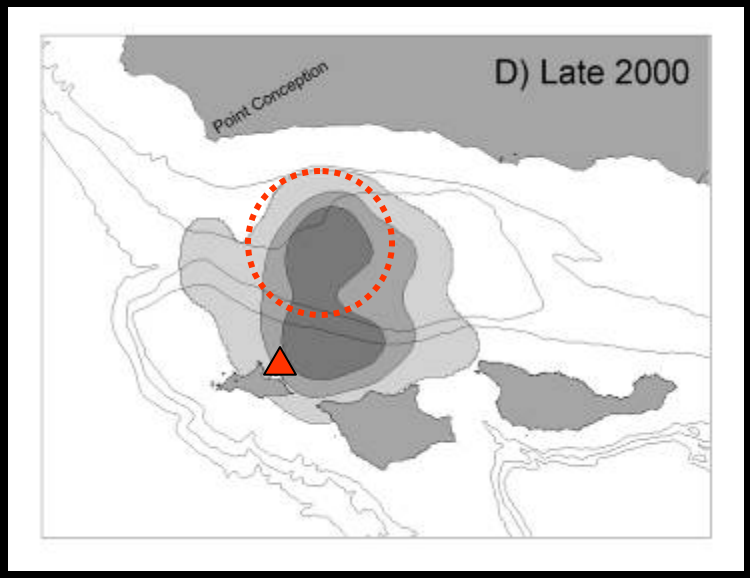
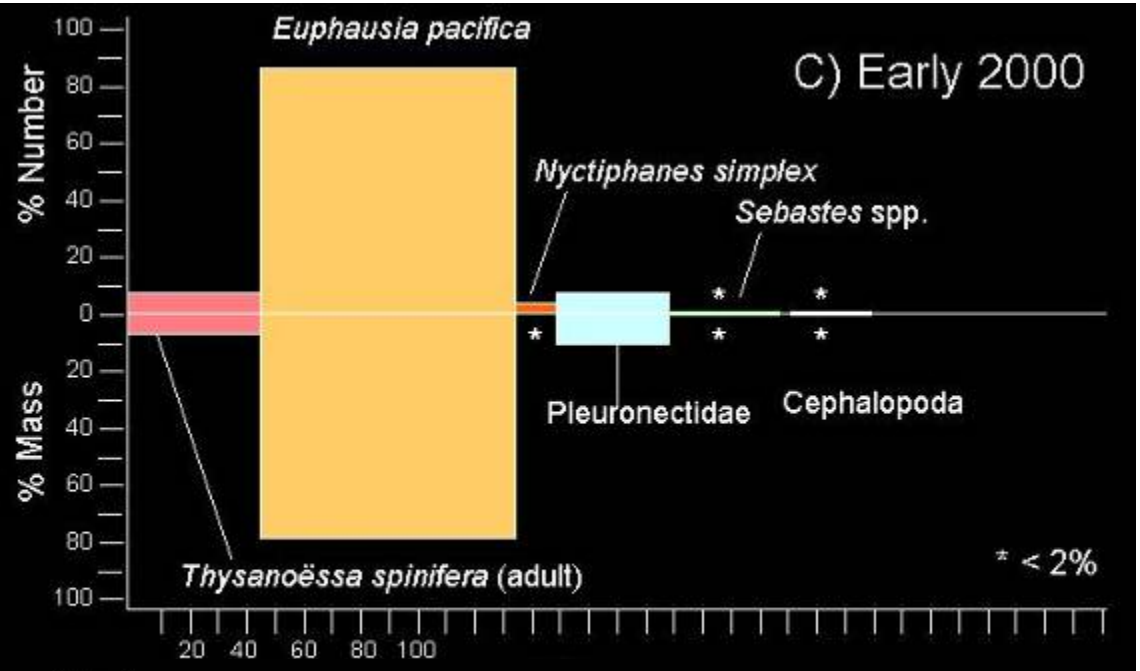
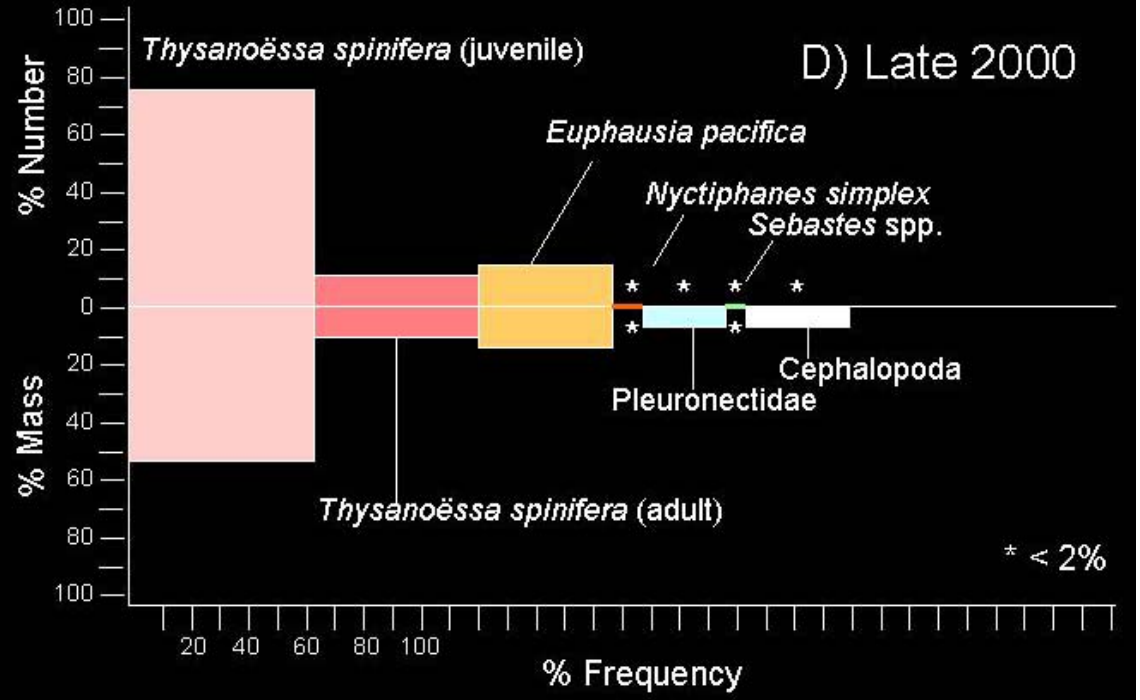
(Adams, Takekawa, Carter 2004a,b; in review)









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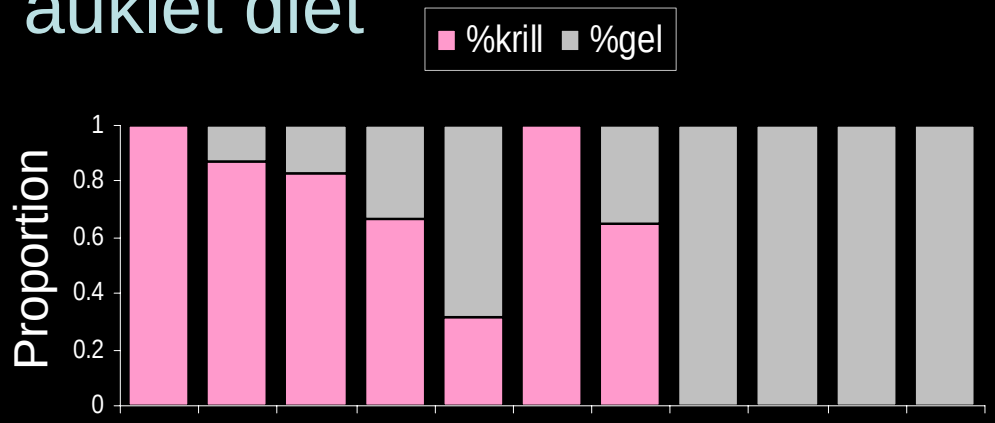
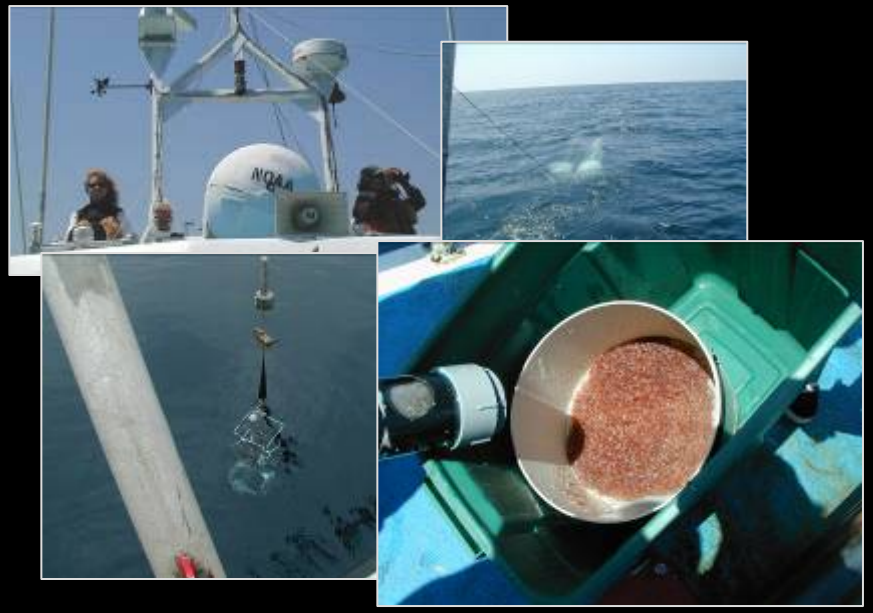
(Adams, Takekawa, Carter 2004. Can J Zool)

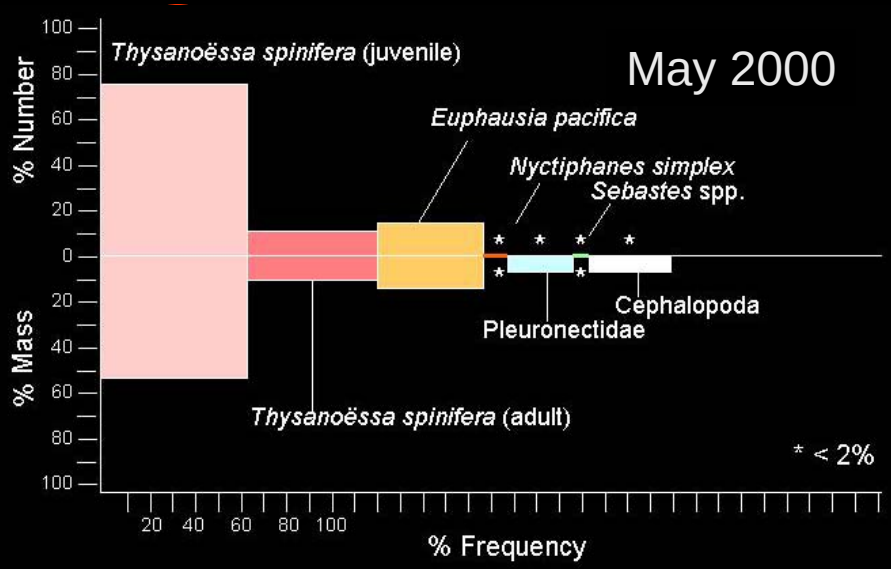
Seasonal changes in zooplankton abundance and auklet diet



May – juvenile krill **June – jellies**



auklet prey



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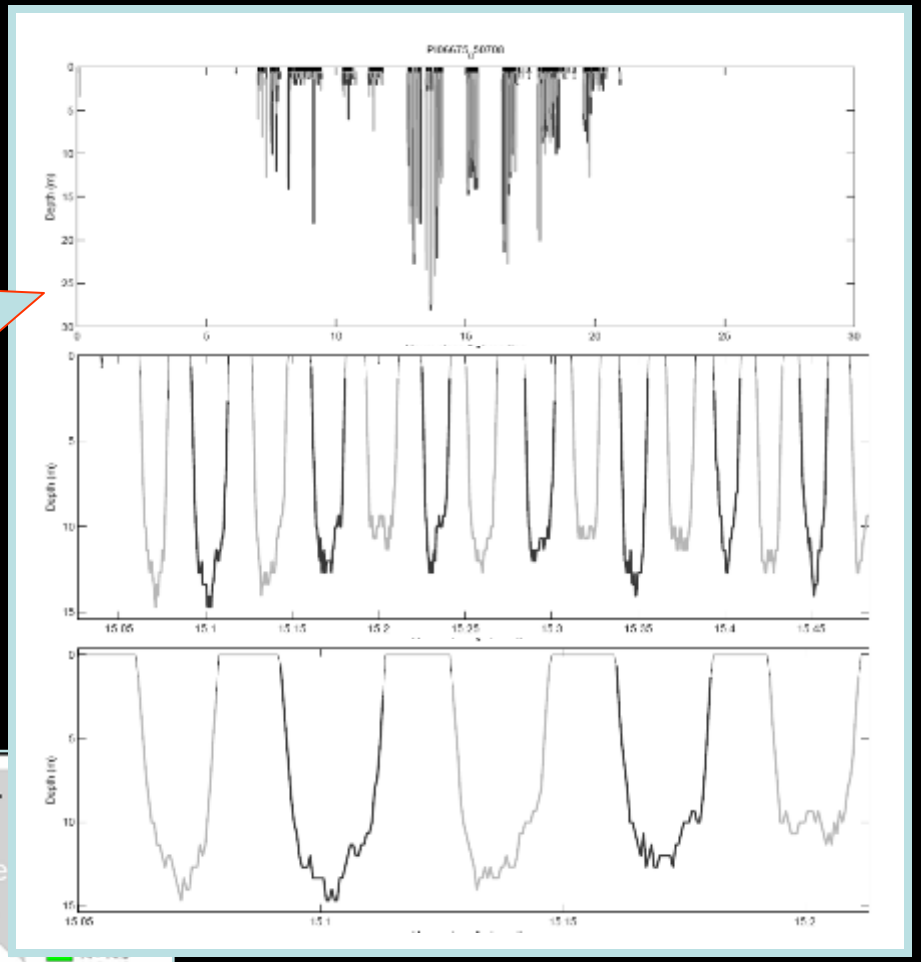
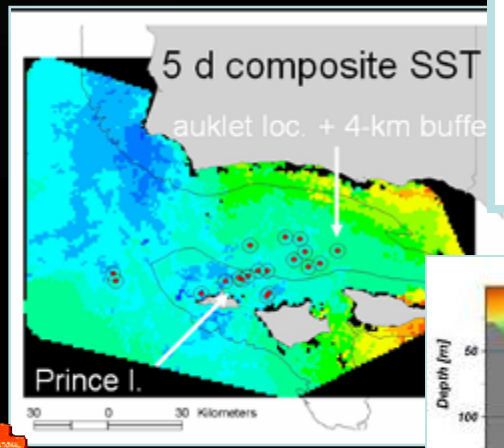
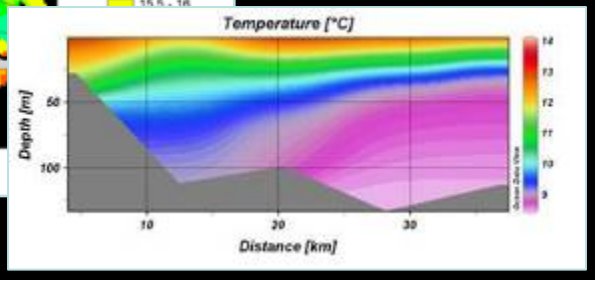
(Adams, Takekawa, Carter 2004; Adams et al. in prep)

Auklet diving: understanding the limits to successful foraging







Horizontal Ocean Habitat

Vertical Ocean Habitat

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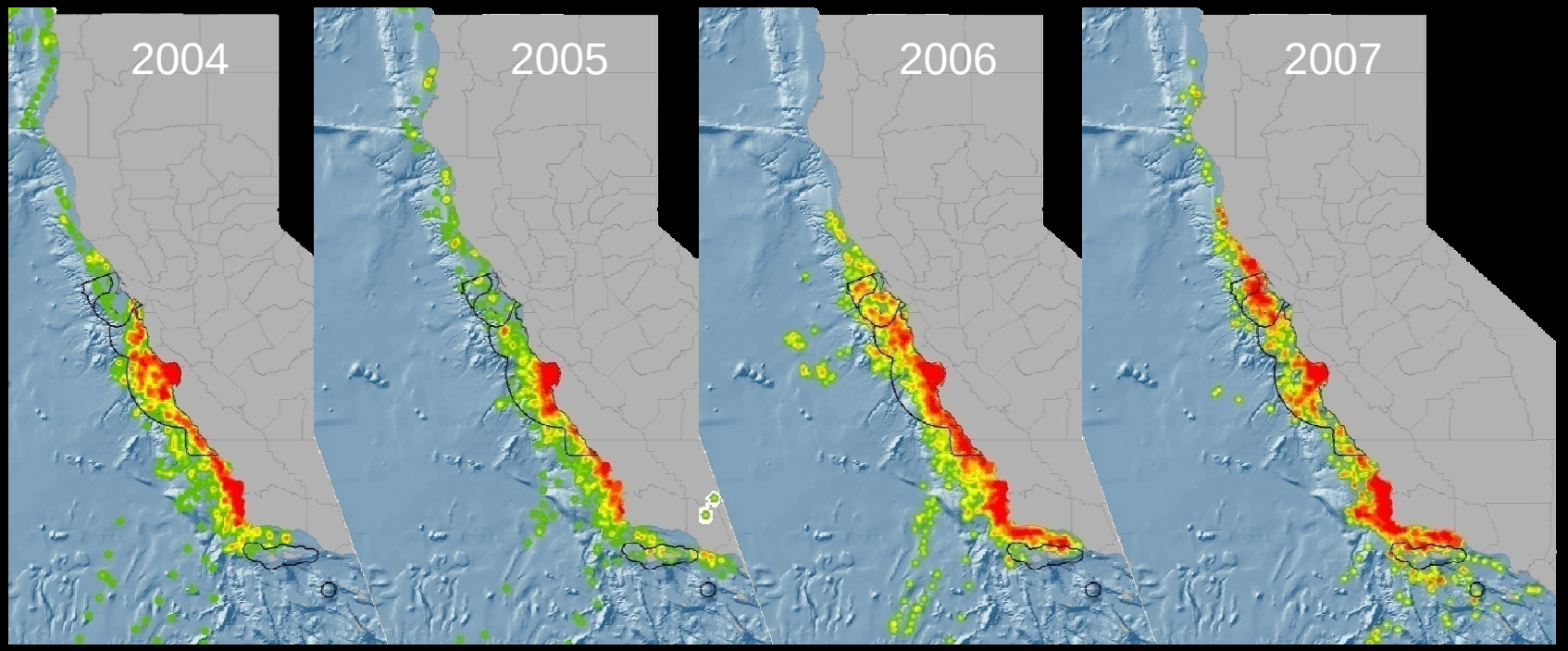
OWCN

Sooty Shearwater: integrator of global-scale mid-trophic-level marine productivity

- Most abundant seabird in the CCS (single flocks can exceed 600,000 individuals)
- Trans-Pacific migrant (Breeds in NZ and Chile)
- Decline by 37% (largest colony in NZ), 70 – 95% in CCS: 1970s – 1990s
- Depend on massive quantities of forage fishes in the CCS (>annual commercial harvest sardine and anchovy)
- Demographic parameters linked to climate variability

Sooty Shearwater: dynamic habitat use & connectivity of west-coast National Marine Sanctuaries



Colors depict probability density (standardized time) for satellite-tracked shearwaters: June – October. Black lines are NM Sanctuaries off CA.

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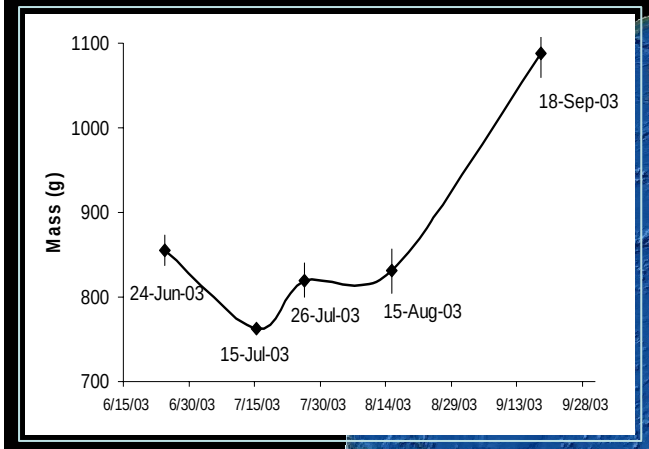
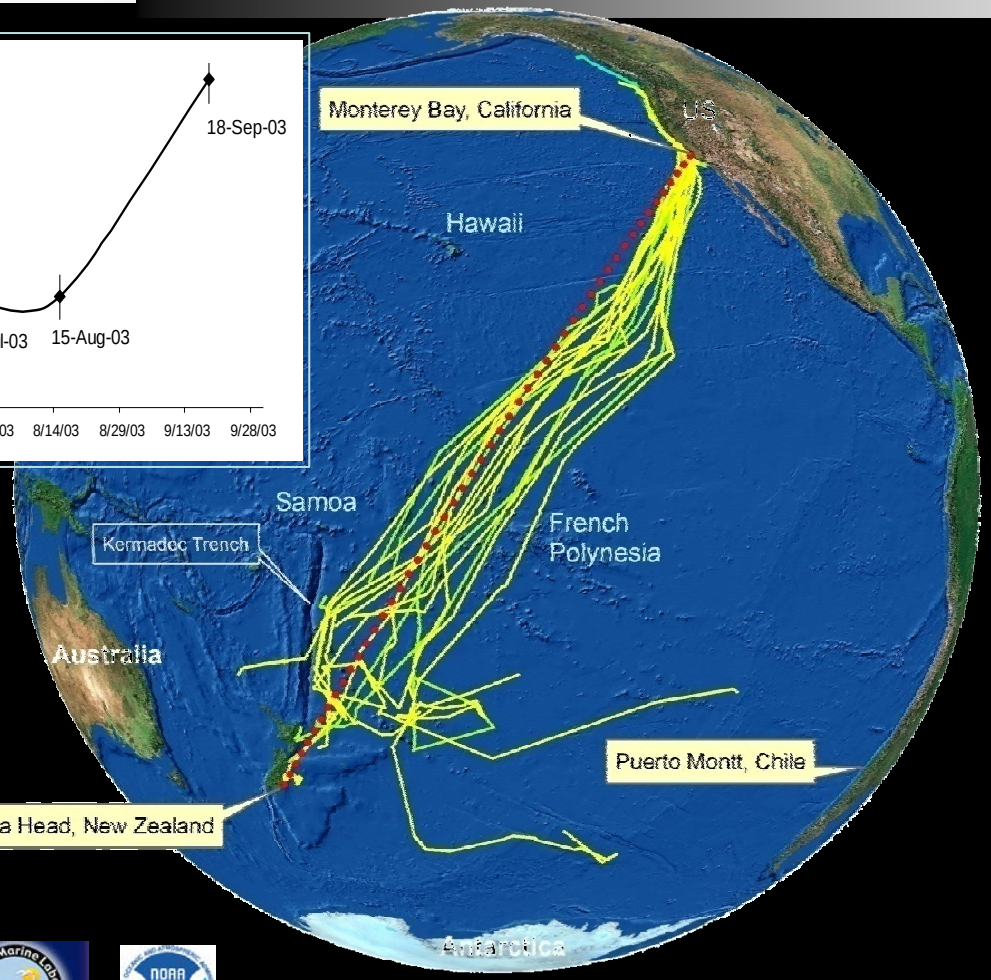
Sea Grant California
Coastal Science Serving California

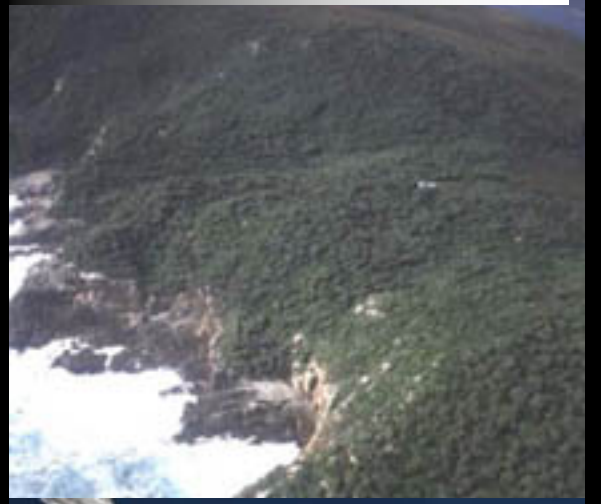
NOAA

Sooty Shearwater migration: wintering conditions and subsequent breeding success





Shearwater colony on Taukehepa, NZ



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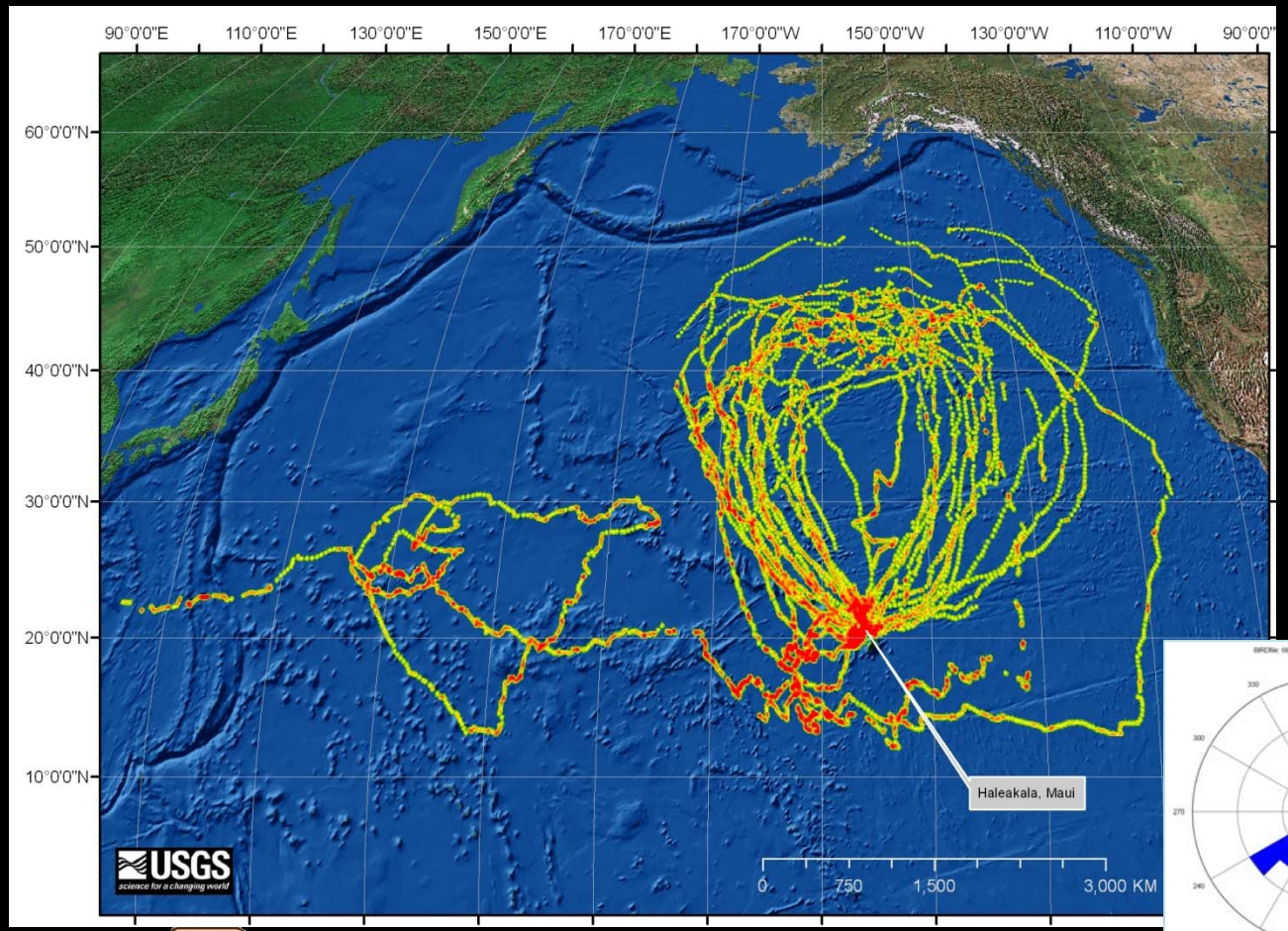
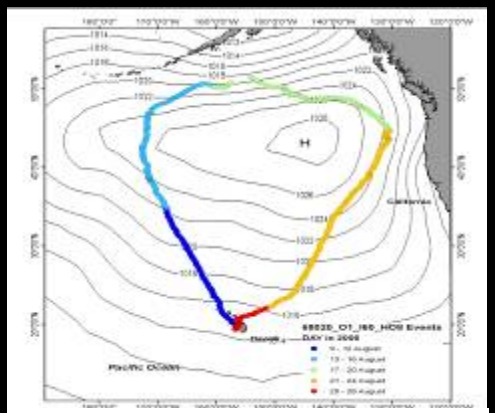
NOAA

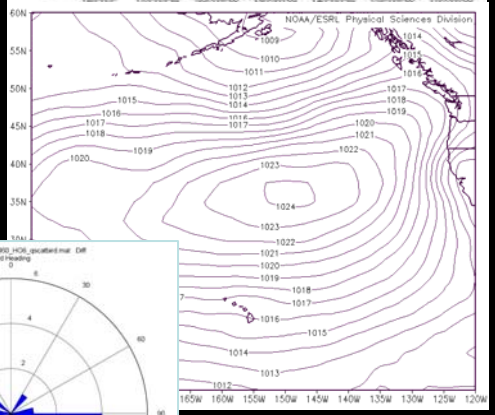
Hawaiian Petrel: dependent on mega-scale wind-patterns and productivity in the NPAC

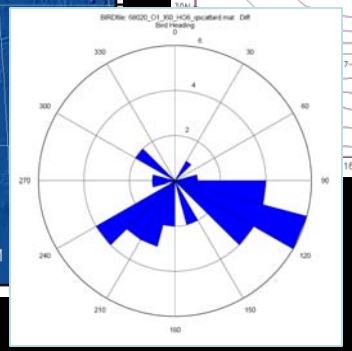
- Endangered, endemic to main Hawaiian Islands
- Extreme life history traits
- Specialized morphology & flight behaviors to extract energy from winds at the ocean surface
- Depends on tuna schools and dolphin herds to force prey out of water
- Foraging movements linked to NPAC wind patterns
- Recent increases in sightings in outer CCS likely result from shift to negative PDO

Hawaiian Petrels track anti-cyclone winds while foraging throughout the NE Pacific







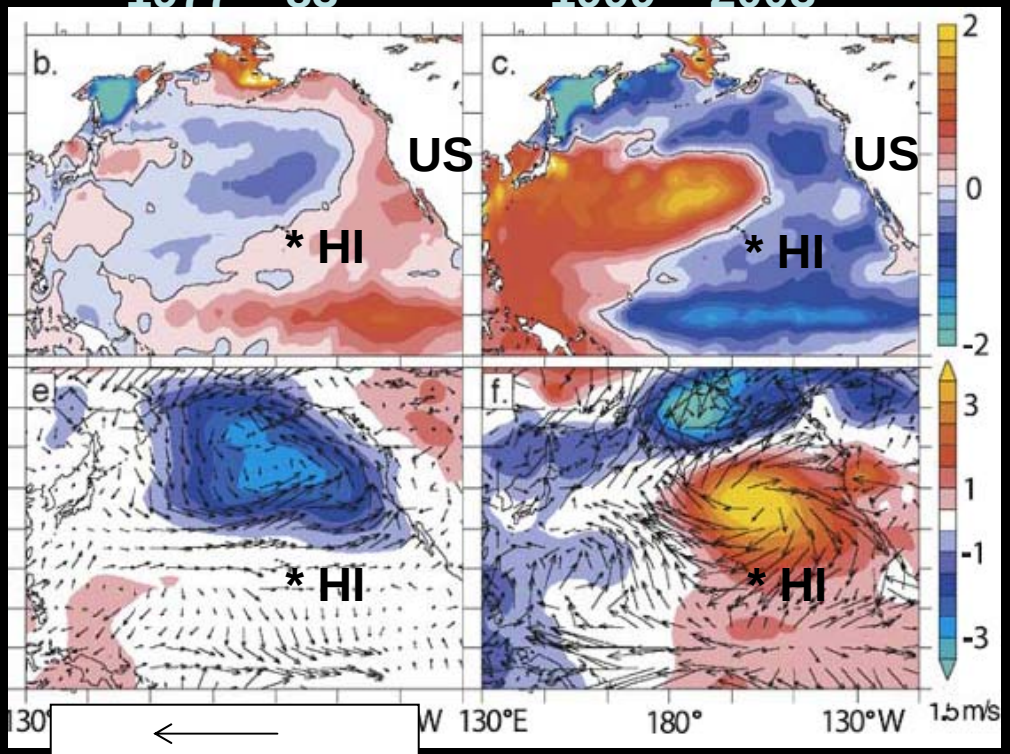


E.T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

How would petrel foraging be affected by climate change?

PDO (+)
1977 – 83

PDO (-)
1999 – 2003



SST Anom

SLP Anom

(Adams etal., unpubl. data)

(Peterson & Schwing (2003) Geophysical Research Let)

Conclusions

- Seabird ecology provides insight to the effects of climate variability on marine ecosystems
- Cassin's Auklet ecology can aid our understanding of how predators and lower-trophic levels (i.e., zooplankton communities) respond to climate variability
- Sooty Shearwaters provide a unique insight to variability in California Current and are excellent meso-trophic-level indicators
- Recovery of Hawaiian Petrels may be limited or enhanced by changing climatic conditions that affect NE Pacific Basin wind patterns

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