



SEABIRDS INDICATE PLASTIC POLLUTION IN THE MARINE ENVIRONMENT:

QUANTIFYING SPATIAL PATTERNS AND TRENDS

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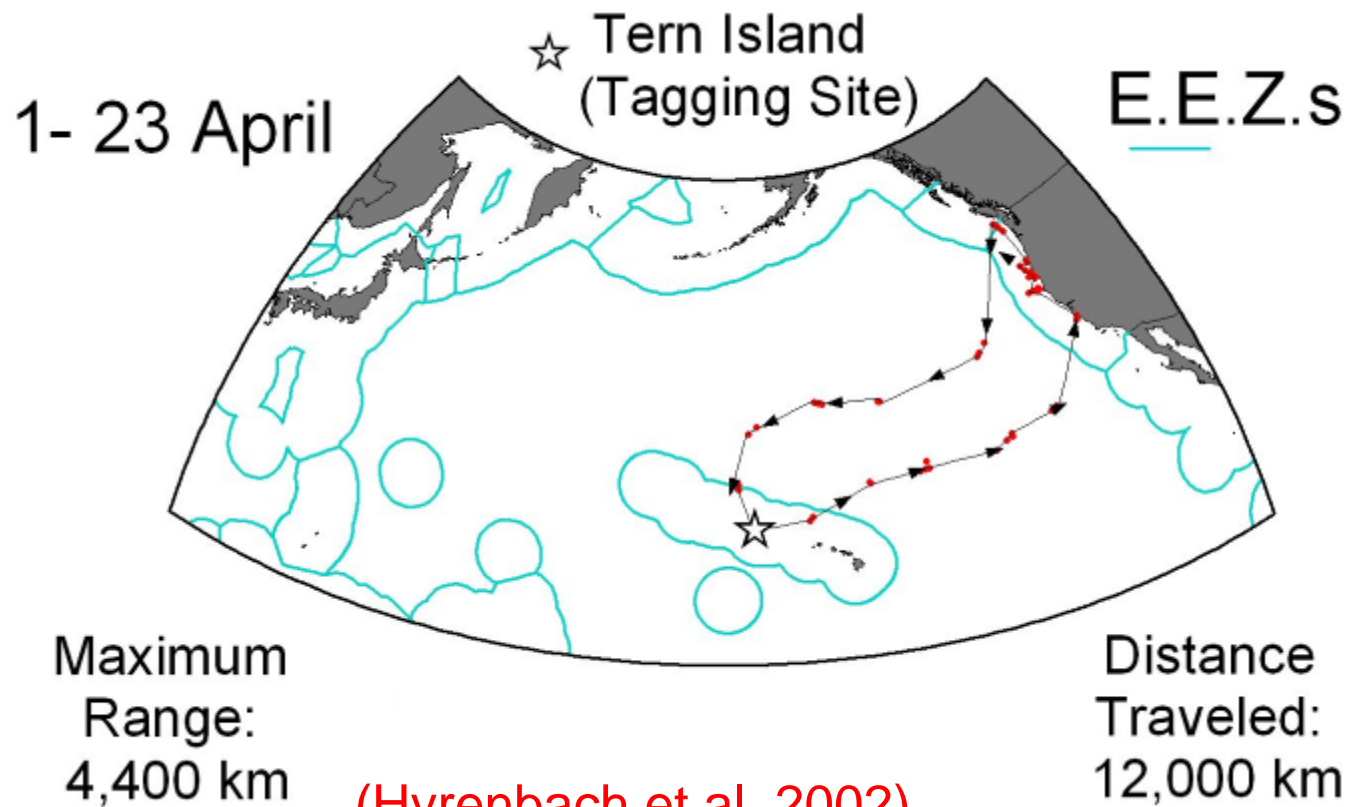


Sea Education Association
Woods Hole, Massachusetts



Hawaii Conservation Alliance, Honolulu, July 31, 2008

Seabirds Forage Over Vast Expanses



(Hyrenbach et al. 2002)



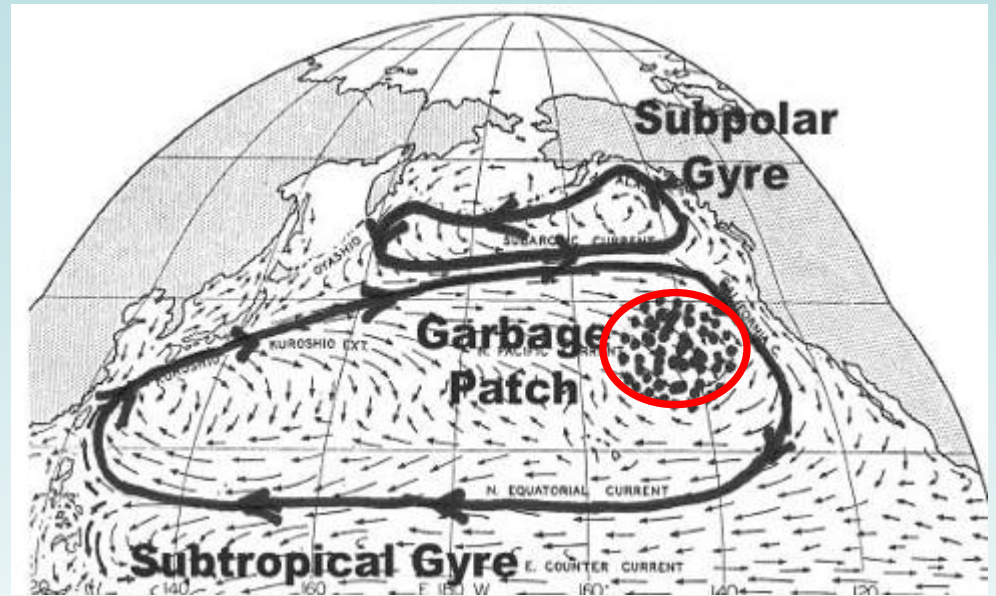
- Foraging on productive continental shelves off the West Coast

Currents Transport and Concentrate Debris

Subpolar and Subtropical Gyres of the North Pacific

Heavy lines: Drift

Dots: Garbage Patch



- Currents carry drifters around the Subpolar Gyre (3 years) and around the Subtropical Gyre (6 years)
- Debris retained in Eastern Garbage Patch for ~ 50 years

Map: Jim Ingraham

Outline

- Motivation
- Objectives
- Investigations
- Summary



Photo: Michelle Hester

Why Study Marine Birds

- Sensitive to fluctuations in marine ecosystems: oceanography, food-web structure, prey availability
- Numerous and conspicuous predators: convenient samplers of environment over many scales

(Montevecchi & Myers 1995, Furness & Camphuysen 1997)



Photos: USGS

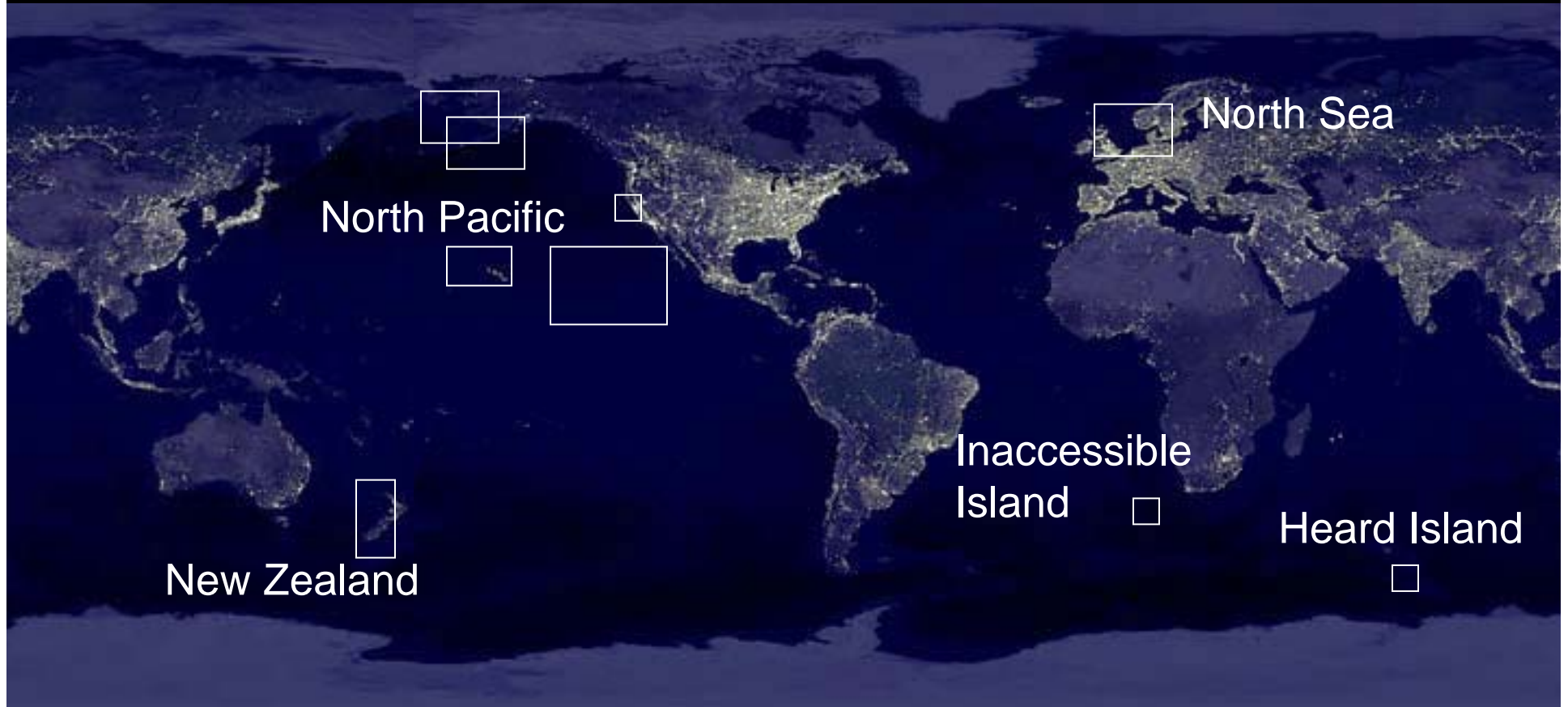
What Traits Make Seabirds Good Samplers



- Make a living in the marine environment
- Top marine predators: zooplankton, fish, squid
- Come to land to breed - often in large colonies
- Deliver food to their chicks

Photos: Michelle Hester

Pervasive Plastic Ingestion by Seabirds



- Alaska, Bering Sea (Robards et al. 1995, Vlietstra & Parga 2002)
- California (Baltz & Morejohn 1976, Nevins et al. 2005)
- Eastern Tropical Pacific (Spear et al. 1995), New Zealand (Collins 2005)
- North Sea (Van Franeker & Meijboom 2002)
- Heard island: Documented in 2001 (Auman et al. 2004)
- Inaccessible island: Increasing from 1984 to 1990 (Ryan & Moloney 1993)

Many Seabirds Ingest Plastic

- Tiny scraps of plastic from Wilson's storm petrel chicks in Antarctic (van Franeker 2005)
- Cigarette lighters, light-sticks, toys from albatross chicks in Hawaii (Kinan 2000)



Wilson's Storm-petrel



Black-footed Albatross

Many Studies Reveal Increasing Trends



Northern Fulmar
(*Fulmarus glacialis*)



Incidence of Ingested Plastic in Alaska Colonies

1969-1977	1988-1990	n	Change
58 %	84 %	38, 19	+26 %

(Robards et al. 1995)

Outline

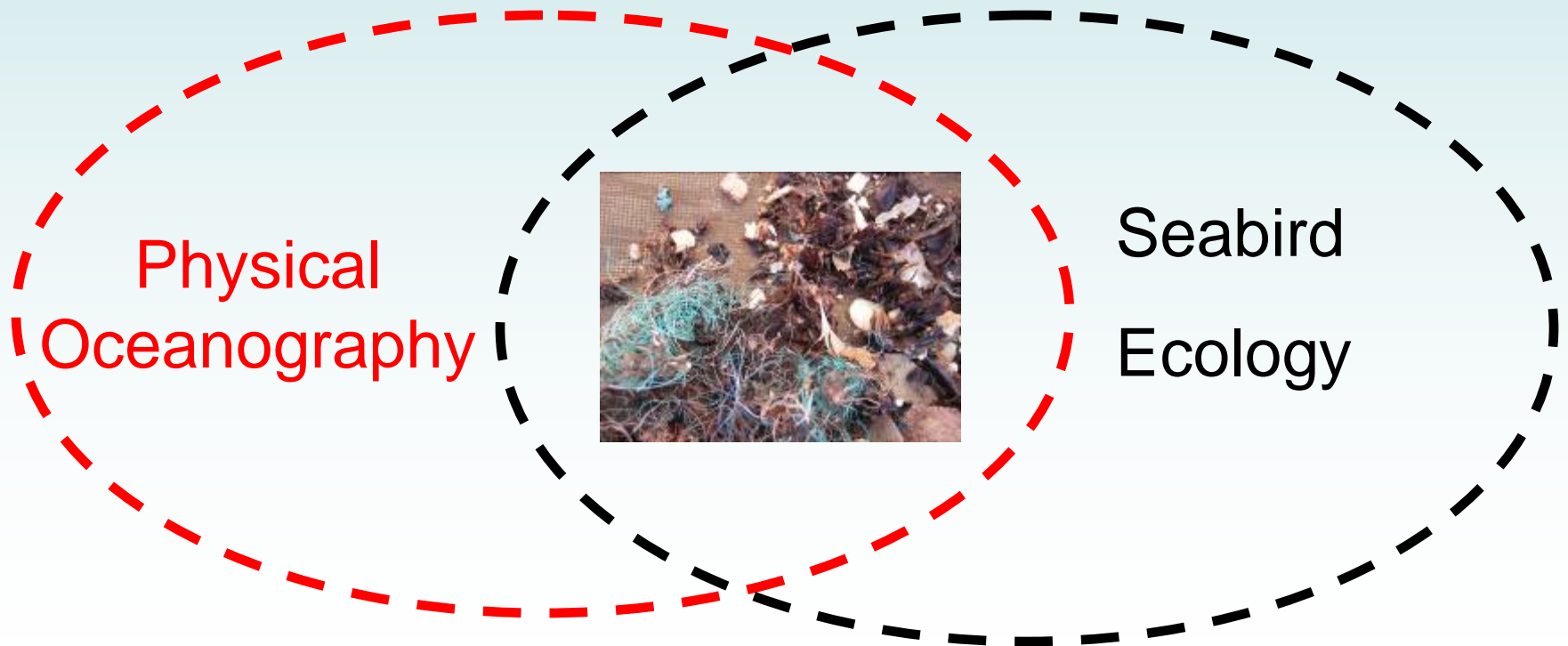
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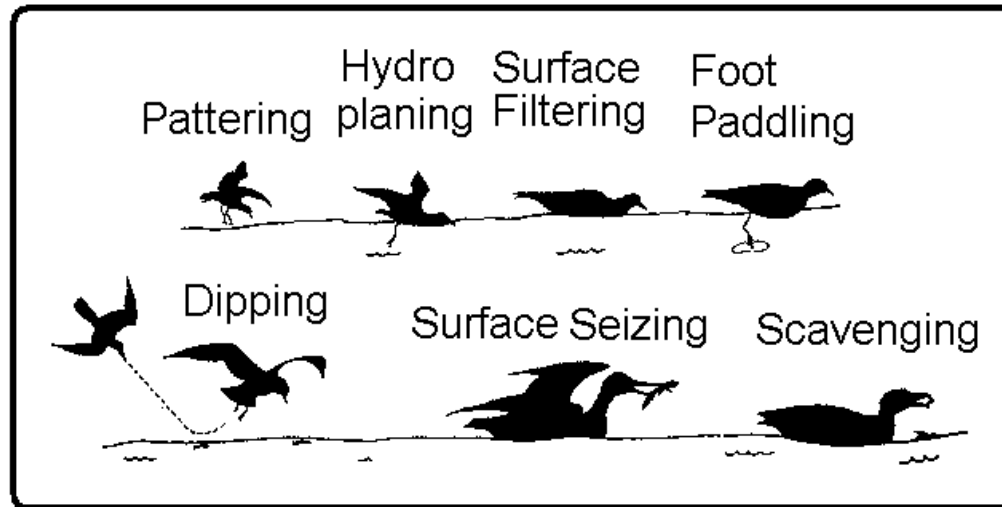
Photo: Michelle Hester

Seabirds as Indicators

Explore the use of seabirds as indicators of plastic in the marine environment

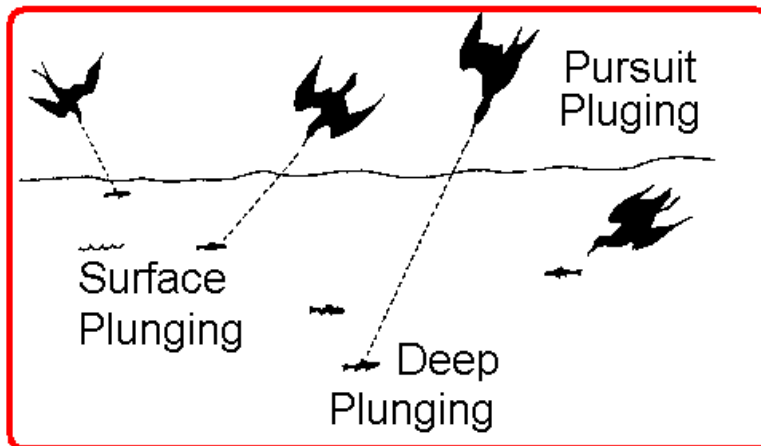


I. Feeding Mode - Guilds

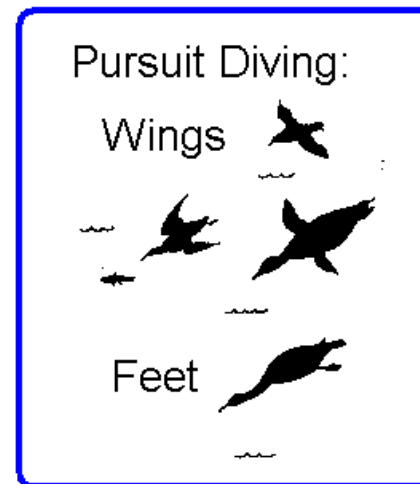


SURFACE FORAGERS

PLUNGERS



DIVERS



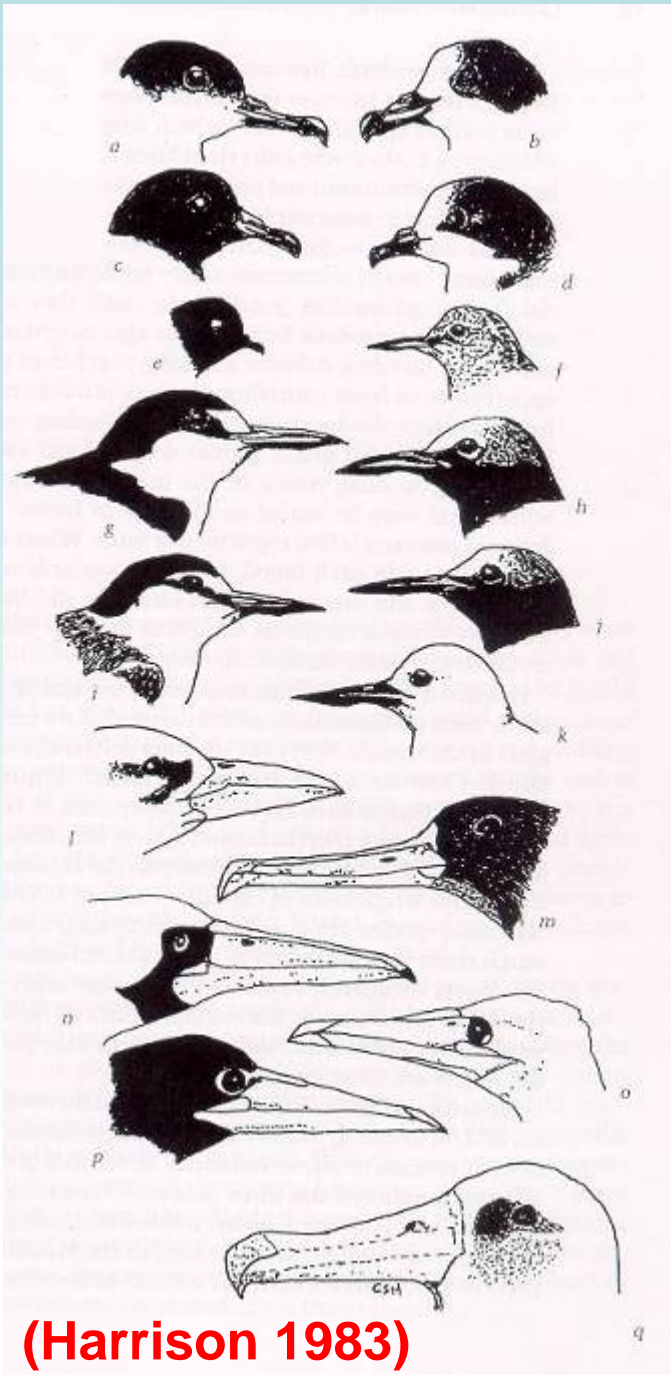
(Ashmole 1971)

II. Body Size

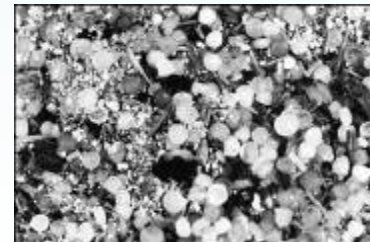
➤ Bigger birds
(with larger bills)
ingest larger items

2 - 4 mm (Shearwaters)

20 - 100 mm (Albatrosses)



(Harrison 1983)



(Fry 1987, Robards et al. 1995, Kinan 2000)

III. Distributions

Laysan albatross forage in subarctic waters, to the north

Black-footed albatross focus on subtropical waters, south

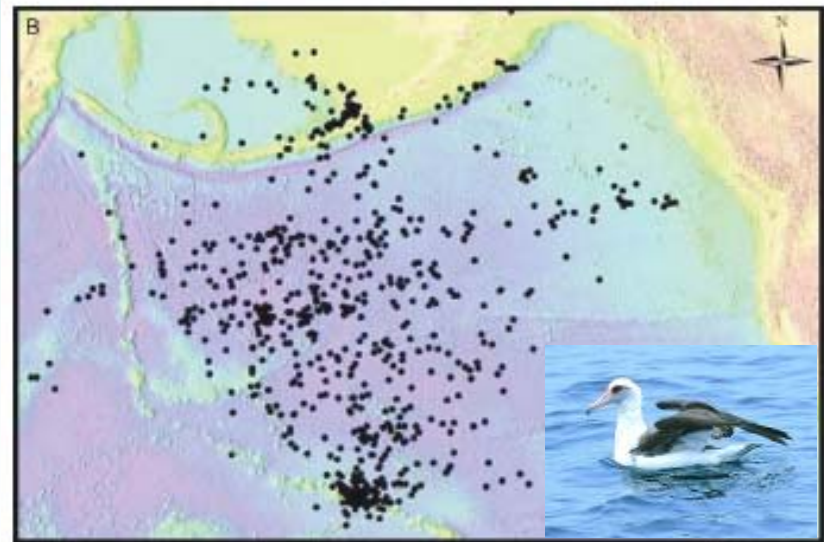
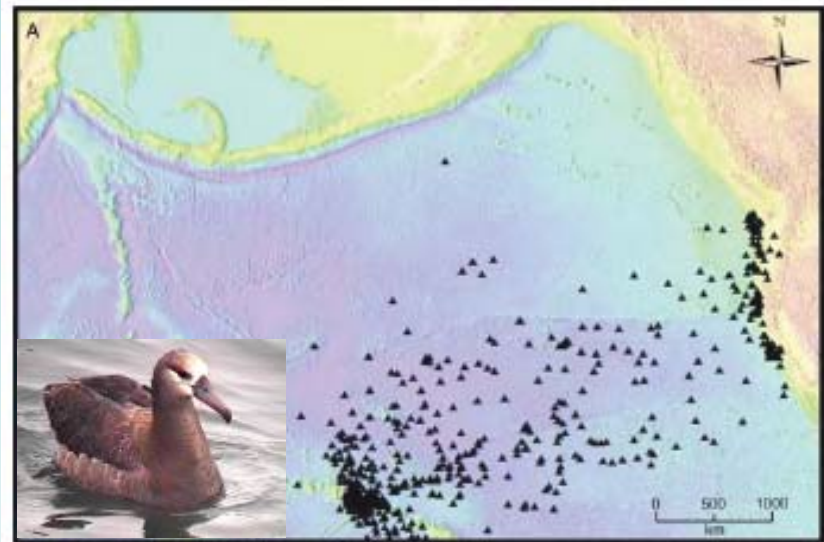
(Hyrenbach et al. 2002)

Regional differences affect pollutant loads (PCBs, DDE)

(Finkelstein et al. 2006)

Debris 10 times more abundant in subtropical region than in subarctic; 100 - 1000 times less abundant in Bering Sea

(Day & Shaw 1987)



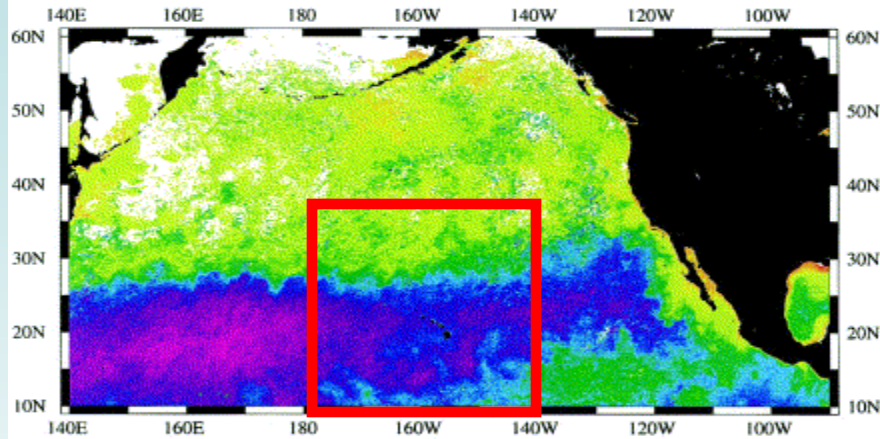
Maps: Finkelstein et al. 2006

IV. Foraging Habitats

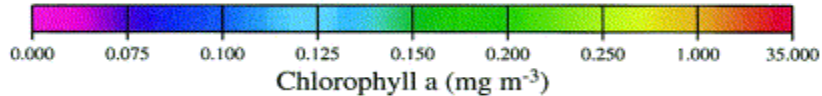
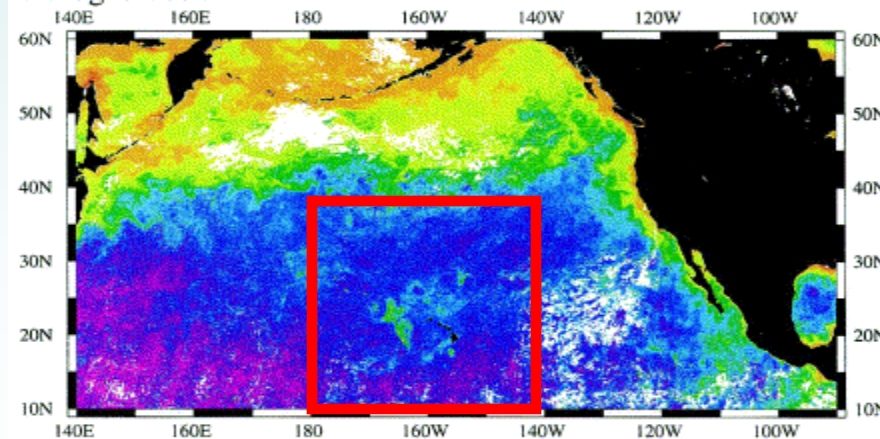
North Pacific Transition Front
(Polovina et al. 2001)

TOPEX Altimetry
(<http://argo.colorado.edu>)

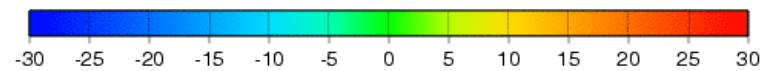
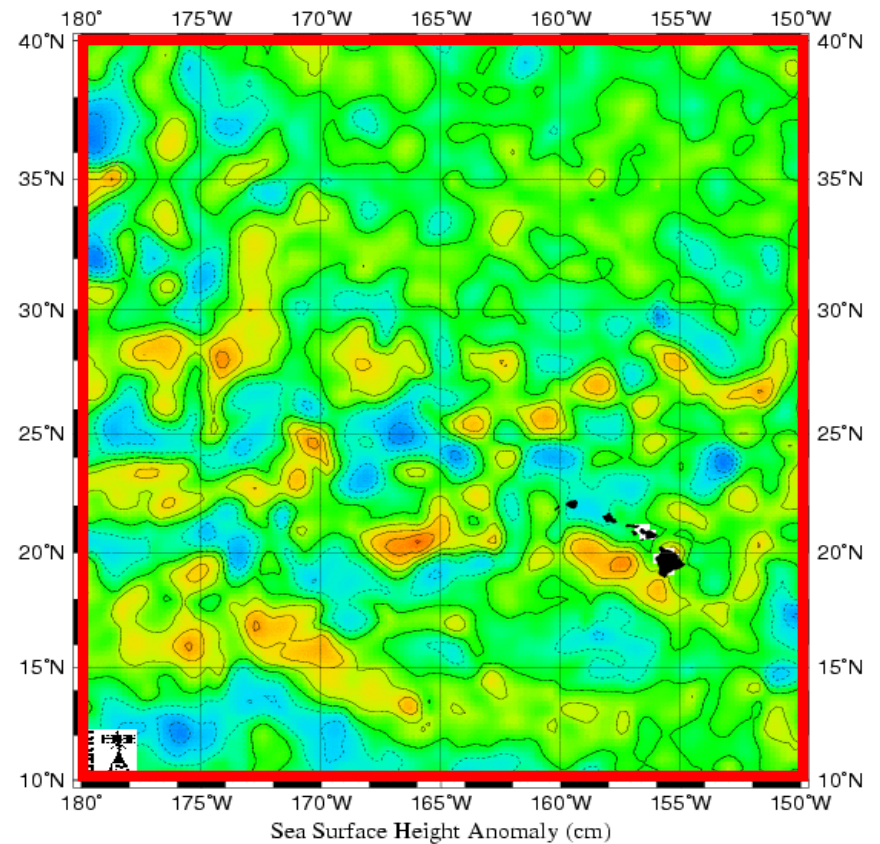
A. February 1998



B. August 1998



Historical Mesoscale Altimetry - Feb 15, 1998



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- Objectives:
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 - Stomach Contents
 - At-sea Distributions
- Summary



Photo: Michelle Hester

Perspective I: Stomach Contents

Goal: To document trends in pelagic plastic debris using northern fulmars

- Two sources of specimen samples:
 - Beach-cast Birds
 - Fisheries Bycatch
- Standardized data analysis methods:
 - Bird Condition
 - Marine Debris



Map: Hannah Nevins

Wide-Ranging Species: Regional Comparisons

Pacific Ocean: Stomach contents of dead fulmars collected in California during winter of 2003. Nevins, Moss Landing Marine Labs

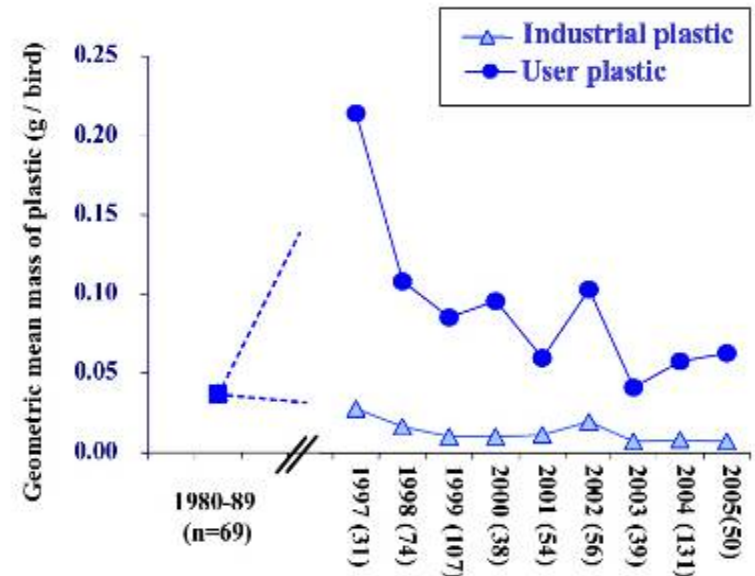
- 71% of fulmars collected in 2003 contained plastic

Atlantic Ocean / North Sea: New Scientist (8 January 2005) Van Franeker, Alterra Marine Lab, Texel, Holland

- 95% of fulmars washed up in North Sea contain plastic



Source: H. Nevins BeachCOMBERS



(Van Franeker & Meijboom, 2007)

Hawaiian Albatross: Ideal Samplers

- Map Foraging Locations / Enumerate Plastics
- Multiple Breeding Sites

Kure Atoll (Kinan 2000)

- Analyzed 144 boluses - Laysan / Black-footed albatross
- Plastic in every one (100%) ~ 60% of bolus weight



Photo: Michelle Hester



Photo: Cynthia Vanderlip

Perspective II: Research Cruises

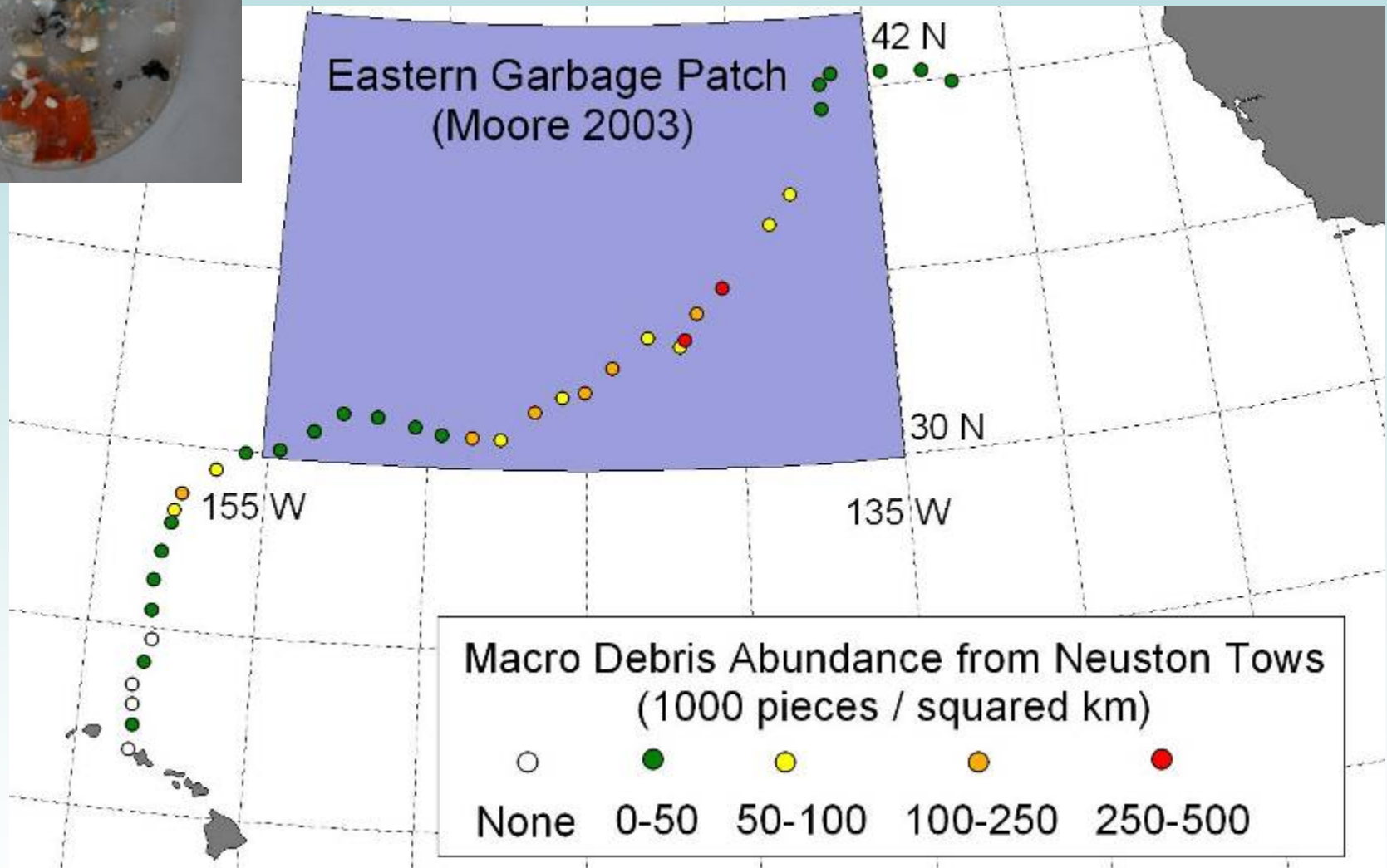


Goal:

To document concurrent seabird and marine debris distributions between Oahu and San Francisco (June 21 - July 19, 2008)

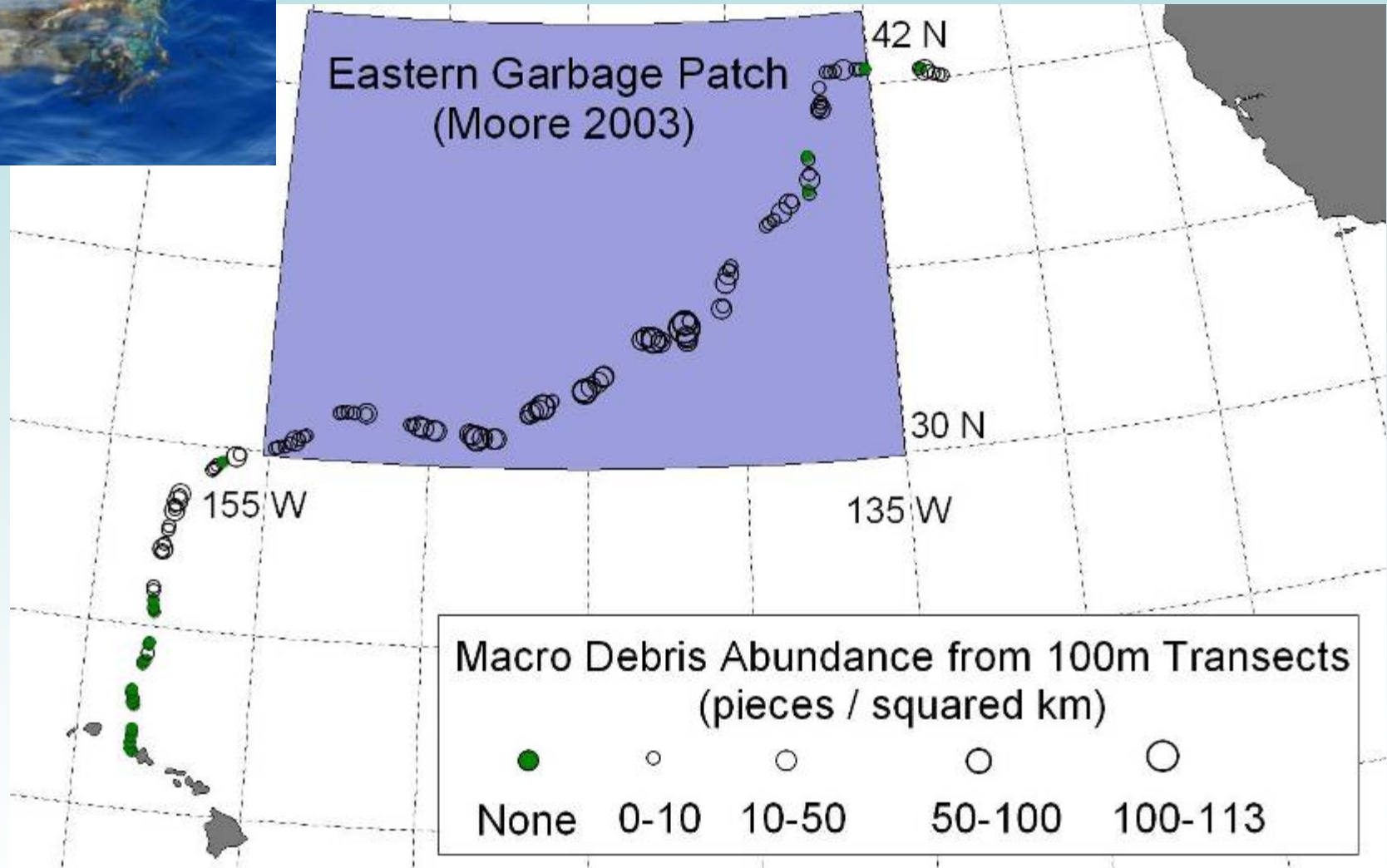
Photos: David Hyrenbach

Net Tows - Marine Debris



39 net tows: 4036 plastic fragments

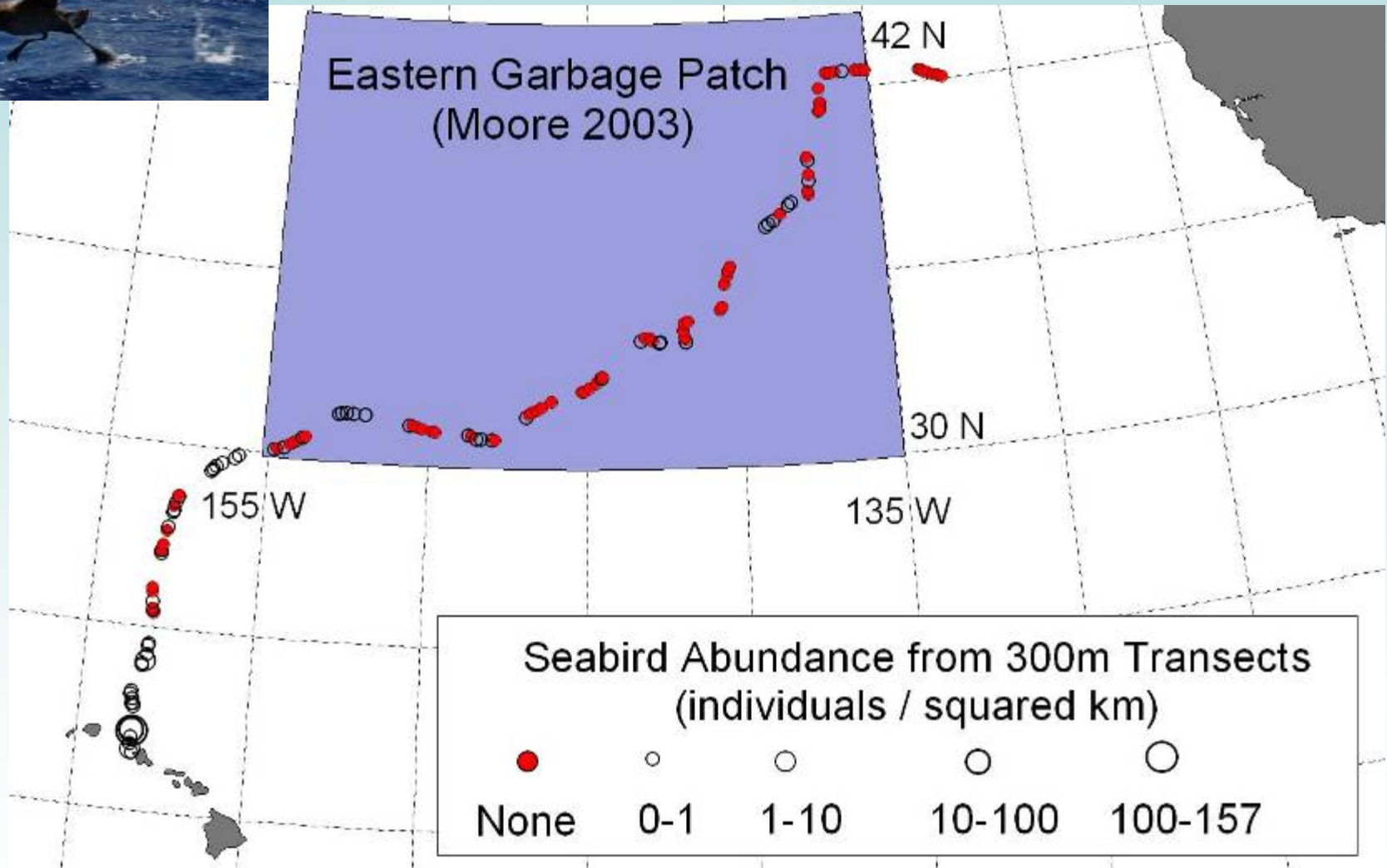
Visual Surveys - Marine Debris



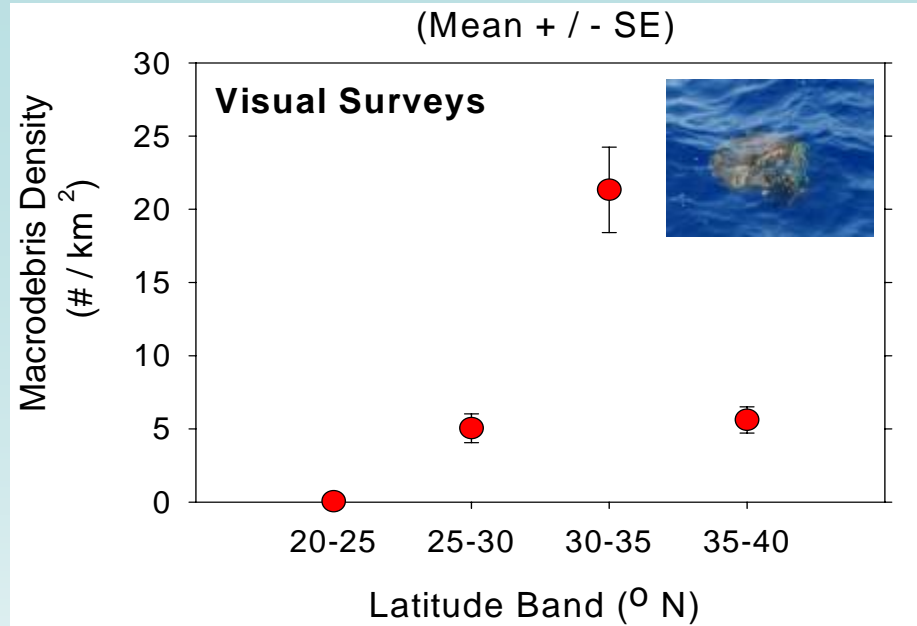
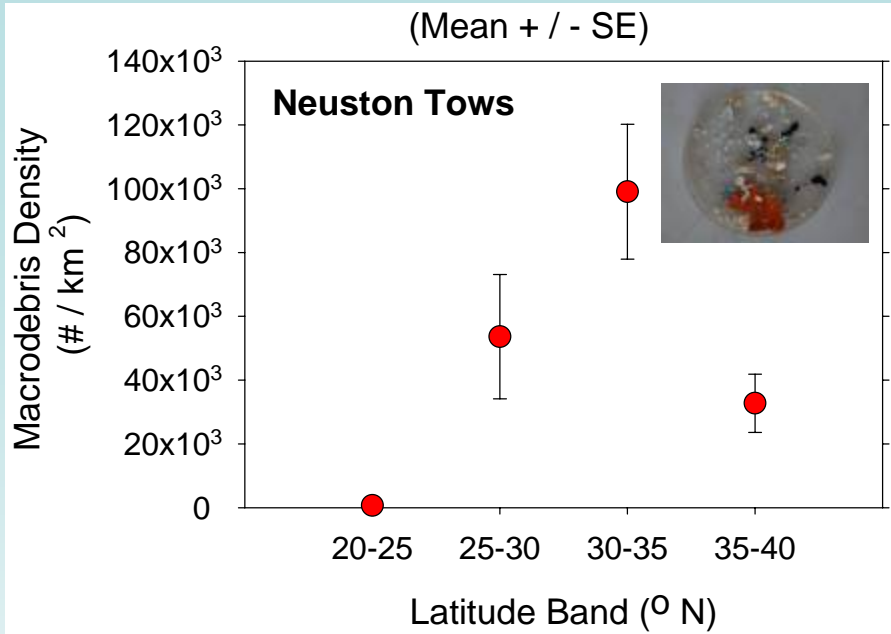
130 transects: 1259 pieces of marine debris



Visual Surveys - Seabirds



130 transects: 173 sightings, 840 individuals



SEABIRDS

Wedge-tailed Shearwater

Sooty Tern

Murphy's Petrel

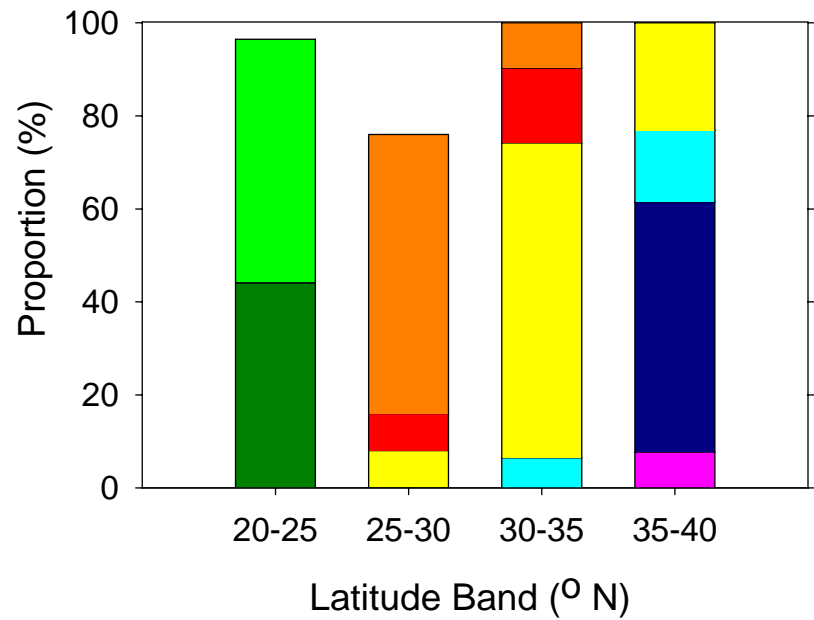
Red-tailed Tropicbird

Black-footed Albatross

Cook's Petrel

Leach's Storm-Petrel

Flesh-footed Shearwater



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Peter Hodum

Seabirds As Biological Samplers of Plastic Pollution



- Many seabirds ingest and feed plastic debris to their young
- Incidence / loads vary across species / geographic areas
 - Surface foragers more susceptible to ingestion
 - Larger birds take larger pieces
- Opportunity: Time Series
- Challenge: Interpretation

Photos: Michelle Hester



Acknowledgements

- **Funding:** National Fish & Wildlife Foundation marine debris program, Moss Landing Marine Laboratories, California Coastal Commission, Cordell Bank National Marine Sanctuary, Hawaii Pacific University, Oikonos - Ecosystem Knowledge
- **Data:** Beach COMBERS, provided unpublished beach deposition and plastic ingestion data
- **Photos:** Cynthia Vanderlip, Irene Kinan, Michelle Hester, USGS, Oikonos - Ecosystem Knowledge



Questions ?



Thank You

Photo: David Hyrenbach