Marine Population Ecology & Dynamics

15 OCTOBER 2021

Today

Mish-mash lecture
- Populations
- Tools for understanding patterns and processes
- Scaling up
- Citizen science

Group 1 paper discussion
- Location: Rix? Library? Outside?

Field trip to Scotts Bay
- Please gather your equipment and meet at the dock ready to get in a boat at 2pm

Office hour poll- when is good this weekend, long term?
- Cole will send out a slack message

What is a species?

- **Biological Species:** Members of actually or potentially interbreeding populations, which are reproductively isolated

- **Morphological species:** Characterized by structural features. Most useful when information on gene flow is unknown

- **Ecological species:** A set of organisms adapted to a particular niche in the environment

What is a population?

- **Population** is defined as a group of individuals of the same species living and interbreeding within a given area

- **Area** is often a subjectively designated geographic range
  - Global vs local

Scientists study a population by examining how individuals in that population interact with each other and how the population interacts with its environment.

Demographic parameters

- Population size
- Density
- Age structure
- Fecundity (birth rate)
- Mortality (death rates)
- Sex ratio
- Immigration and emmigration

Population vs community ecology

Population ecology is the study of populations; specifically, how populations change over time and what factors contribute to that change.

Community ecology is the study of communities; specifically, the organization, function, and **interactions** between species within a community.

Patterns are easy to see

- Visually, the patterns are at a scale very recognizable to the human eye
- Things happen at a visible temporal scale
  - 1 visit
  - Within a lifetime

Processes are "easily" testable

- Actual "size" of the system is quite small
- Count individuals at almost every level in the ecosystem

What happens when we don’t want to or can’t use the intertidal as a proxy?

Species of interest like a whale might not fit the intertidal dynamics
Intertidal is really affected by abiotic factors –extremes
Lots of change- tidal cycle not the same as other places
Wild fire and drought are not easily replicable in the intertidal

How do we scale up?

How do we scale up?

If we want to scale up, we need to be able to survey/monitor/count our population in a way that is meaningful so that we can continue to think about patterns and processes

Macrosystems ecology: understanding ecological patterns and processes at continental scales

James B Heffernan[1*†], Patricia A Soranno[2†], Michael J Angilletta Jr[3], Lauren B Buckley[4], Daniel S Gruner[5], Tim H Keitt[6], James R Kellner[7], John S Kominoski[8], Adrian V Rocha[9], Jingfeng Xiao[10], Tamara K Harms[11], Simon J Goring[13], Lauren E Koenig[10], William H McDowell[10], Heather Powell[13], Andrew D Richardson[14], Craig A Stow[15], Rodrigo Vargas[16], and Kathleen C Weathers[17]

Macrosystems ecology is the study of diverse ecological phenomena at the scale of regions to continents and their interactions with phenomena at other scales. This emerging subdiscipline addresses ecological questions and environmental problems at these broad scales. Here, we describe this new field, show how it relates to modern ecological study, and highlight opportunities that stem from taking a macrosystems perspective. We present a hierarchical framework for investigating macrosystems at any level of ecological organization and in relation to broader and finer scales. Building on well-established theory and concepts from other subdisciplines of ecology, we identify feedbacks, linkages among distant regions, and interactions that cross scales of space and time as the most likely sources of unexpected and novel behaviors in macrosystems. We present three examples that highlight the importance of this multiscaled systems perspective for understanding the ecology of regions to continents.

Front Ecol Environ 2014; 12(1): 5–14, doi:10.1890/130017

In this paper, we present a conceptual framework for investigating ecological patterns and processes at regional to continental scales. Ecological phenomena operate across a range of scales (Figure 1), but the development of ecological theory of regions to continents lags behind that of finer scales. Better understanding of broad scales is needed because these are the extents over which many environmental problems have their causes and consequences. Our framework incorporates existing theories from other ecological subdisciplines and environmental disciplines, to promote broad-scale ecology as more general, integrative, and predictive.

We define "macroscales" as regional to continental extents with distances spanning hundreds to thousands of kilometers (ie larger than landscapes; Urban *et al.* 1987). "Components" at these spatial scales (Figure 2) are biological (eg species, populations, communities), geophysical (eg climate, physiography, hydrology, geochemistry), and social (eg political systems, economies, cultures), and can span timescales ranging from days to millennia. When interacting with one another and with phenomena at other spatial or temporal scales, these components constitute a "macrosystem"; macrosystems ecology (MSE) is the study of such extensive and multiscaled systems. This perspective treats patterns and processes as dynamic and interactive, both within and across scales of time and space.

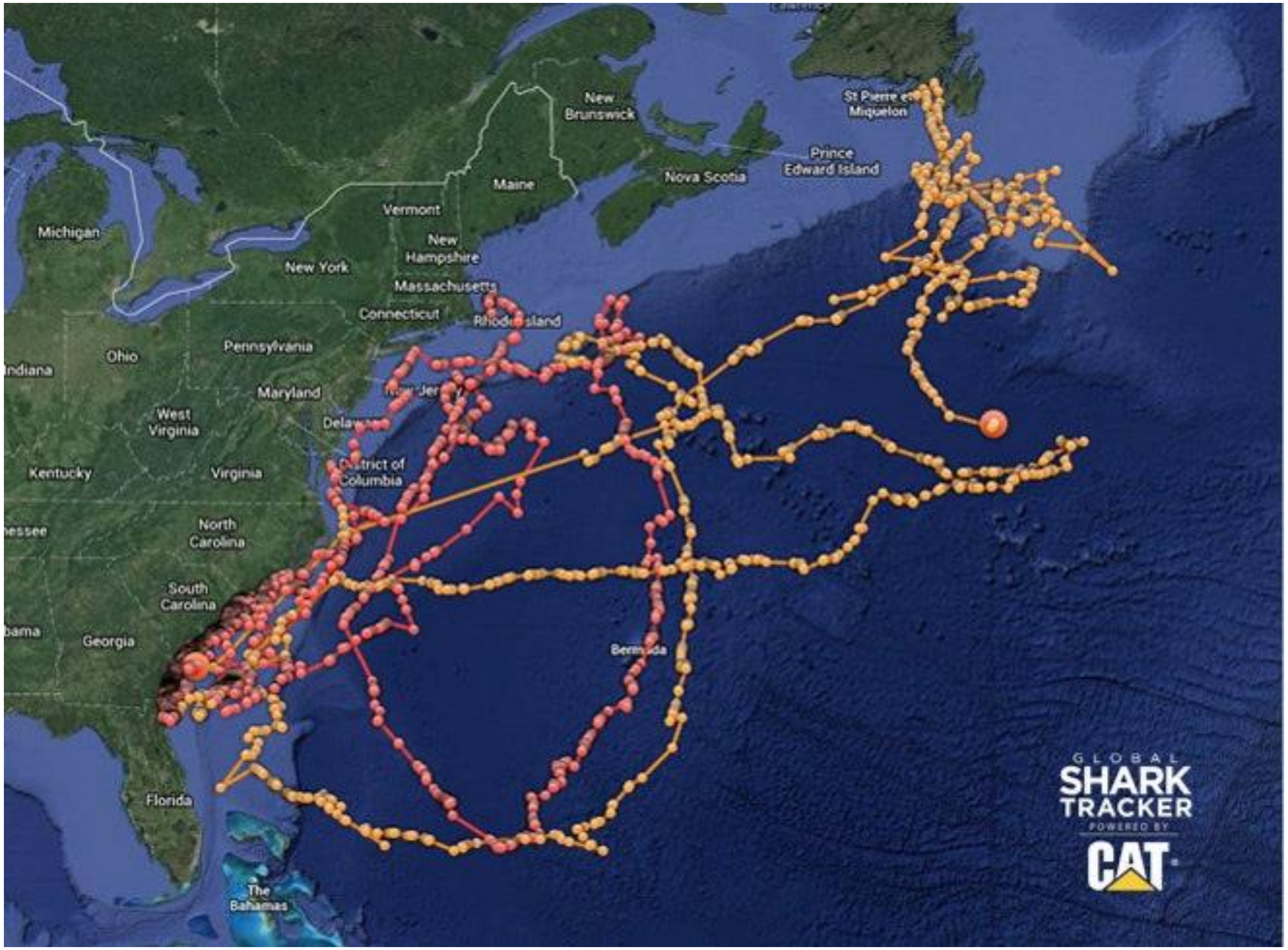
In a nutshell:

- Macrosystems ecology (MSE) treats the components of regions to continents as a set of interacting parts of a system
- Theory and concepts for macrosystems can come from a wide range of ecological subdisciplines and environmental disciplines

Motivations

The emergence of MSE has been driven by three main factors: pressing societal needs for ecological predictions at these wider scales; the increasing focus on mechanistic studies that cover broad extents across a range of ecologi-

Front Ecol Environ 2014; 12(1): 5–14, doi:10.1890/130017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Pennsylvania
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Maryland
West Virginia
Kentucky
Virginia
District of Columbia
North Carolina
South Carolina
Georgia
Florida
The Bahamas
GLOBAL
SHARK
TRACKER
POWERED BY
CAT

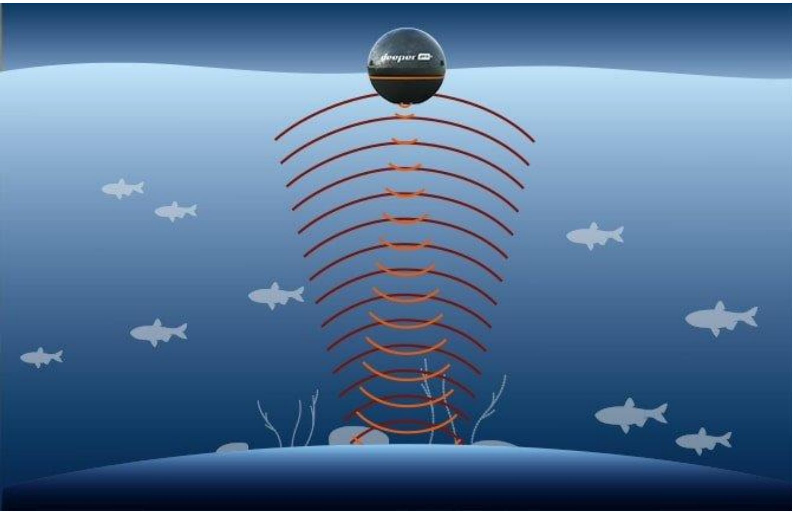
In the ocean especially we can use other proxies to help us “track” and estimate what we can’t see.

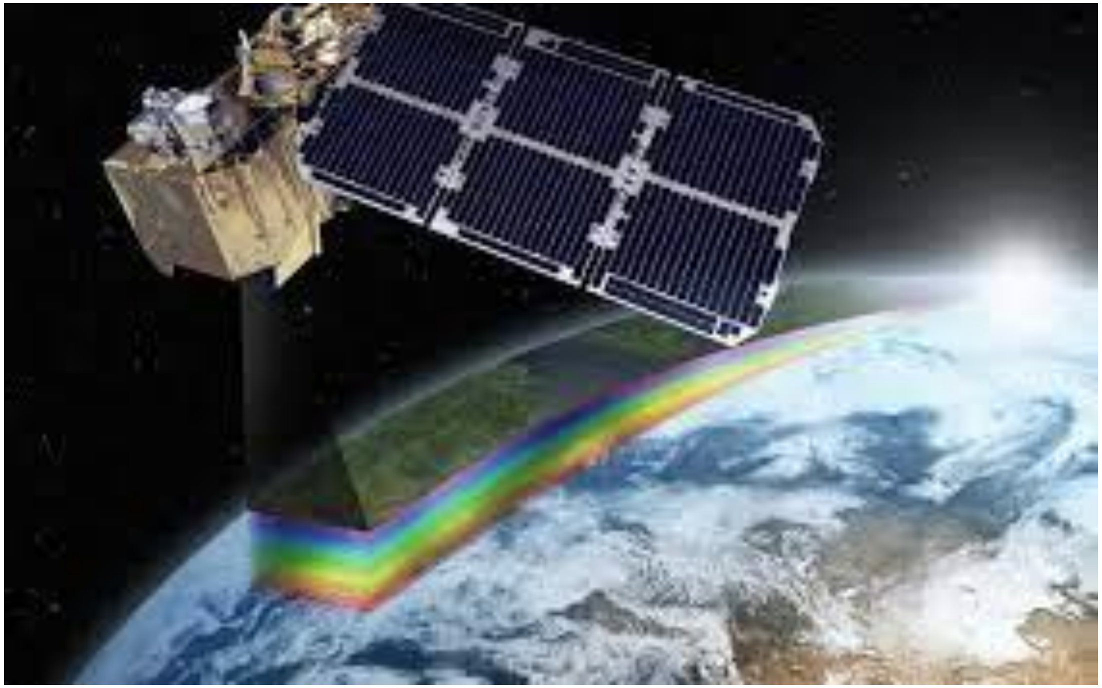
- Oceanographic currents
- SS temperatures
- Known habitat

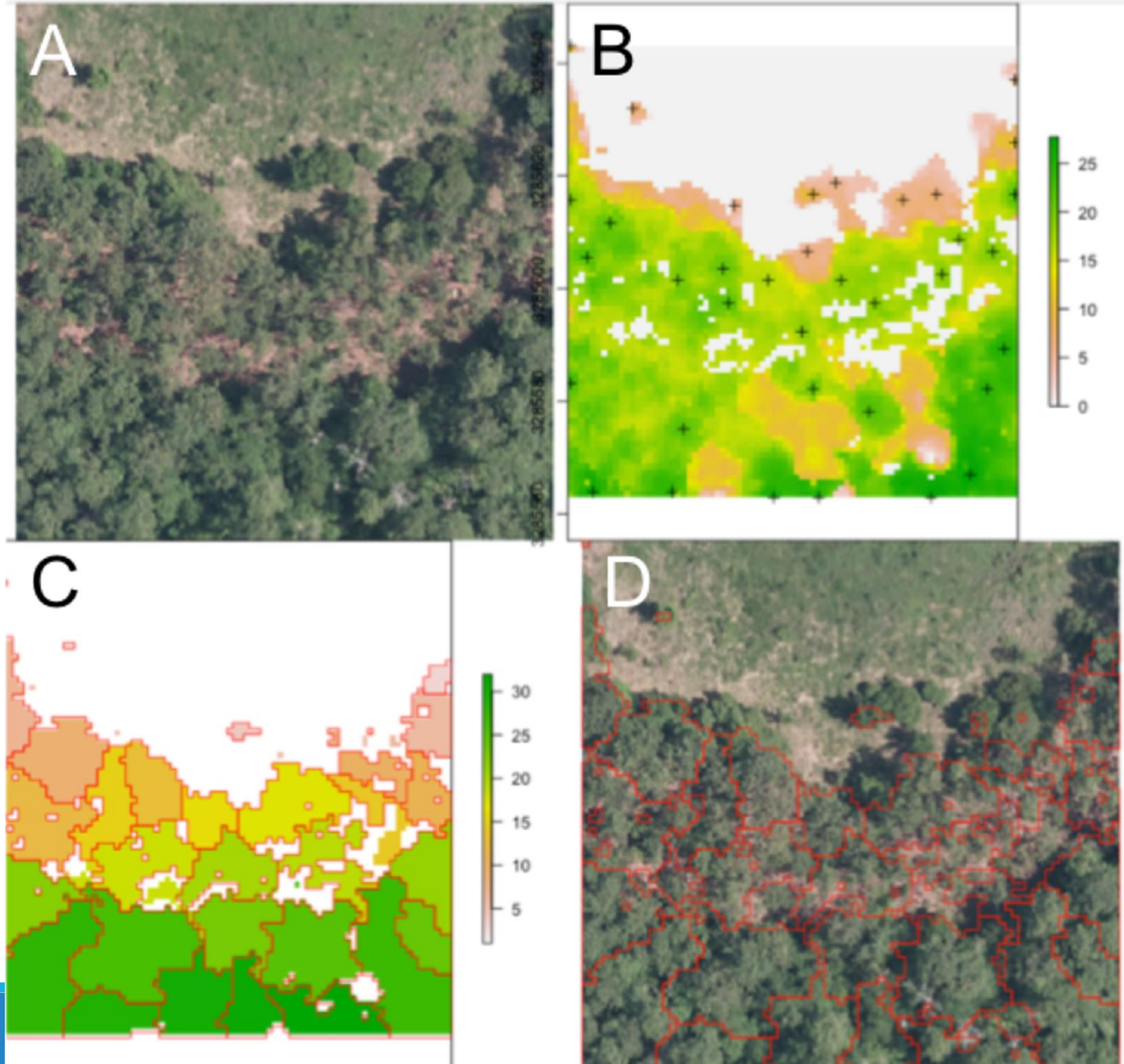
How do we do that sampling?

Remotely sensed data---

- Substrate
- Kelp beds
- Phytoplankton
- Jellyfish



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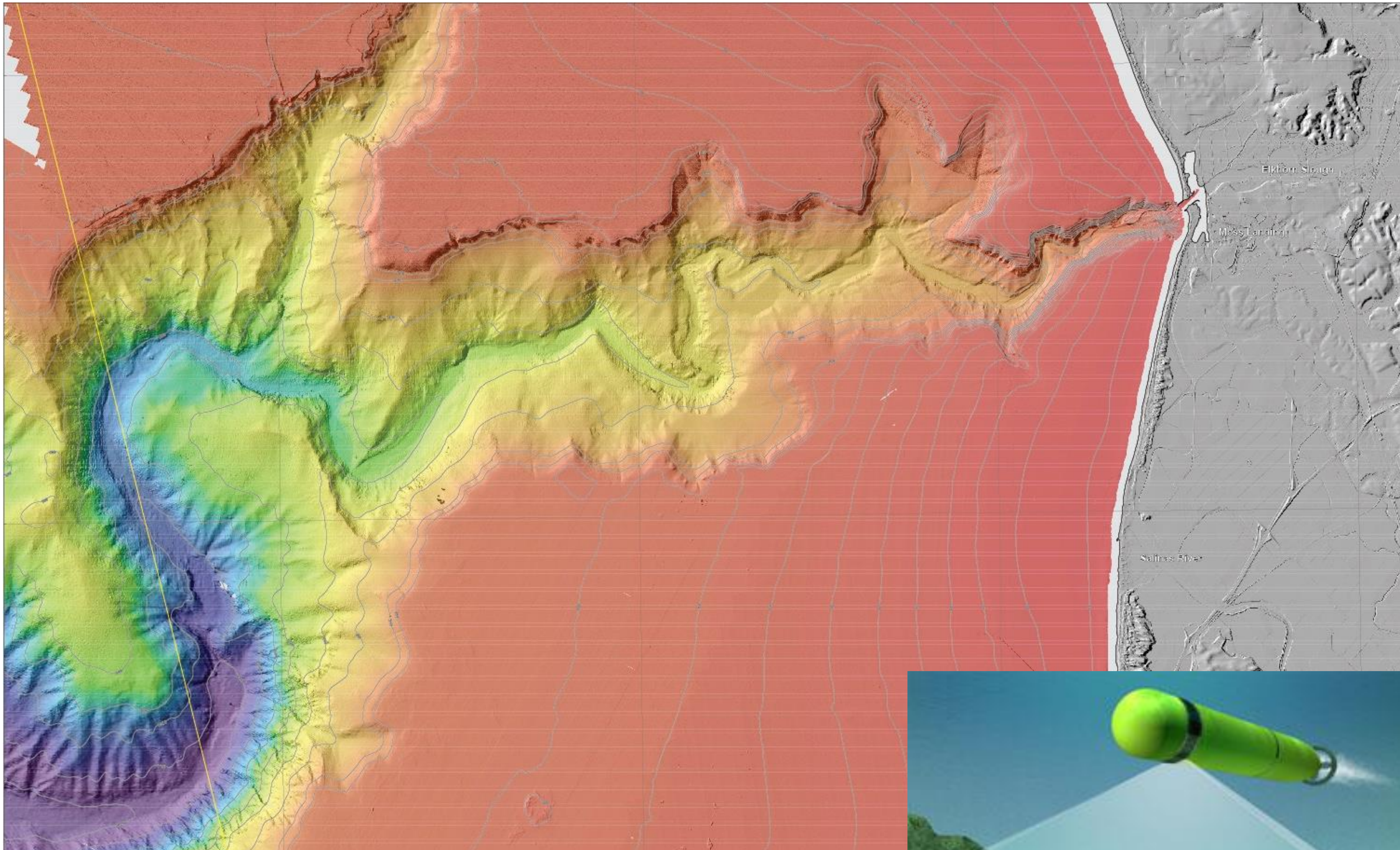
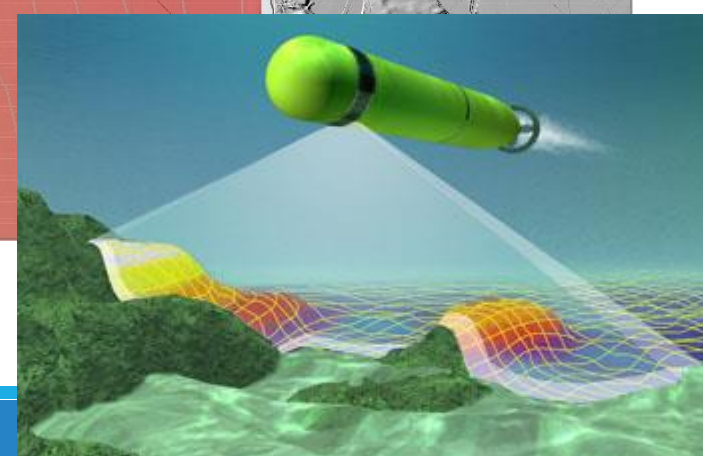
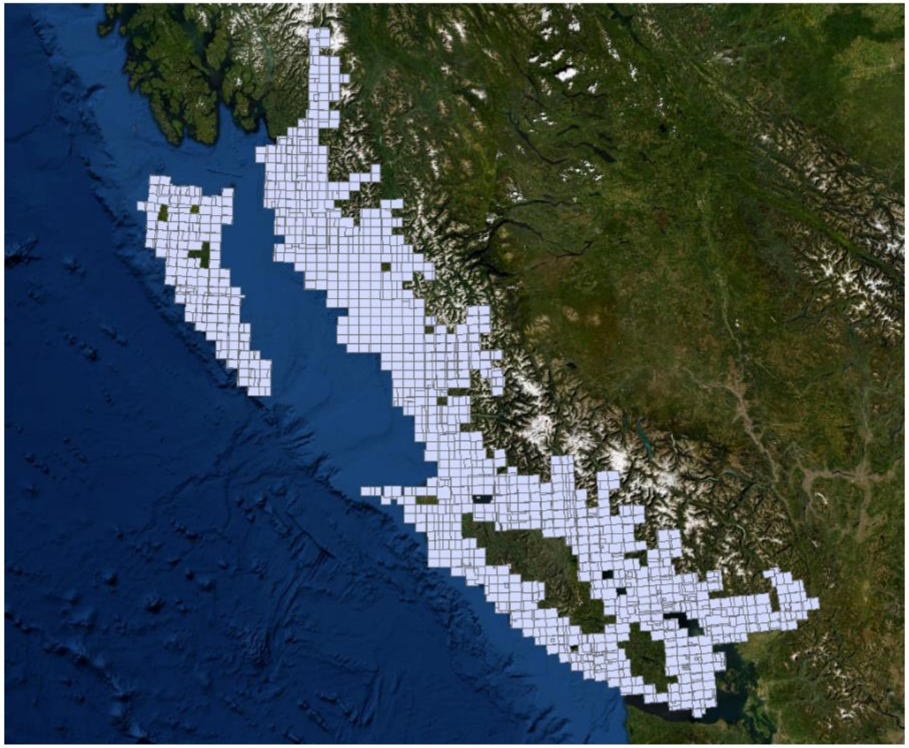

Elkhorn Slough
Moss Landing
Salinas River



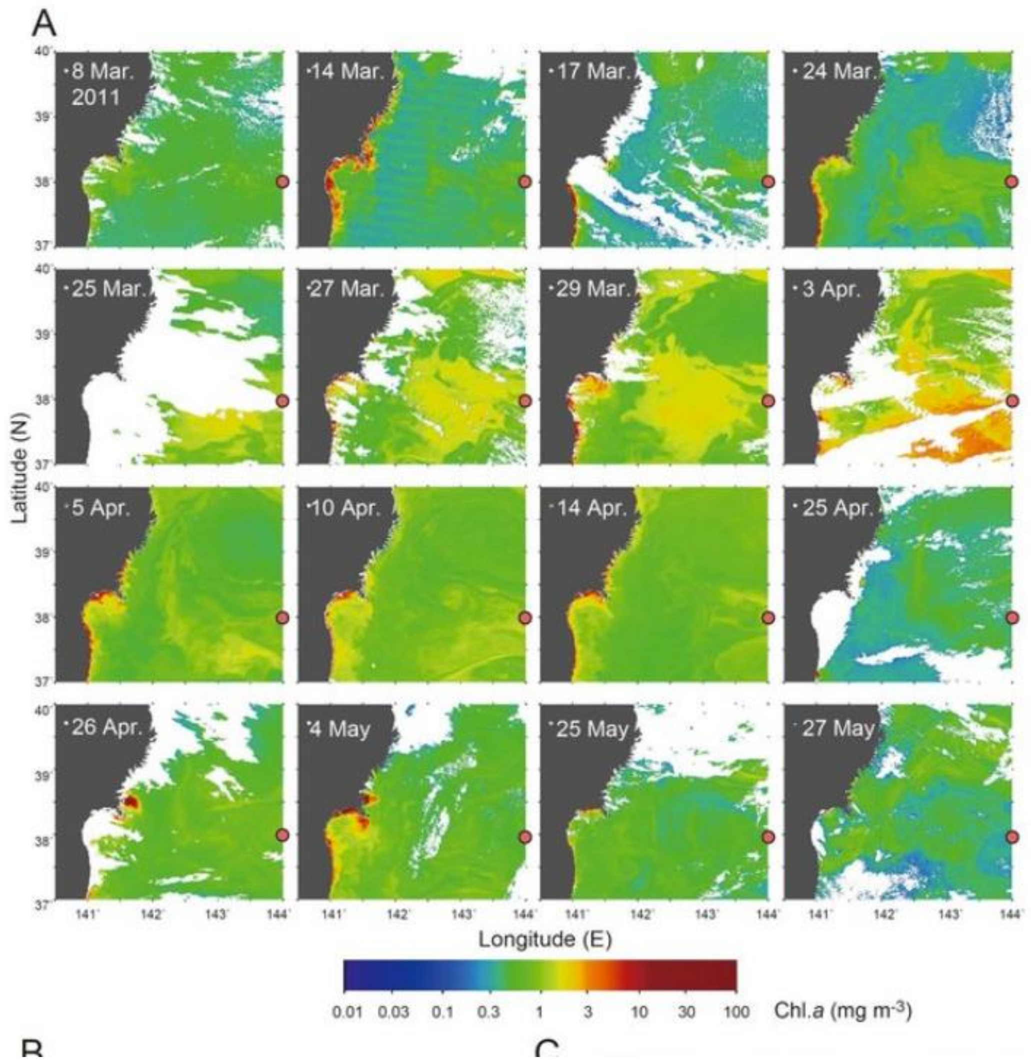
Spatial-Temporal Kelp Dynamics:

The SPECTRAL lab is engaged in multiple projects focusing on the use of remote sensing technologies to map kelp forests on the coast of British Columbia. With multiple scientific and community partners we hope to gain a better understanding of kelp distribution, dynamics and change by developing novel techniques for kelp detection and image analysis.

Spatial temporal kelp resilience on the BC coast



Coverage of Satellite Imagery on the BC Coast. (Canadian Hydrographic Service)



Figure

Caption

Figure 4 | Phytoplankton blooming indicated by remote sensing and phytodetritus from the sea bed in Japan Trench on June 2011. (A): The Chlorophyll a concentration images taken from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on board the Aqua satellite (courtesy of NASA, JAXA/EORC and Tokai University). … Read more

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RESEARCH ARTICLE

Jellyfish distribution in space and time predicts leatherback sea turtle hot spots in the Northwest Atlantic

Bethany Nordstrom, Michael C. James, Boris Worm

Published: May 14, 2020 • https://doi.org/10.1371/journal.pone.0232628

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Subject Areas

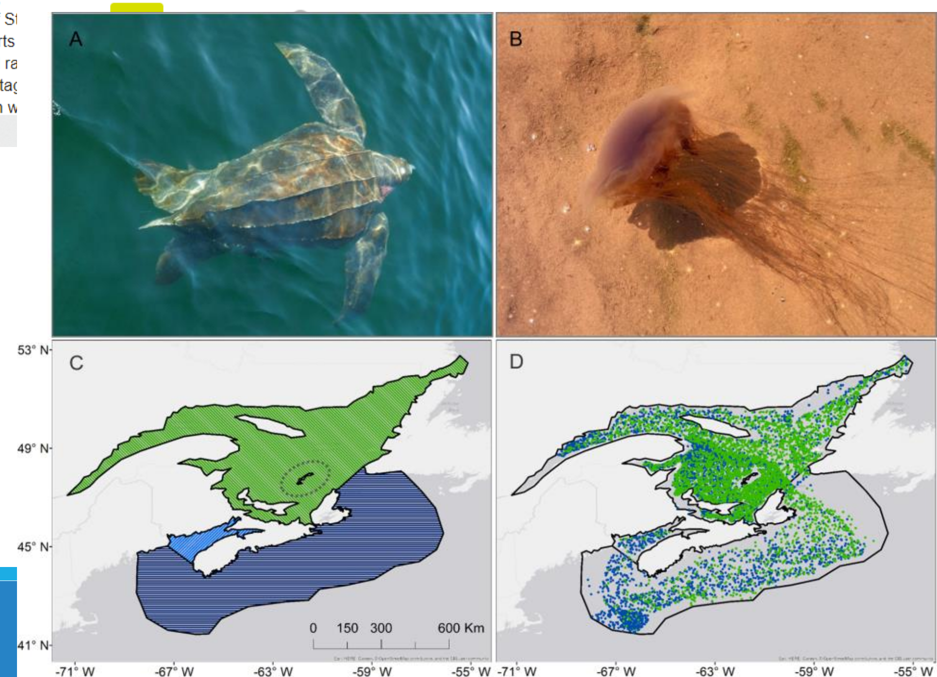
Jellyfish

Abstract
Introduction
Materials and methods
Results
Discussion
Supporting information
Acknowledgments
References
Reader Comments (0)

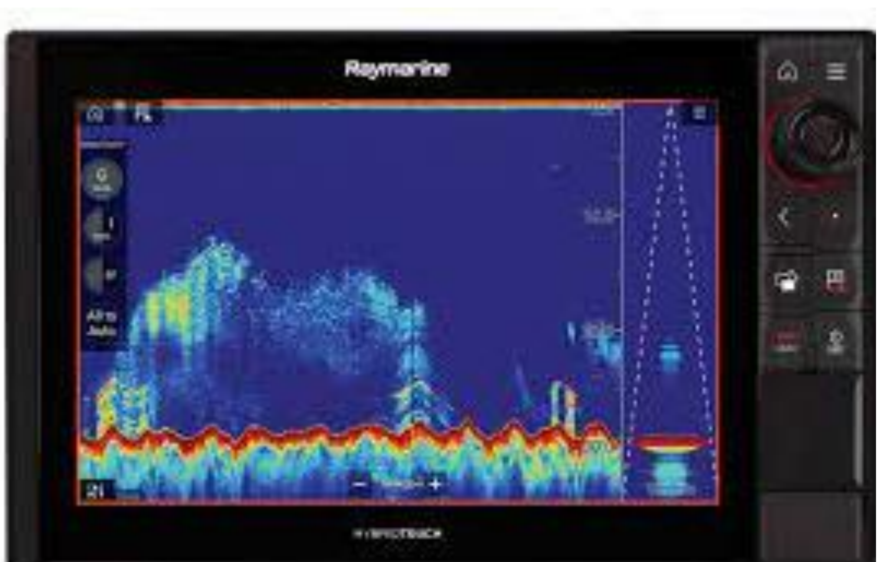
Abstract

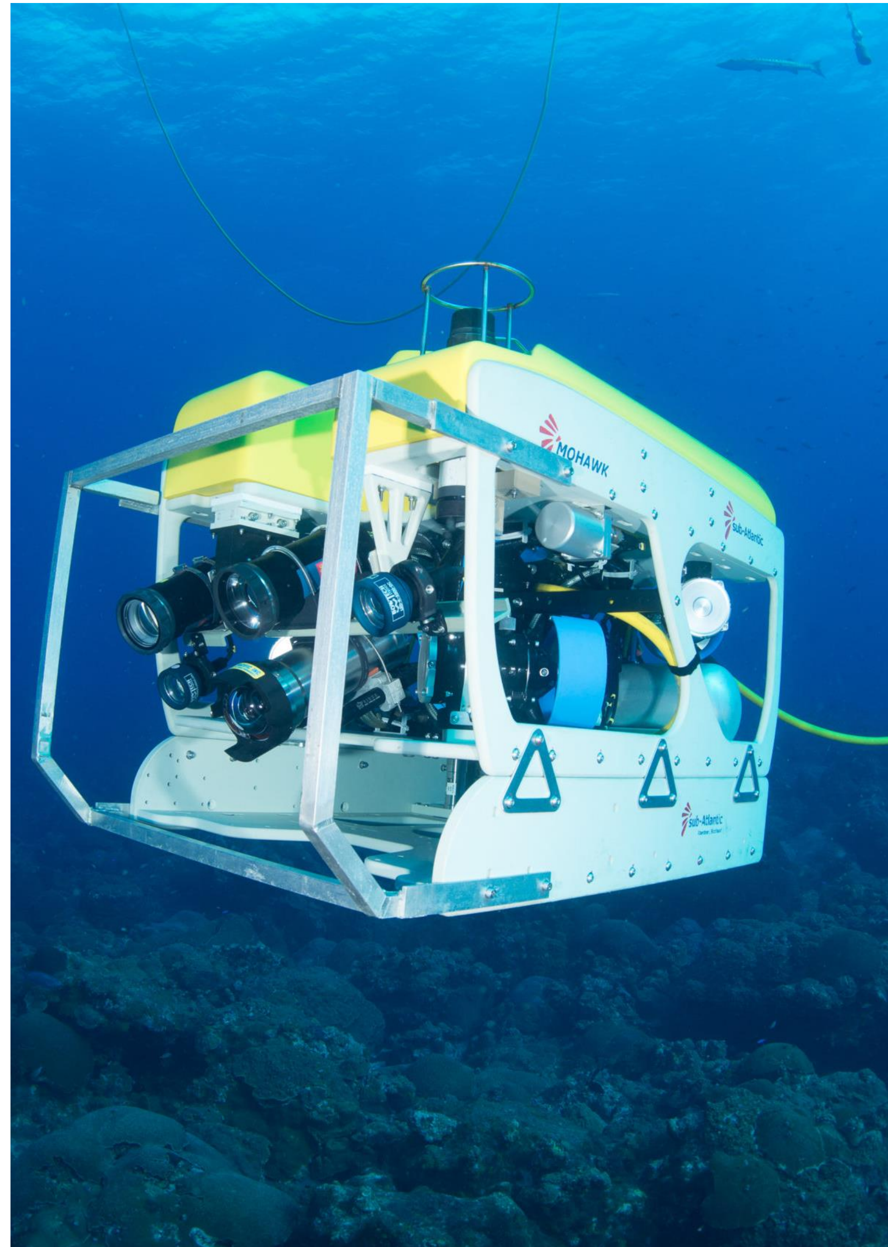
Leatherback sea turtles (*Dermochelys coriacea*) migrate to temperate Canadian Atlantic waters to feed on gelatinous zooplankton ('jellyfish') every summer. However, the spatio-temporal connection between predator foraging and prey-field dynamics has not been studied at the large scales over which these migratory animals occur. We use 8903 tows of groundfish survey jellyfish bycatch data between 2006–2017 to reveal spatial jellyfish hot spots, and matched these data to satellite-telemetry leatherback data over time and space. We found highly significant overlap of jellyfish and leatherback distribution on the Scotian Shelf (r = 0.89), moderately strong correlations of jellyfish and leatherback spatial hot spots in the Gulf of St Lawrence (r = 0.59), and strong correlations in the Bay of Fundy (r = 0.74), which supports much lower jellyfish density. Over time, jellyfish bycatch data revealed a slight northward ra shift in the Gulf of St. Lawrence, consistent with gradual warming of these waters. Two-stag generalized linear modelling corroborated that sea surface temperature, year, and region w

rch



But what about marine species?


Raymarine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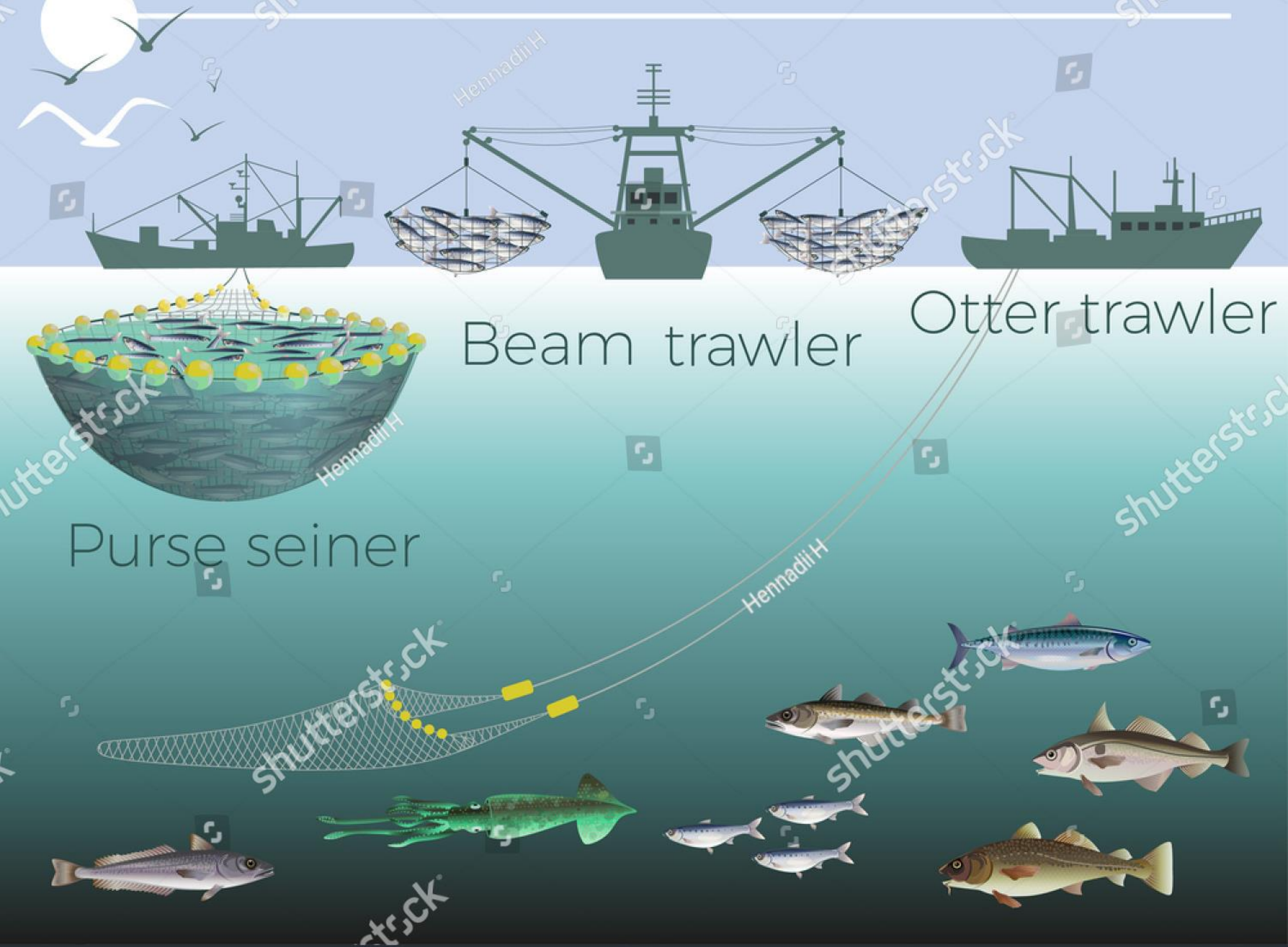
Beam trawler
Otter trawler
Purse seiner

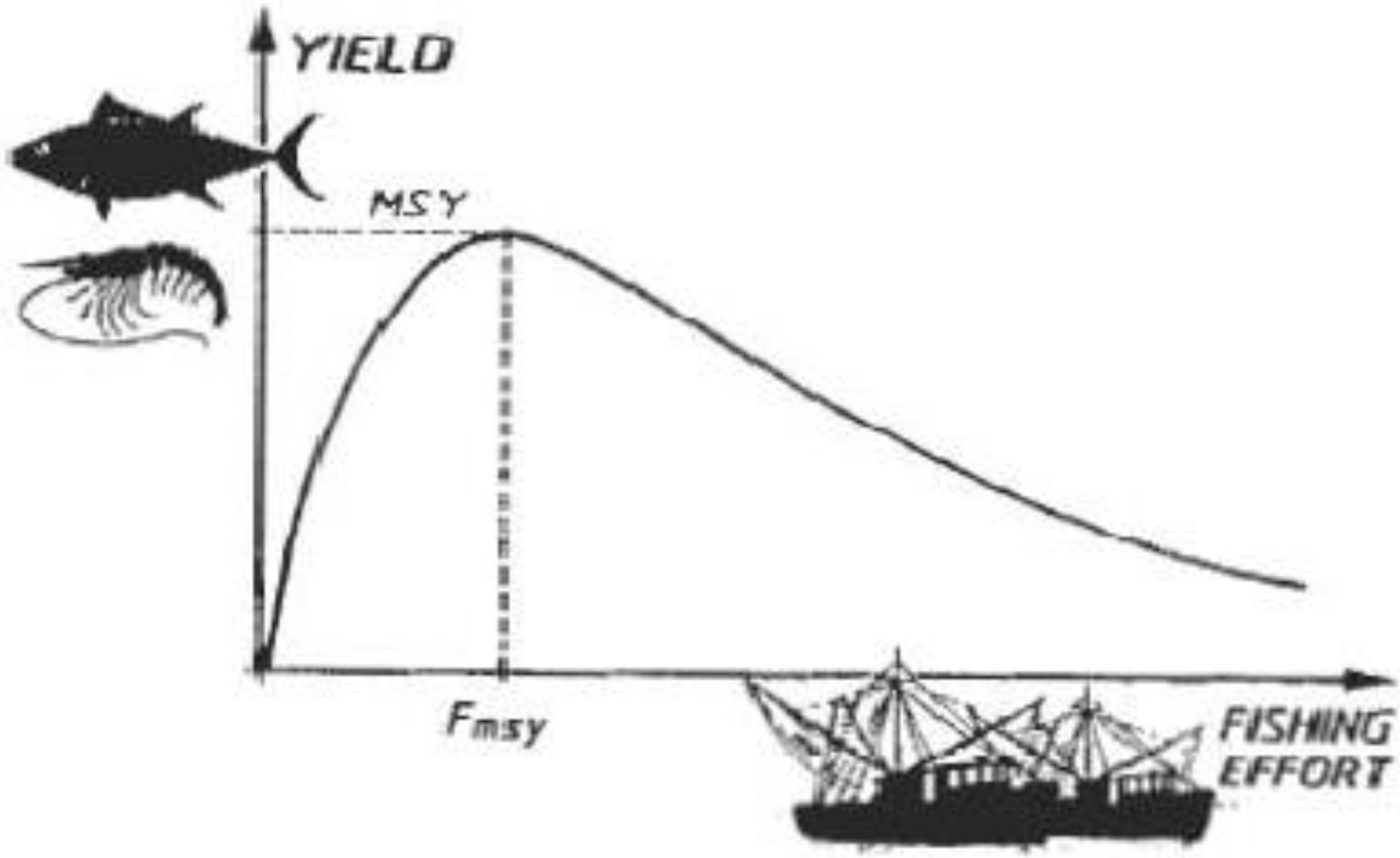

Figure 1.0: Fish Stock Assessment

Path-dependent institutions drive alternative stable states in conservation

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[a]Department of Ecology, Evolution, and Natural Resources, Rutgers University, New Brunswick, NJ 08901; [b]Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ 08544-1003; and [c]School of Forestry and Environmental Studies, Yale University, New Haven, CT 06460

Edited by Pablo A. Marquet, Pontificia Universidad del Chile, Santiago, Chile, and accepted by Editorial Board Member B. L. Turner November 19, 2018 (received for review May 8, 2018)

Understanding why some renewable resources are overharvested while others are conserved remains an important challenge. Most explanations focus on institutional or ecological differences among resources. Here, we provide theoretical and empirical evidence that conservation and overharvest can be alternative stable states within the same exclusive-resource management system because of path-dependent processes, including slow institutional adaptation. Surprisingly, this theory predicts that the alternative states of strong conservation or overharvest are most likely for resources that were previously thought to be easily conserved under optimal management or even open access. Quantitative analyses of harvest rates from 217 intensely managed fisheries supports the predictions. Fisheries' harvest rates also showed transient dynamics characteristic of path dependence, as well as convergence to the alternative stable state after unexpected transitions. This statistical evidence for path dependence differs from previous empirical support that was tests designed for multisolution models, quantifies how history can sway societies toward or away from resource conservation.

Results

We explain patterns of resource harvest rate based on the idea that institutions maximize rent (net benefit function u) (19). Rent is to society, which includes fishers and managers. We assume four features common to many institutions managing a renewable re-
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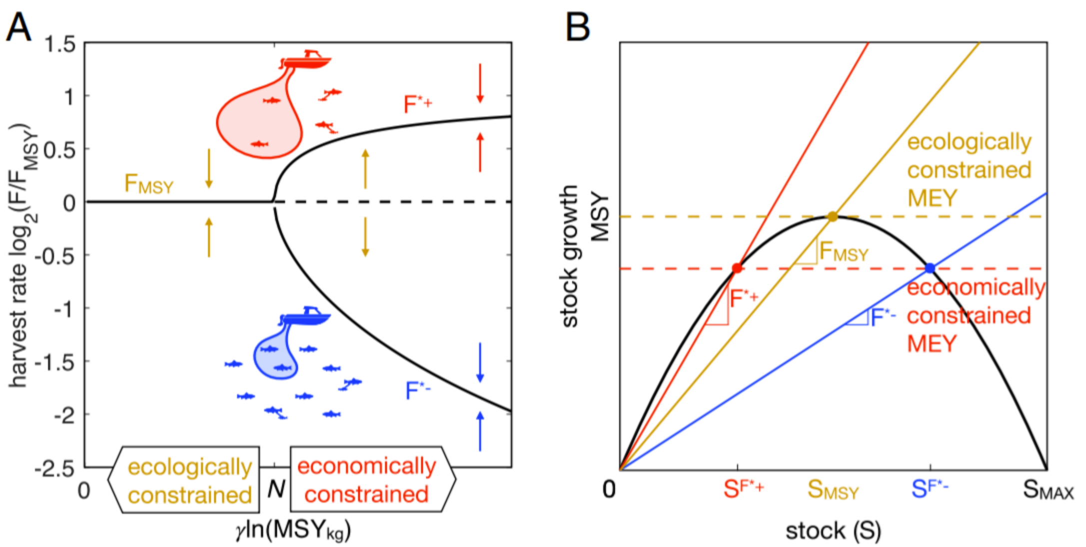
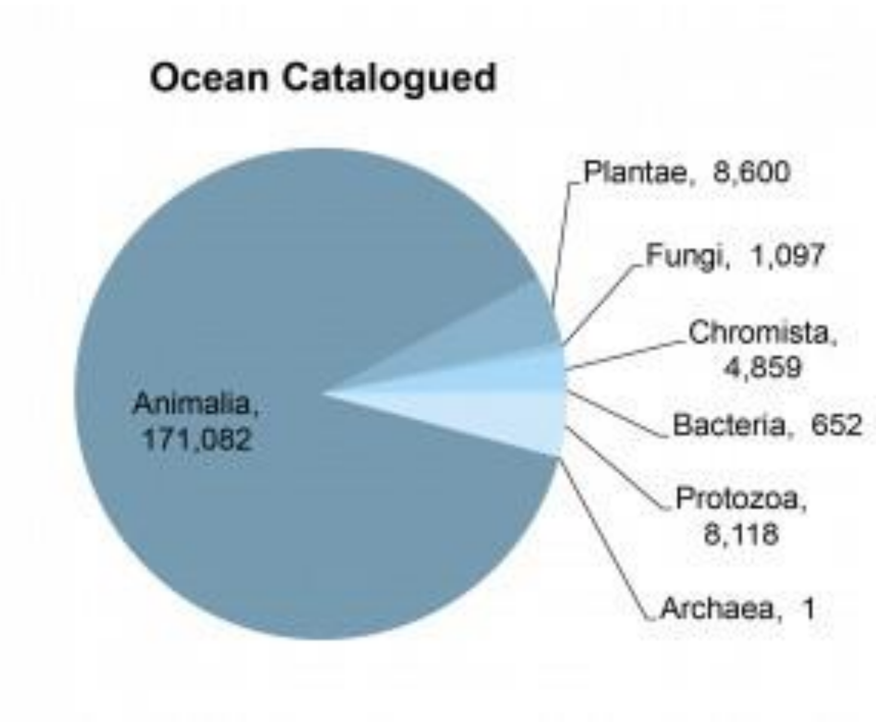


Hydrate!

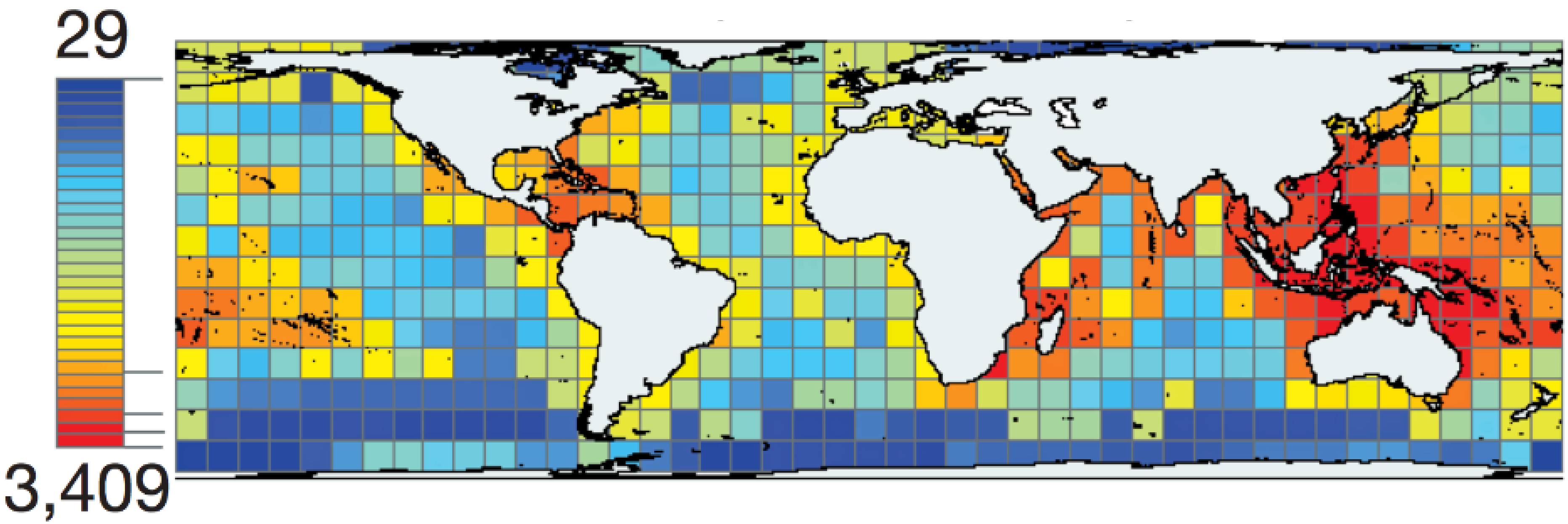
Documenting Challenges

- Species diversity, abundances, and ranges
- Identifying and cataloguing taxonomy
- Detecting spatial and temporal changes
- Challenges are also opportunities



Mora et al. 2011

Documenting Challenges: Species Diversity



Tittensor et al. 2010

Documenting Challenges: Rare Species

- Limited information
  - Identification
  - Ranges
  - Function

- Ecological and biological inconsistent assemblages

- Geographical region specific

Documenting Challenges: Cryptic Species

- Cryptic diversity
  - Distinct species classified as one due to morphological similarity
- Paramount for
  - Estimating species diversity
  - Tracking populations
  - Biogeographic patterns
  - Monitoring disturbances

Documenting Challenges: Cryptic Species

- Species Complex
  - Group of organisms similar in appearance
  - Conservation limitations
- Molecular techniques are proving invaluable
- Brasier et al. 2016
  - Cryptic diversity in 50% of the 15 species targeted, and 10 overlooked morphospecies
  - Increased total species by 233%

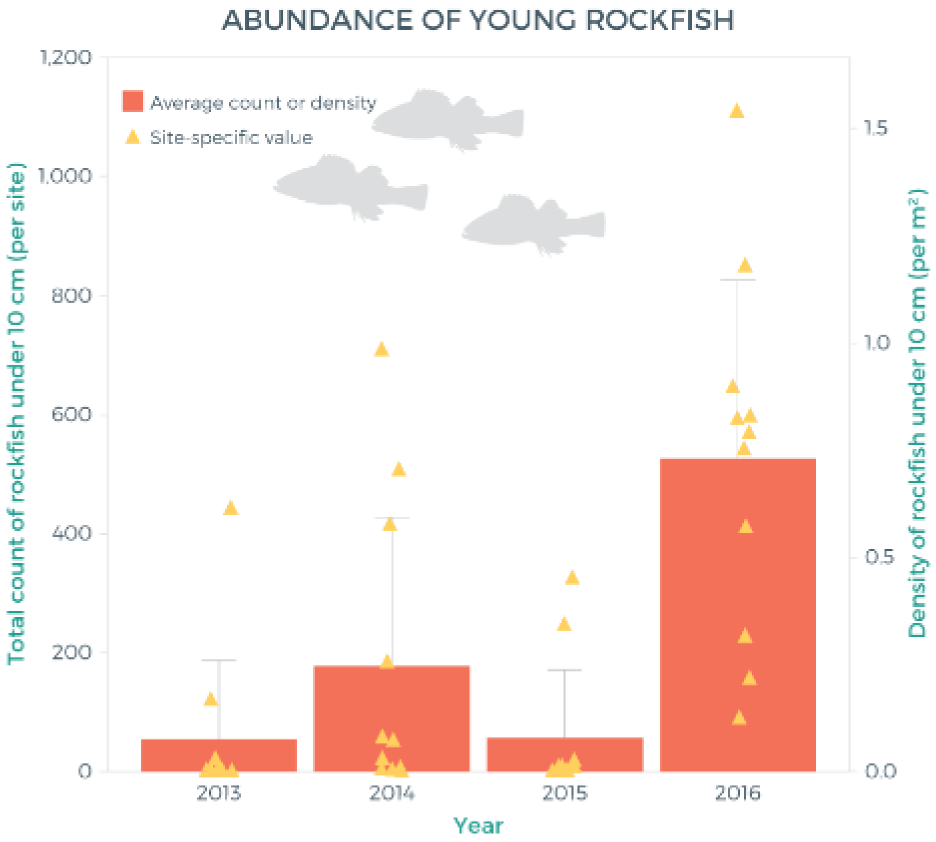
DNA barcoding uncovers cryptic diversity in 50% of deep-sea Antarctic polychaetes

Madeleine J. Brasier[1], Helena Wiklund[2], Lenka Neal[2], Rachel Jeffreys[1], Katrin Linse[3], Henry Ruhl[4] and Adrian G. Glover[2]

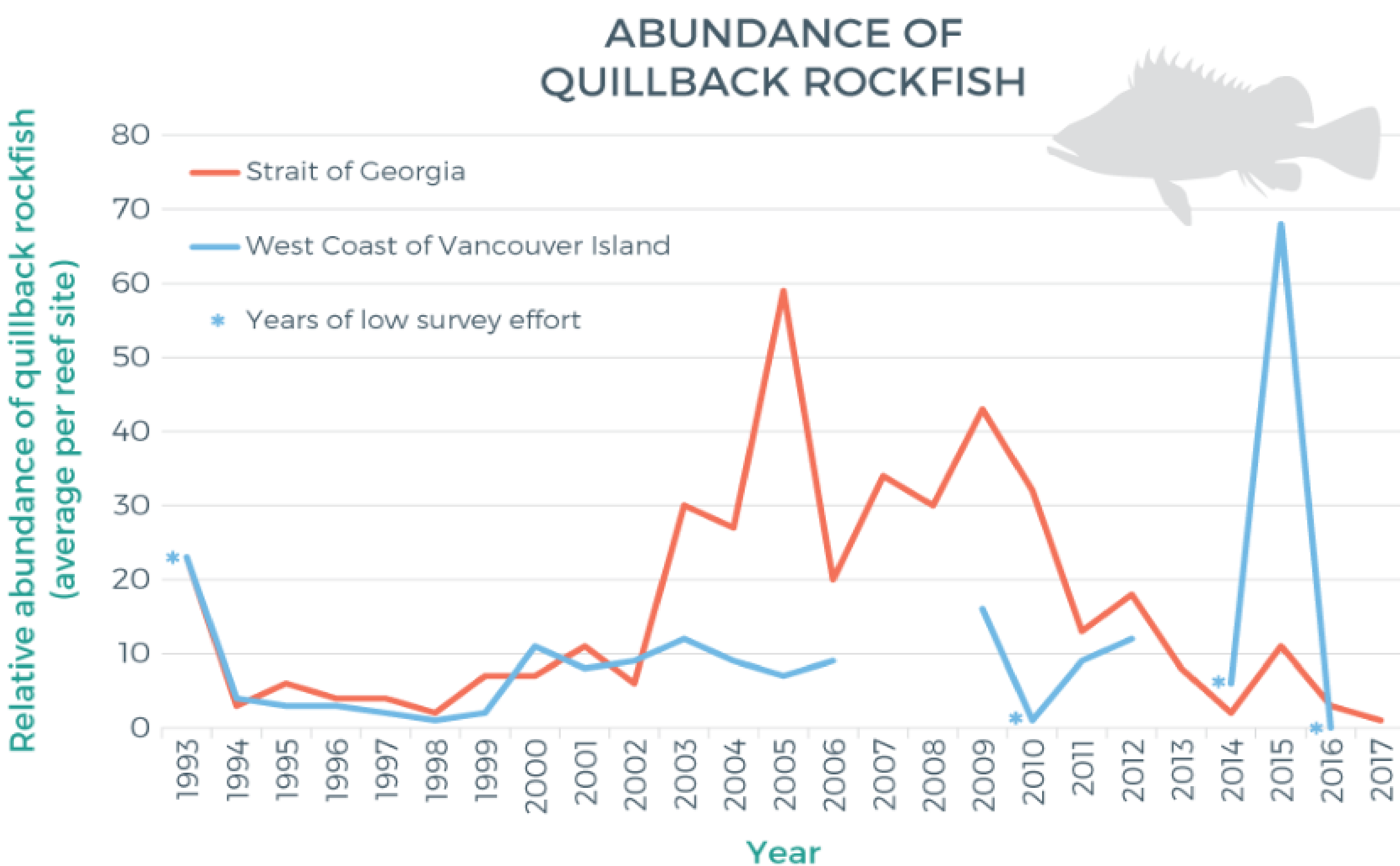
Documenting Challenges: Cryptic Species

Documenting Challenges: Abundances

- Number of individuals in a population
- Potentially dire consequences if estimates are incorrect

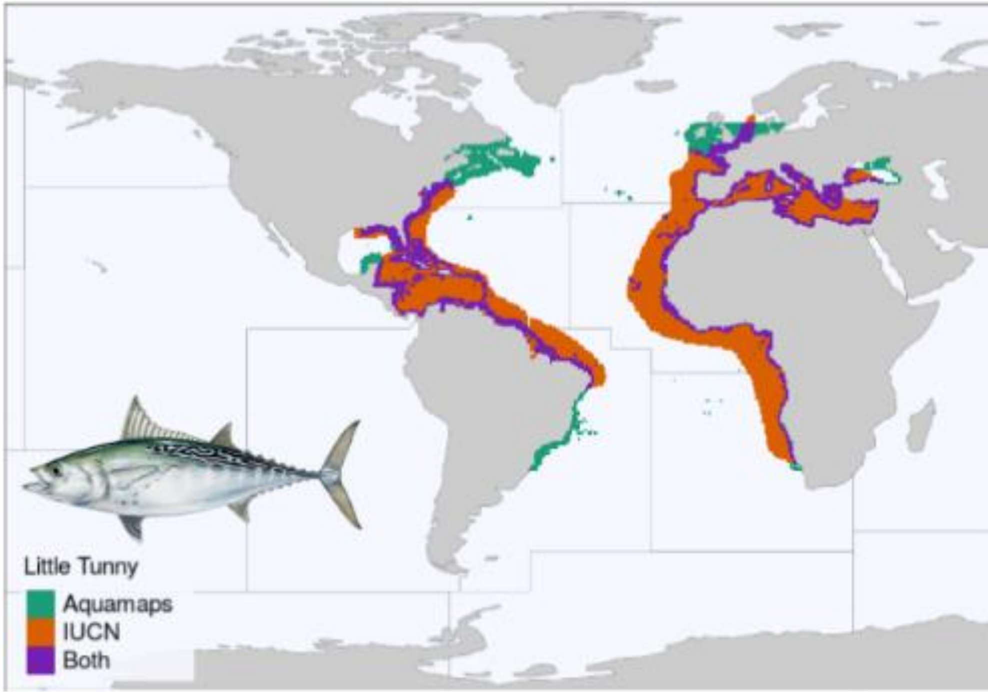


Documenting Challenges: Abundances

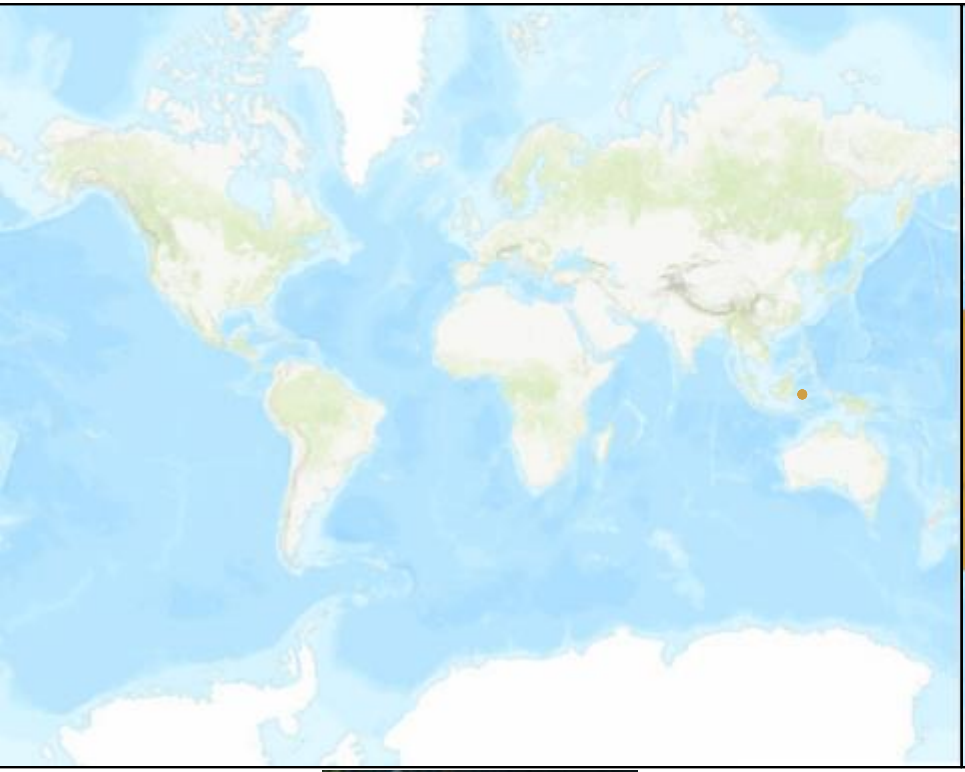


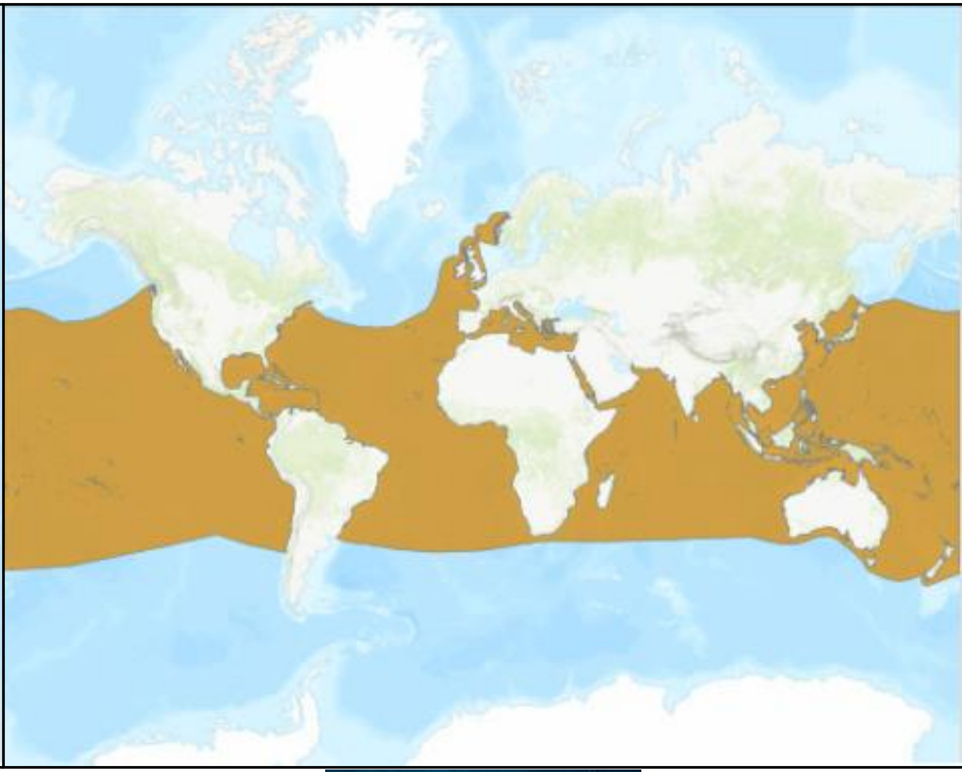
Documenting Challenges: Species Ranges

- The area utilized by a species throughout its lifetime
- Regulated by biotic and abiotic forces
  - Predators/Prey
  - Metabolic requirements
- IUCN: The estimation of species distributions constitutes the core of assessments



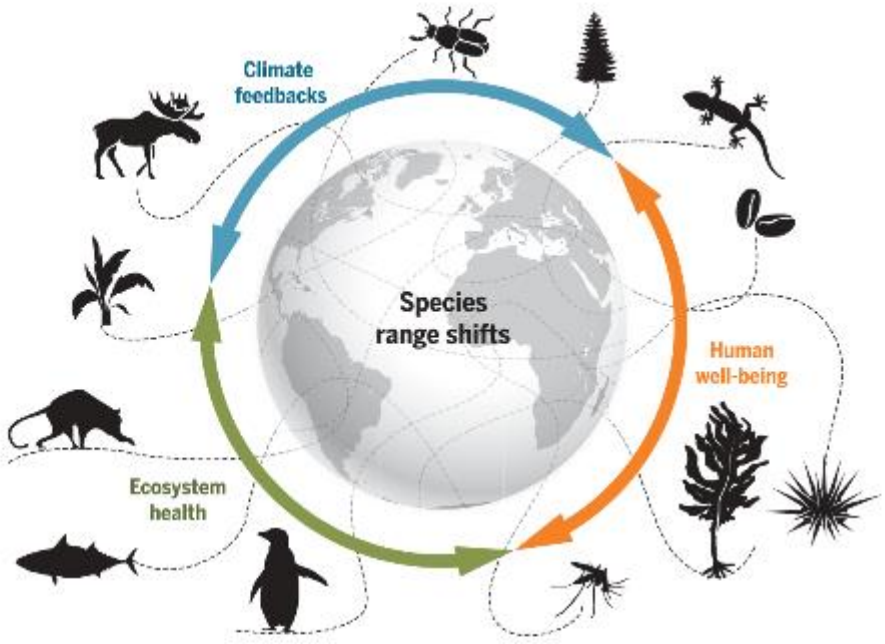
Documenting Challenges: Species Ranges

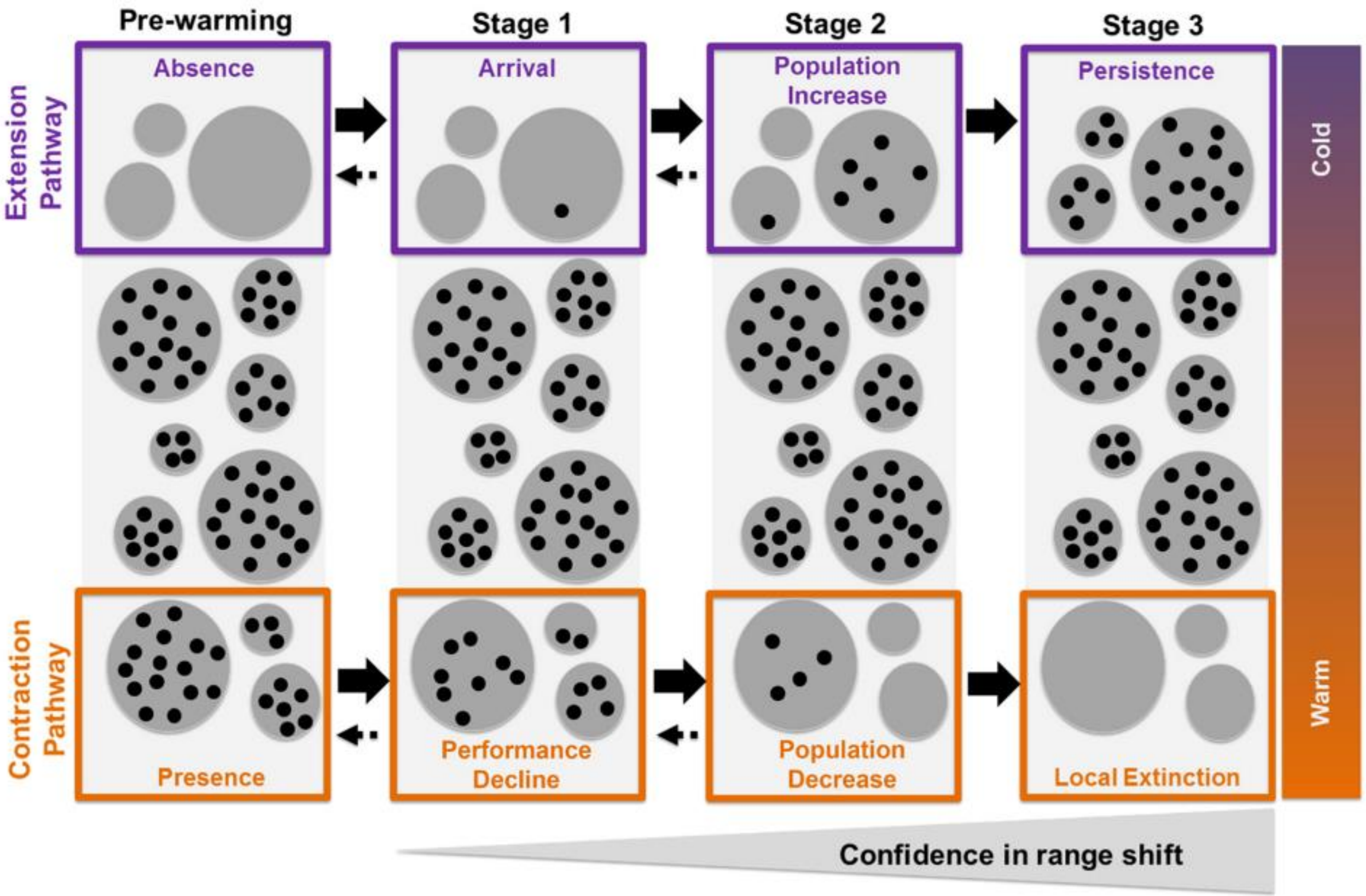




Documenting Challenges: Range Shifts

- Change in the location of the range boundary
- Driven by changes to biotic or abiotic conditions
- Temporary or permanent





Bates et al. 2014

Documenting Challenges: Range Shifts

- Northern California
- Substantial changes in the distributions of 67 southern species
- 37 poleward range extensions
- Drastic increases in the recruitment for certain species

SCIENTIFIC REPORTS

Article | Open Access | Published: 12 March 2019

Widespread shifts in the coastal biota of northern California during the 2014–2016 marine heatwaves

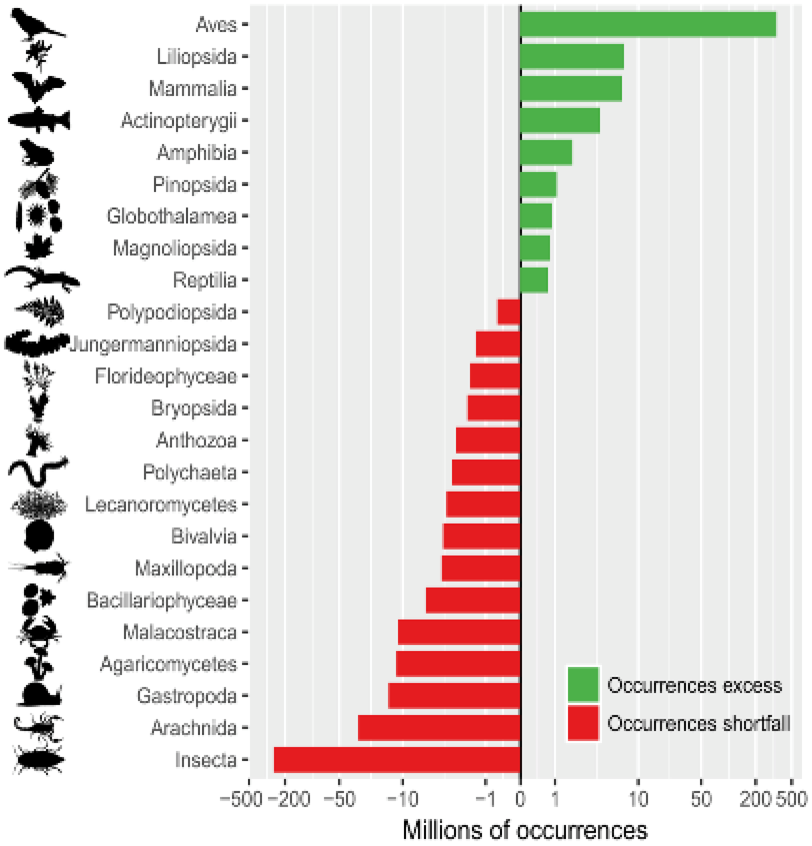
Eric Sanford, Jacqueline L. Sones, Marisol García-Reyes, Jeffrey H. R. Goddard & John L. Largier

Documenting Challenges: Stochastic Dispersal

- 9.0 earthquake strikes Japan
- Creates a 38m tsunami
- Over the next 5 years debris continuously lands in America
- 634 pieces of marine debris, carried 289 living invertebrate and fish species
- None previously reported to have rafted between continents

Documenting Challenges: Taxonomic Bias

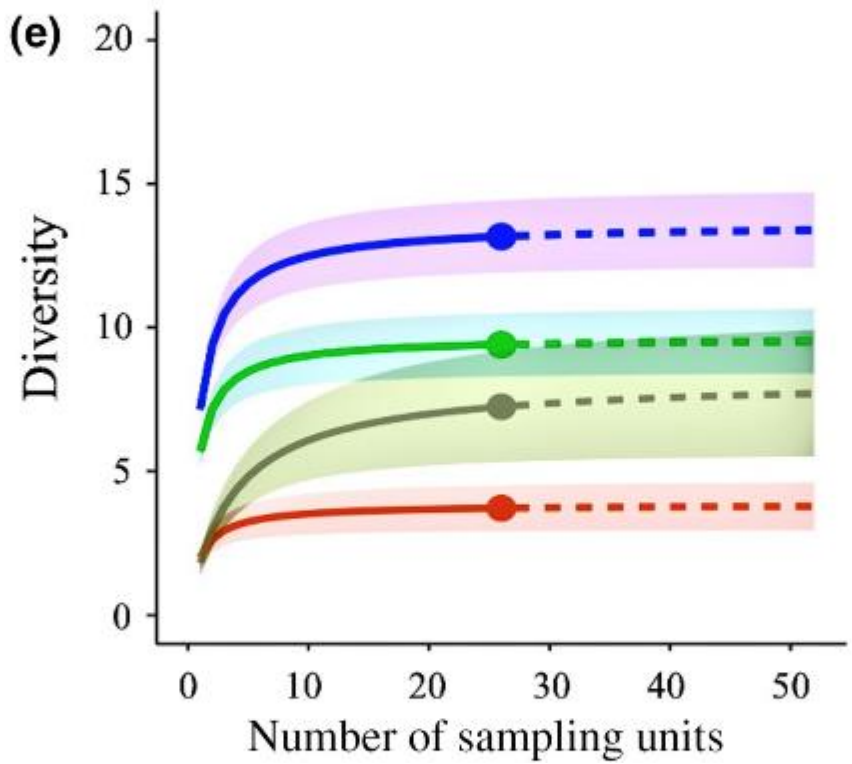
- Disparities in knowledge of organisms, and the extent they are studied
- Exists across a range of biological disciplines
- Discrimination based on
    - Taxonomy
    - Body sizes
    - Charisma
    - Societal preferences
    - Space and time
- Ensuring biodiversity is representatively sampled is urgent for achieving efficient conservation strategies



Troudet et al. 2017

Documenting Challenges: Sampling Bias

- Certain members of the population have a lower sampling probability than others
- Species relatively abundances must be considered
- Sampling method is critical
- Is it possible to eliminate sample bias in ecology?



Is there a central theme to addressing these challenges?

Quality Data

- Can be validated
- Up to date taxonomy
- Spans spatial and temporal ranges
- Wide taxonomic focus

Global Surveys

- Very expensive
- Difficult permitting
- Potentially lack longevity

Citizen Science Surveys

- Volunteers collect data as part of a scientific effort
- Currently increasing rapidly, but roots extend to the foundation of modern science
- Reef Check, Reef Life Survey, Bioblitz, REEF, iNaturalist

REEF CHECK

RLS
REEF LIFE SURVEY

REEF
www.REEF.org

iNaturalist

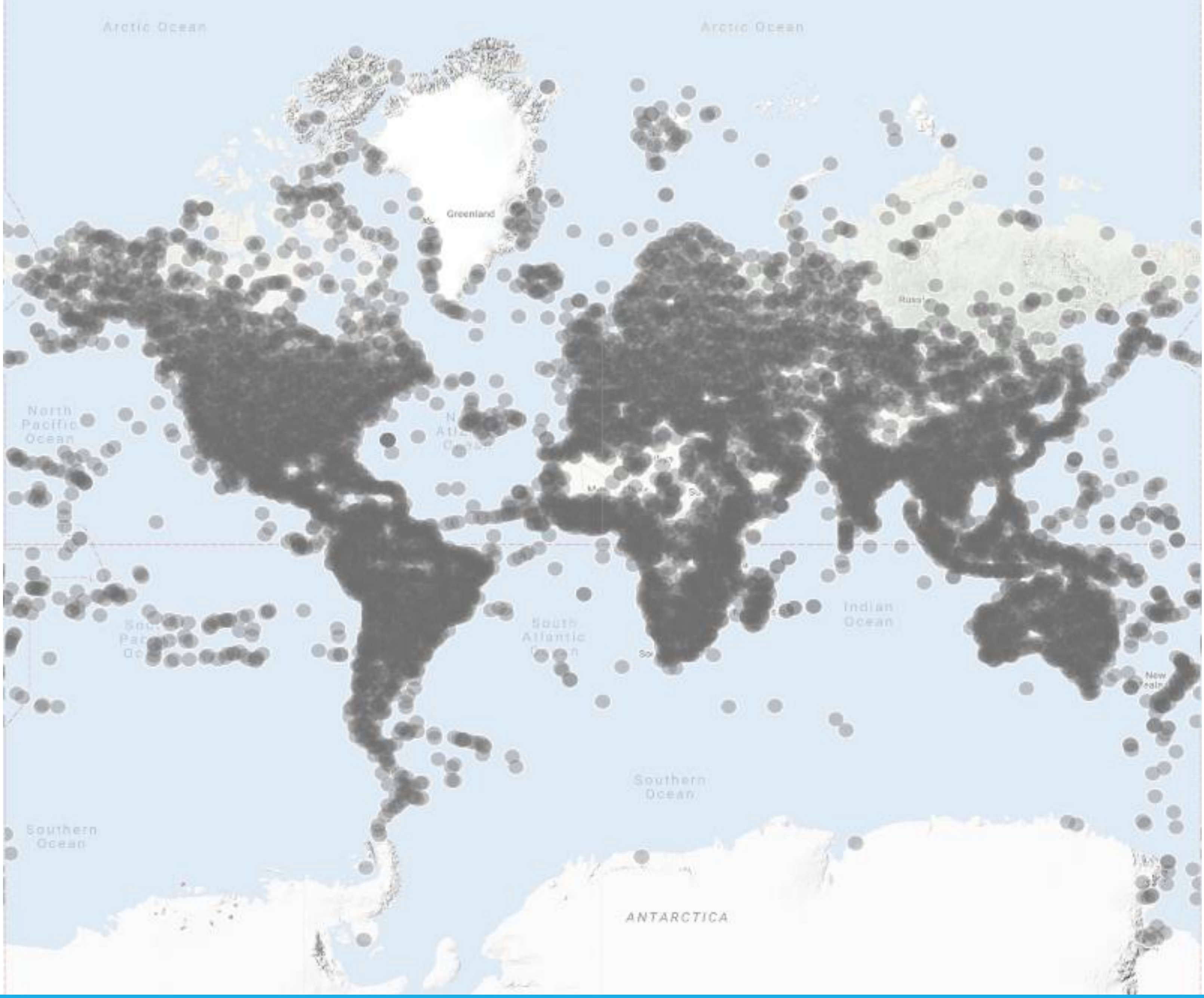
- Began as the Master's project at UC Berkeley
- Free App
- Open source data
- Over 27 million observations, of 230,000 species, collected by 760,000 volunteers
- Uses species photos, identification algorithms and a network of members to confirm observations

How It Works

Record your observations

Share with fellow naturalists

Discuss your findings


Arctic Ocean
Arctic Ocean
Greenland
North Pacific Ocean
Indian Ocean
South Atlantic Ocean
Southern Ocean
Southern Ocean
ANTARCTICA

Contributing To iNaturalist

- **Appropriate interactions with subjects**

- Take quality photos
  - Fill the frame
  - Identifiable
  - Multiple
  - Wild organisms

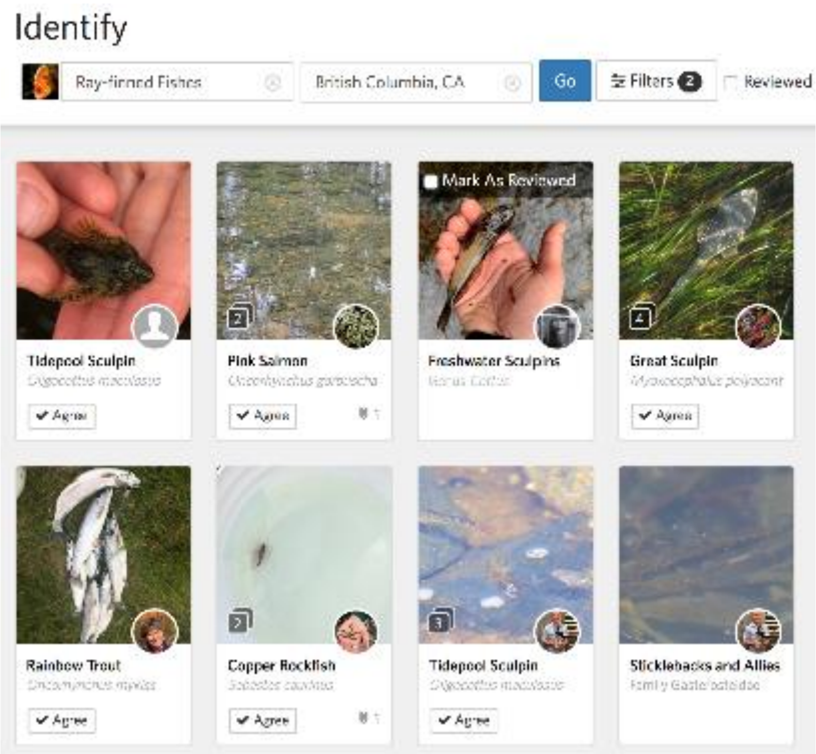
- Upload to iNaturalist
  - Make an account
  - Log as an observation
  - Mark location
  - Explore algorithms suggestions
  - Be taxonomically conservative

seek by iNaturalist

Contributing To iNaturalist

- Identify others observations
  - Browse recent uploads
  - Search for taxa
  - Review features, photos and suggestions
  - Confirm or suggest

- Consider making a project
  - Region
  - Taxa



iNaturalist Applications

- Conservation Planning
  - Population declines
  - Increasingly utilized by COSEWIC
- Species Ranges
  - Extensions
  - Declines
  - Invasions
- Taxonomy
- BC Parks, Brian Starzomski, and John Reynolds
  - ‘Your task will be to create the iNaturalist projects for the parks, and then spend your summer exploring BC Parks photographing flora and fauna’

the plant journal S E B

Protocol Note | Open Access

iNaturalist as a tool to expand the research value of museum specimens

J. Mason Heberling, Bonnie L. Isaac

First published: 07 November 2018 | https://doi.org/10.1002/aps3.1193

Trends in Ecology & Evolution

LETTER | VOLUME 27, ISSUE 2, P66, FEBRUARY 01, 2012

Taxonomy that matters: response to Bacher

Lucas N. Joppa • David L. Roberts • Stuart L. Pimm

Published: December 28, 2011 • DOI: https://doi.org/10.1016/j.tree.2011.11.015

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AN INTERNATIONAL JOURNAL FOR BOTANY AND MYCOLOGY

Research Article | Full Access

***Kalanchoe* (Crassulaceae) as invasive aliens in China – new records, and actual and potential distribution**

Zhi-Qiang Wang, Daniel Guillot, Ming-Xun Ren, Jordi López-Pujol

nature

COMMENT

The case for technology investments in the environment