# Marine Population Ecology & Dynamics

18 OCTOBER 2021

# This week

Finish up species ID assignment

- Make sure you return your species to their rightful place
- CLEAN YOUR SPACE AND GEAR!!
- Return GoPros

Population demographics

Matrix modeling assignment

- Guest lecture Emma Atkinson (Tuesday)

Biodiversity

- Intro
- Sampling methods design

# Today

Lecture

- Demographic parameters and species life history
- Understanding past dynamics:
  - Historical ecology
- Projecting future dynamics
  - Population models
  - Life history tables

Species ID presentations: 0945

Intro to modeling lecture: 1130

Group 2 paper discussion: 1430

**Due today @1700!!!**

- **Species id guides**
- **Group 1 paper discussion summary**

# Common questions in (marine) population ecology:

- What factors affect species' distribution and abundance?
- How might species' populations change into the future?
- What can be done to recover populations once they have declined?
- Why are some species more vulnerable to extinction than others?

# Demographic parameters

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

# **Demography**: the study of these processes

**Births**

Immigration


Emigration

**Deaths**

**General model of population growth:**

$$N_{t+1} = N_t + B_t - D_t + I_t - E_t$$

What is the term we use when thinking about an individual's ability to not die and reproduce?

# Fitness

The term "fitness" in evolutionary biology means the ability of an organism to pass on its genetic material to its offspring.

Biological or "Darwinian" fitness is **being able to live long enough to reproduce and keep the population or species alive**.

# Key “question” for species

Should you measure out your reproductive effort over many seasons, or save it all up for a one-time mating frenzy as soon as you're able?

These trade-offs relate to the r/K selection theory of life history strategies.

# r-K selection

Arises directly from logistic population growth model (MacArthur & Wilson 1967; Pianka 1970)

- $r_0$: density-independent rate of population growth
- *K*: carrying capacity

Evolution of life history strategies leads to:

**r-selected species**

- selection for ability to colonize and reproduce rapidly
- good colonizers, poor competitors

***K*-selected species**

- selection for ability to contribute to N when the population is near K
- good competitors, poor colonizers

# What are life history traits?

From a "fitness" perspective, there are only two important events in life: **reproduction and death.**

Traits that determine the timing and details of these events are termed life history traits:

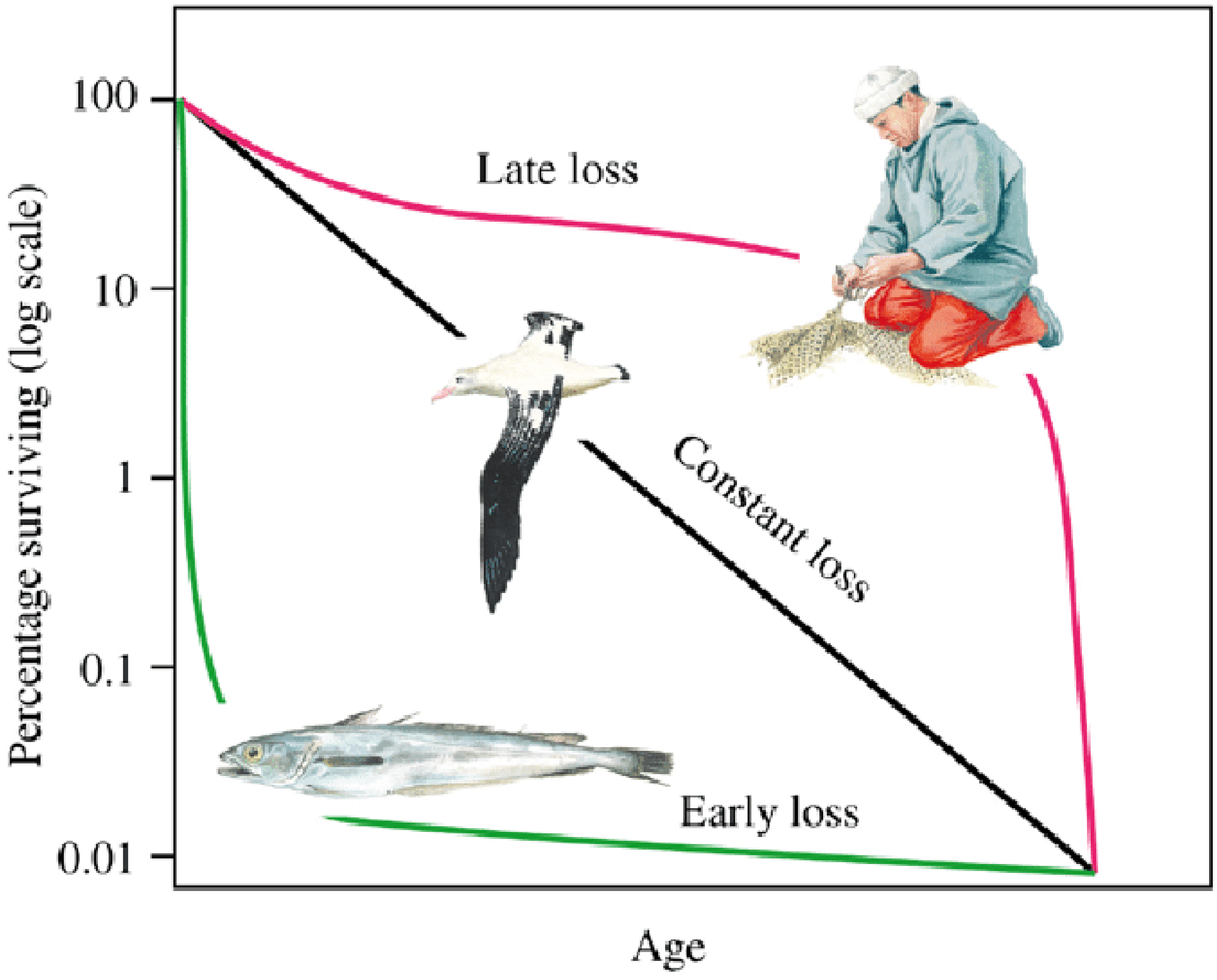
| | r | K |
|---|---|---|
| 1. Age at first reproduction | Young | Old |
| 2. Total life span | Short | Long |
| 3. Mode and frequency of reproduction | Fast | Slow |
| 4. Fecundity | High | Low |
| 5. Parental care | Low | High |

# r-K selection

The predictions of r-K selection stimulated vast amounts of research on life history evolution

But...

- Many species don't fall neatly into these categories (combinations of r-selected traits and K-selected traits)
- Predictions are vague enough that many different results are "consistent" with them
- Carrying-capacity is not a demographic parameter so traits that influence resource use do not directly translate to a specific K


Late loss
Constant loss
Early loss
100
10
1
0.1
0.01
Percentage surviving (log scale)
Age

# Life history traits:

Organisms must make tradeoffs among certain traits that typically cause them to come to evolutionary equilibrium at intermediate values.

**Life history traits are evolutionary solutions to the ecological problems of the risk of mortality and the acquisition of food,** and they are expressed in reaction norms that determine the particular traits that an organism will exhibit when its genes encounter a specific environment during development.

# Life history variation

**Purple sea urchin**
***(Strongylocentrotus purpuratus)***

**Life span:** mean: 8.8 years; max: 50+ years
**Reproduction:** Annual broadcast spawner (fall) with larval period 2-3 months. Gonads 15-20% of body weight in spawning season.

**Blue whale**
***(Balaenoptera musculus)***

**Life span:** 80-110 years; Sexual maturity 5-10 years.
**Reproduction:** Mating in late fall/Winter; internal fertilization and live birth of 1 calf every 2-3 years after 10-12 months gestation.

# Life history traits:

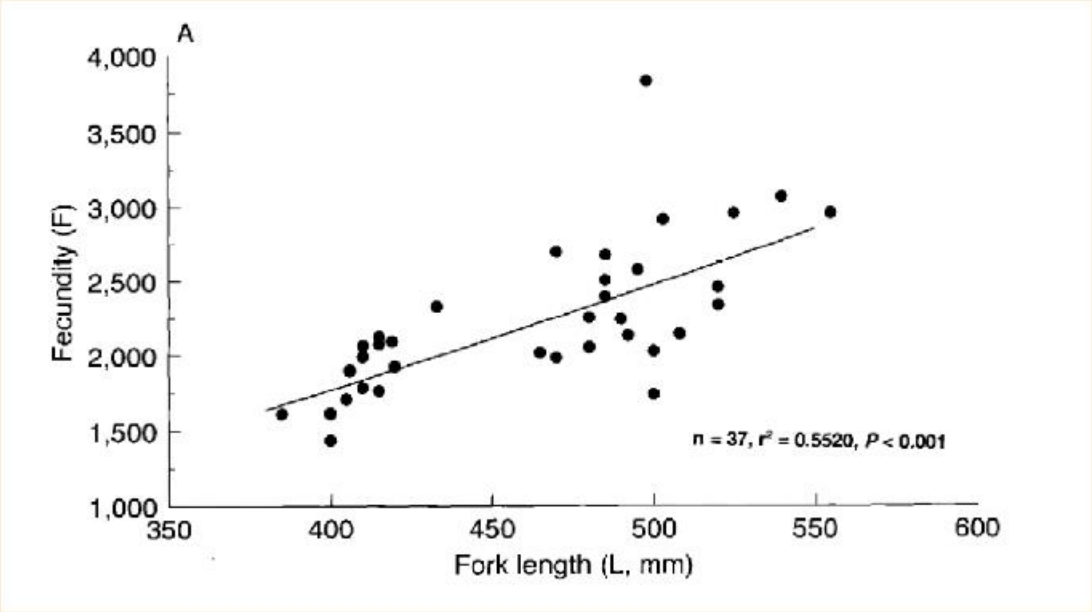
- **Maturity**- age at 1st reproduction
  - Copepods (7-30 days), White shark (33 yrs)

- **Parity**- # of episodes for reproduction
  - Sockeye salmon (1), Brown booby (16-20)
  - Semelparity vs. Iteroparity (annual, perennial)

- **Fecundity**- # offspring/episode
  - Harbor seal (1), Lionfish (30,000-40,000)

- **Aging/Senescence**- survival/life span
  - Ostracod (~40 days), Blue Whale (80-120 yrs)

# Sockeye salmon fecundity increases with size




Semelparity, so put nearly all available energy into fecundity

Bigger body = more energy for offspring

MPA news
International News and Analysis on Marine Protected Areas

Vol. 9, No. 3
September 2007

# Big Old Fat Fecund Female Fish: The BOFFFF Hypothesis and What It Means for MPAs and Fisheries Management

Modern fisheries management has often guided fishermen to select the large individuals of targeted stocks, either by using size-selective gear or releasing small individuals back to the water. The reasoning has been that this allows smaller, younger individuals to grow up to reproductive age, thereby sustaining the stock.

Recent research, however, shows that removing the larger, older individuals of a population may actually undermine stock replenishment. This appears especially to be the case for removal of larger, older females, which often produce significantly more offspring — and sometimes stronger offspring — than younger females do.

Some researchers have proposed the idea that maintaining old-growth age structure can be important for replenishing fished populations. It is termed the Big Old Fat Fecund Female Fish (BOFFFF) hypothesis. This month, *MPA News* briefly examines this hypothesis and what role marine reserves could play in maintaining old-growth age structure of fishery stocks.

## Maternal variability and size-selective fishing

"There often are different environmental constraints facing younger vs. older adults," he says. "Smaller females are more susceptible to predation, and so may be more restricted to safer habitats and thus different food supplies. Smaller females must also devote more energy to growth than larger females, which can devote more energy to reproduction."

He notes that the BOFFFF hypothesis applies better to some species than to others. The species for which it has been best demonstrated are long-lived and live in temperate waters: Atlantic cod (*Gadus morhua*) can live over 20 years, and Pacific rockfishes (genus *Sebastes*) can exceed 200 years in age. In contrast, says Hixon, short-lived and/or tropical species tend not to exhibit the same

### Tribute to Steven Berkeley

This *MPA News* coverage of the BOFFFF hypothesis pays tribute to the work of Steven Berkeley, credited with developing the hypothesis in his work on Pacific rockfish. Berkeley, a fisheries ecologist at the University of California at Santa Cruz, died of pancreatic cancer on 27 June 2007. He was 60 years old. In his most recent research, he examined how knowledge of maternal age effects in rockfishes could help identify which species were most likely to benefit from protection in marine reserves. The American Fisheries Society is planning a scholarship in his honor.

# Variation in demographic rates between populations/species

Via natural selection

## Life history

Age and stage-specific patterns and timing of events during an organisms' life cycle including birth, maturation, reproduction, senescence, and death.

## Environment

(e.g. temperature, light availability [affecting productivity of the system])

## Biotic interactions

Predation, competition, disease….

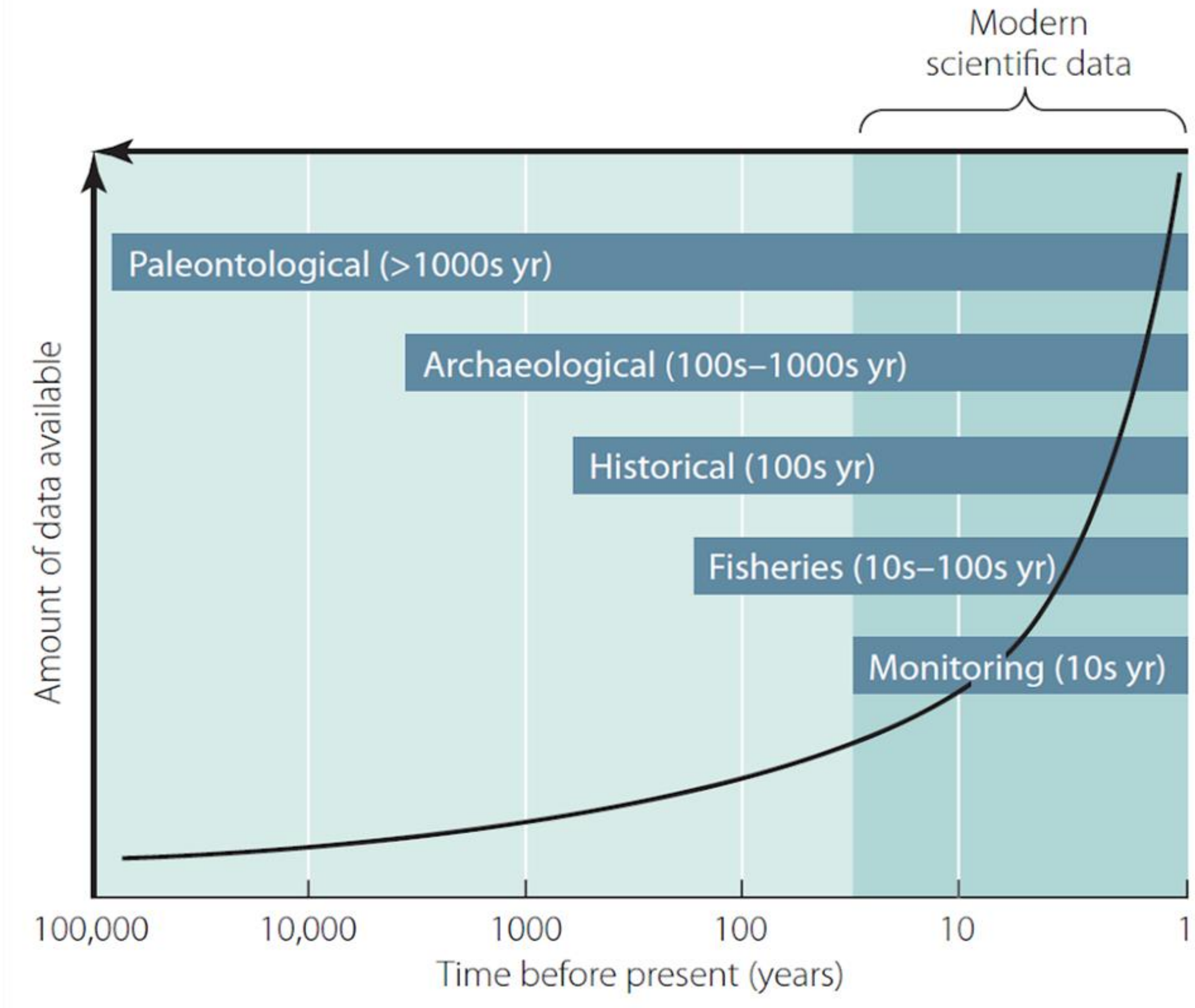
# Hydrate!

**How have populations changed over time?**

**Where do we get the information to assess historical population sizes and rates?**

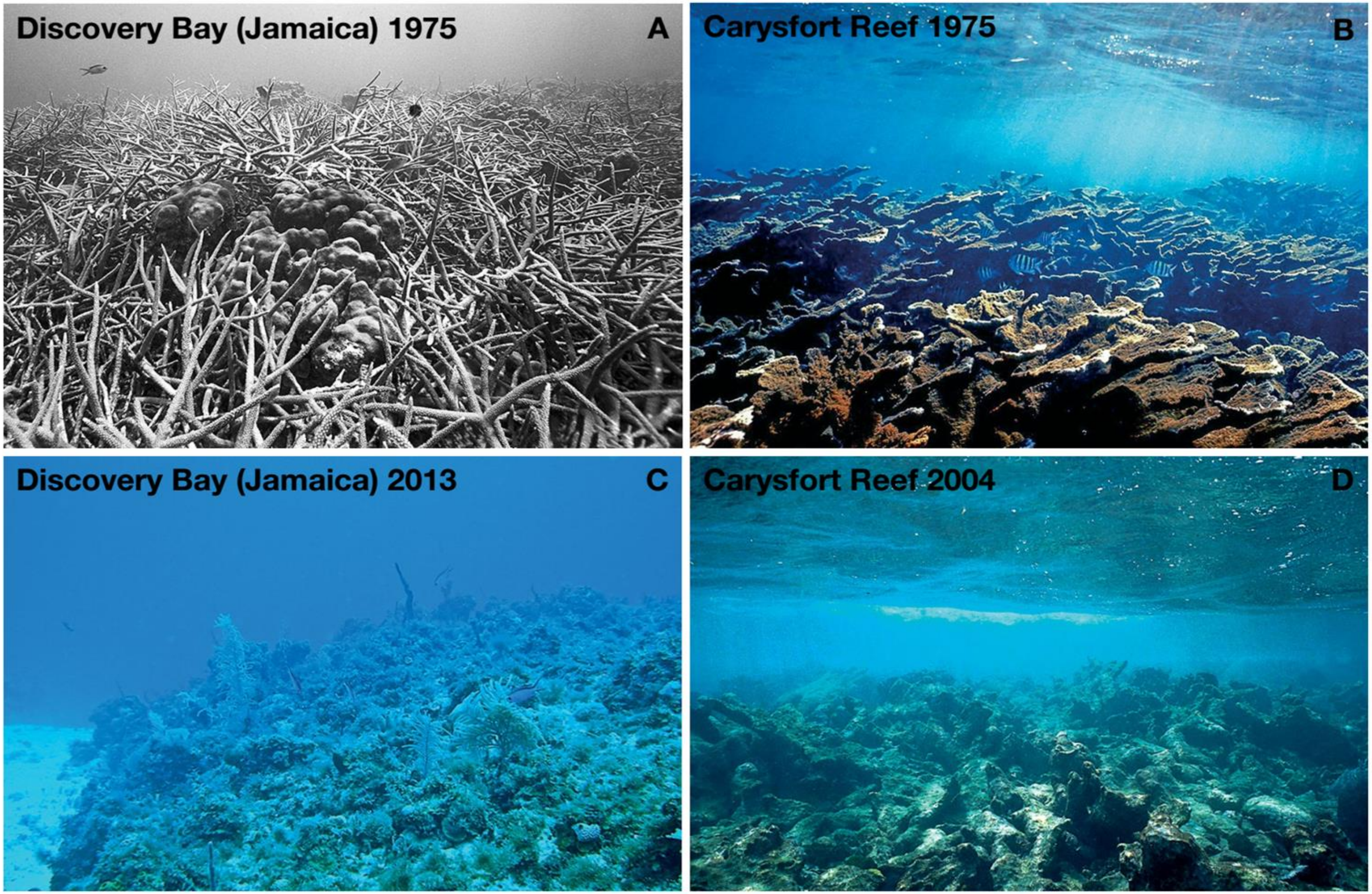
**Historical ecology!**

**Historical ecology uses a variety of information sources to estimate ecosystem state and changes from past times until the present.**


Modern
scientific data
Paleontological (>1000s yr)
Archaeological (100s–1000s yr)
Historical (100s yr)
Fisheries (10s–100s yr)
Monitoring (10s yr)
Amount of data available
100,000
10,000
1000
100
10
1
Time before present (years)

# Tracking Ecosystem Change

## The case of coral reefs



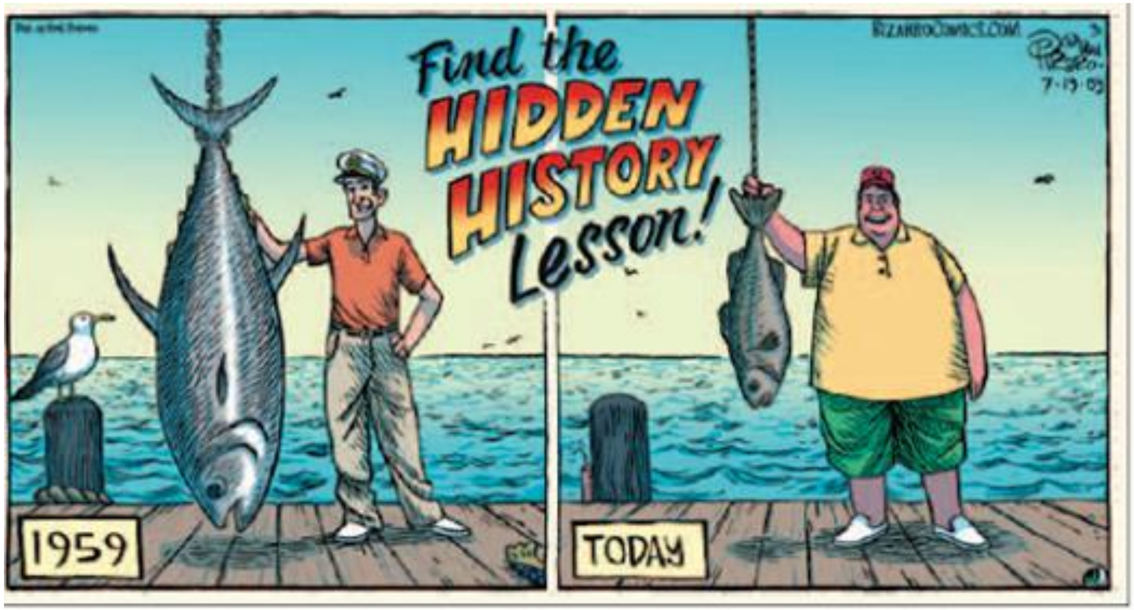

Jackson et al. 2014

# Flora Keys fish landings


Jackson et al. 2014

# Florida Keys fish landings


Jackson et al. 2014

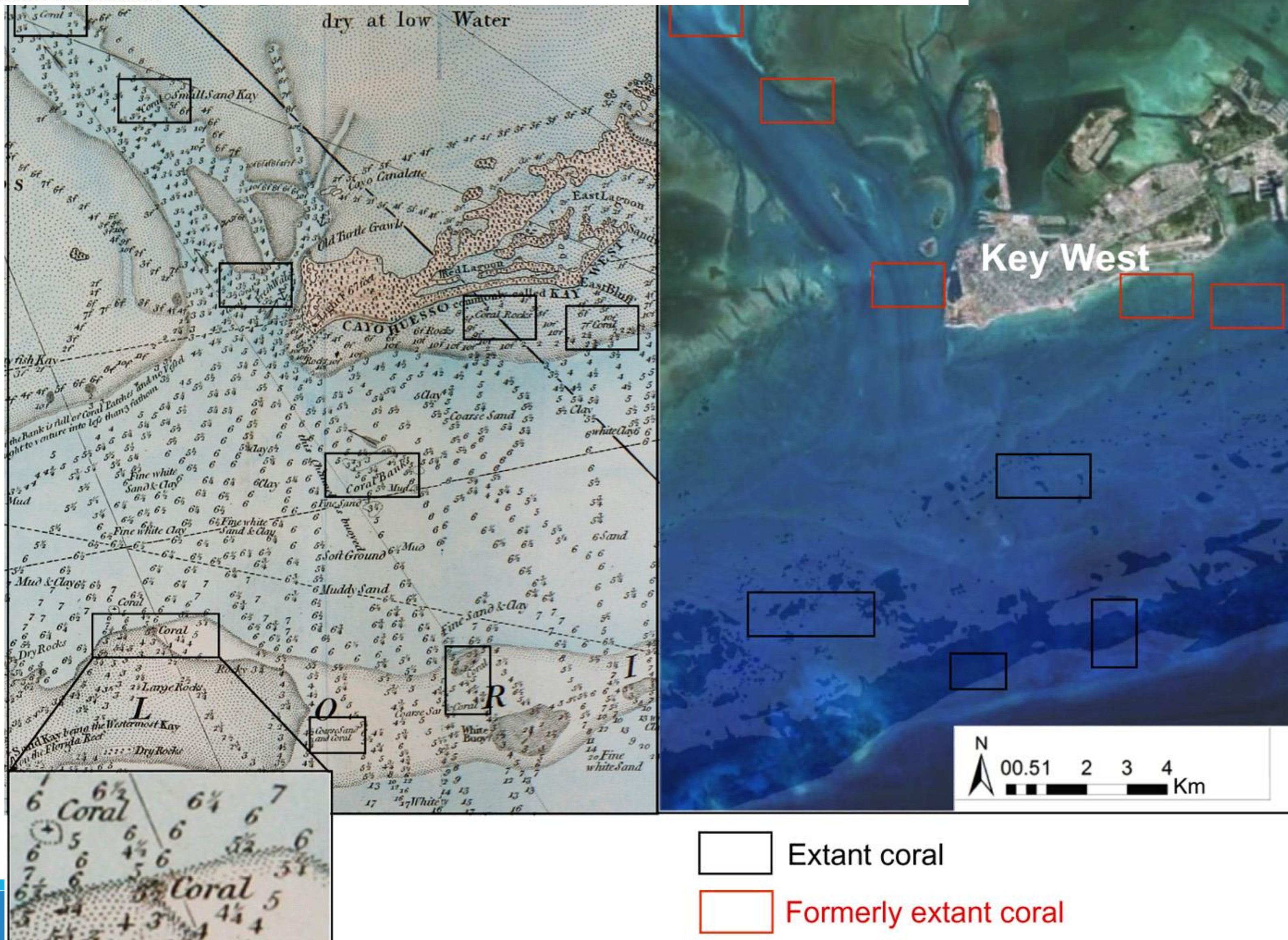

BIZARROCOMICS.COM
Find the HIDDEN HISTORY Lesson!
1959
TODAY

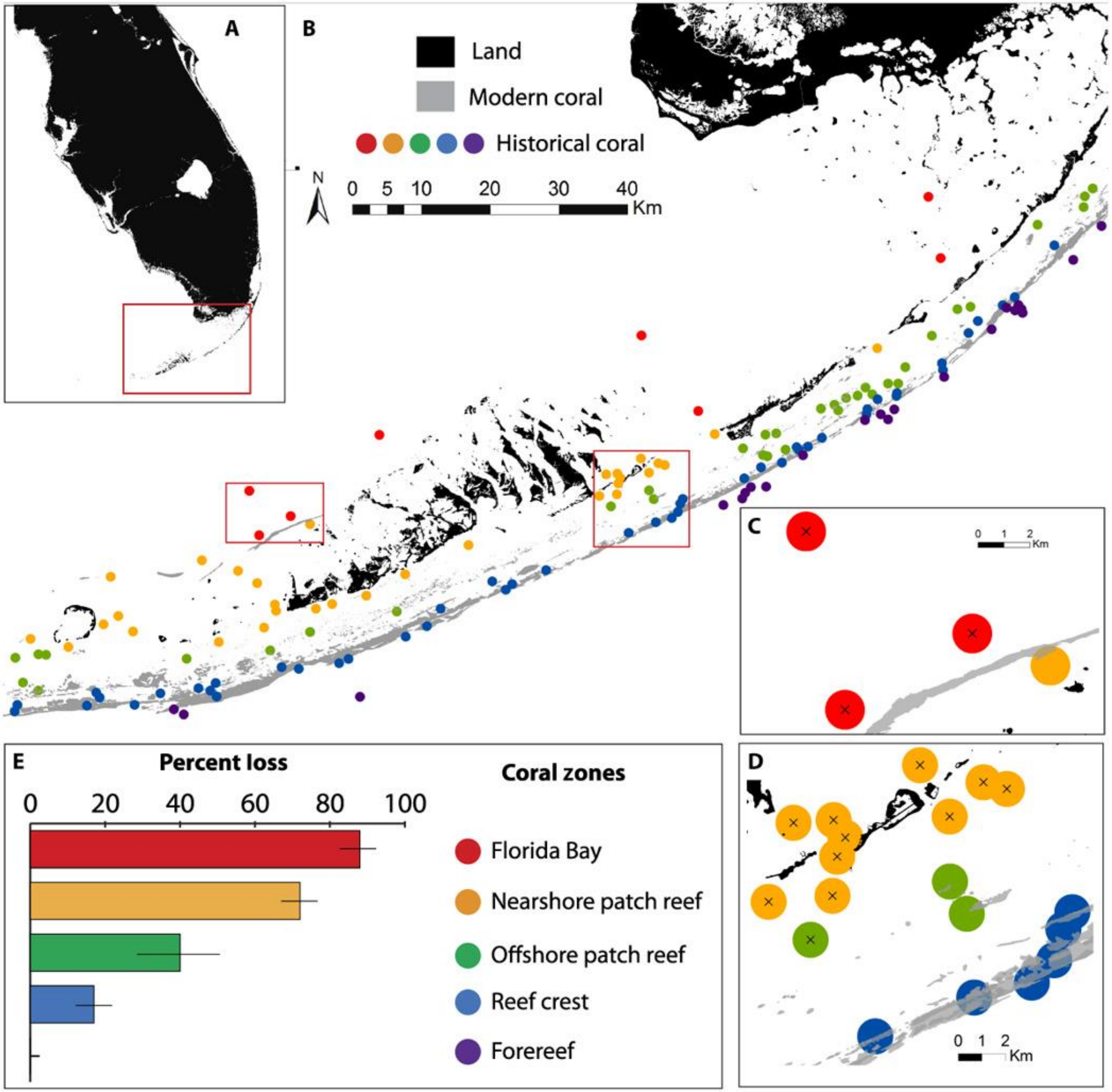
B)


SIZE MATTERS!
BIG FISH were a common catch just 50 years ago.
Not anymore!
1950s
Where have all the BIG FISH gone?
Overfishing has left few big fish in the ocean.
As the fish we catch have gotten smaller, we've forgotten what a really big fish should look like! Our baseline of comparison for how big a "big fish" should be has shifted.
In the late 1950s, Florida Key's fishermen caught big trophy fish—some over 6 feet long. Today, despite improvements in fishing technology, most trophy fish caught there measure just a foot in length.
Trophy fish—the "big" winners—are getting smaller and
1957
Early 1980s
2007
Photos like these provide a historical perspective to help us understand changes in fish size and numbers and what they should look like...
...so that we know how to restore and sustain them.
YOU CAN HELP!
• Speak Up!
–At the supermarket or restaurant, ask if the seafood is sustainable.
Tell them you support fishing practices that ensure there will be plenty of fish for future generations.
• If you go fishing, follow the regulated size and catch limits.
• Support marine protected areas that help conserve, protect, and enhance biodiversity.
See how scientists use old logs, journals, photos to solve ecological mysteries at

# Ghost reefs: Nautical charts document large spatial scale of coral reef loss over 240 years

Loren McClenachan[1,*], Grace O'Connor[2], Benjamin P. Neal[3], John M. Pandolfi[4] and Jeremy B. C. Jackson[5,6]
+ See all authors and affiliations



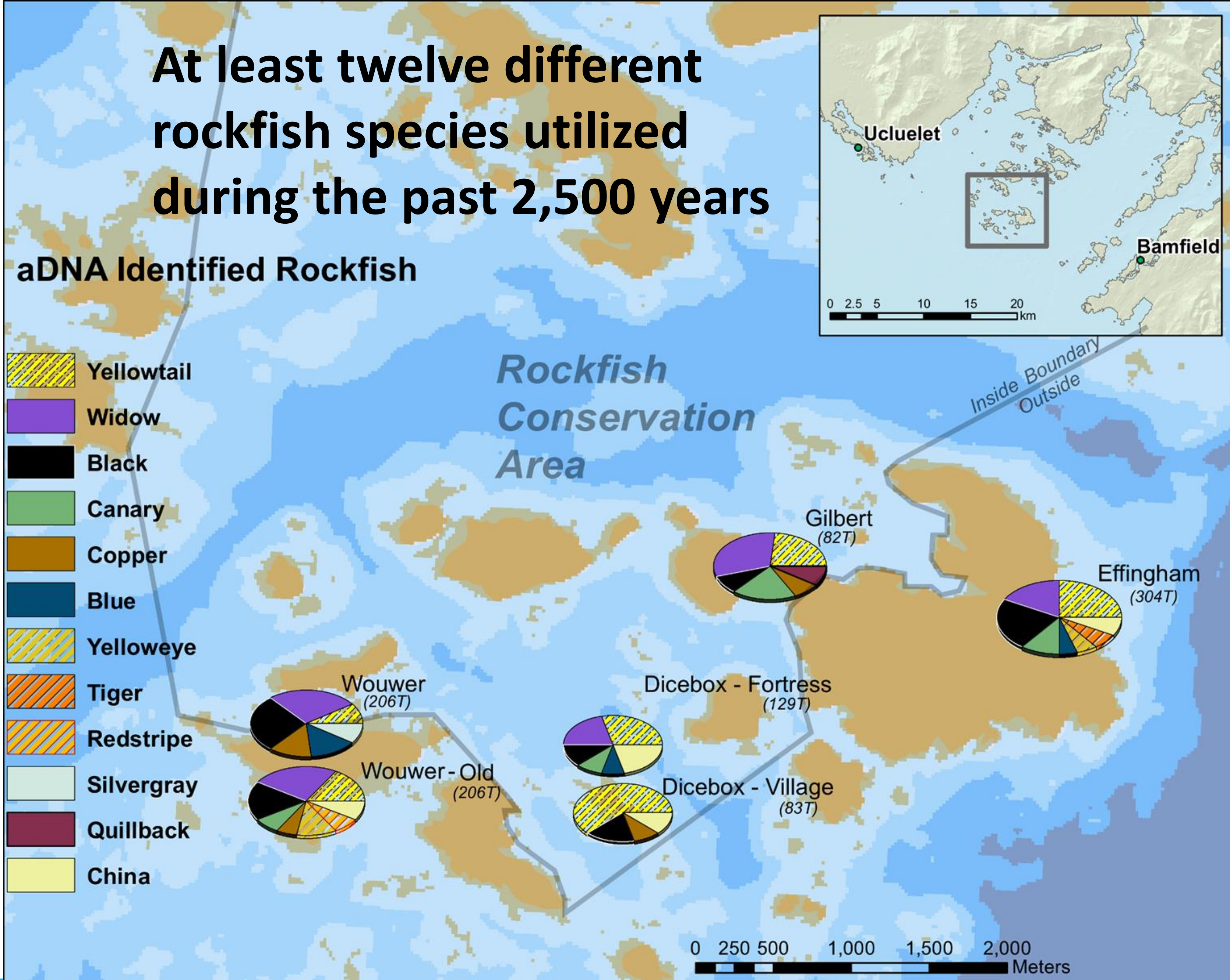

A
B
Land
Modern coral
Historical coral
N
0 5 10 20 30 40
Km
C
0 1 2
Km
D
0 1 2
Km
E
Percent loss
0 20 40 60 80 100
Coral zones
Florida Bay
Nearshore patch reef
Offshore patch reef
Reef crest
Forereef

# Ancient DNA analysis of Indigenous rockfish use on the Pacific Coast: Implications for marine conservation areas and fisheries management

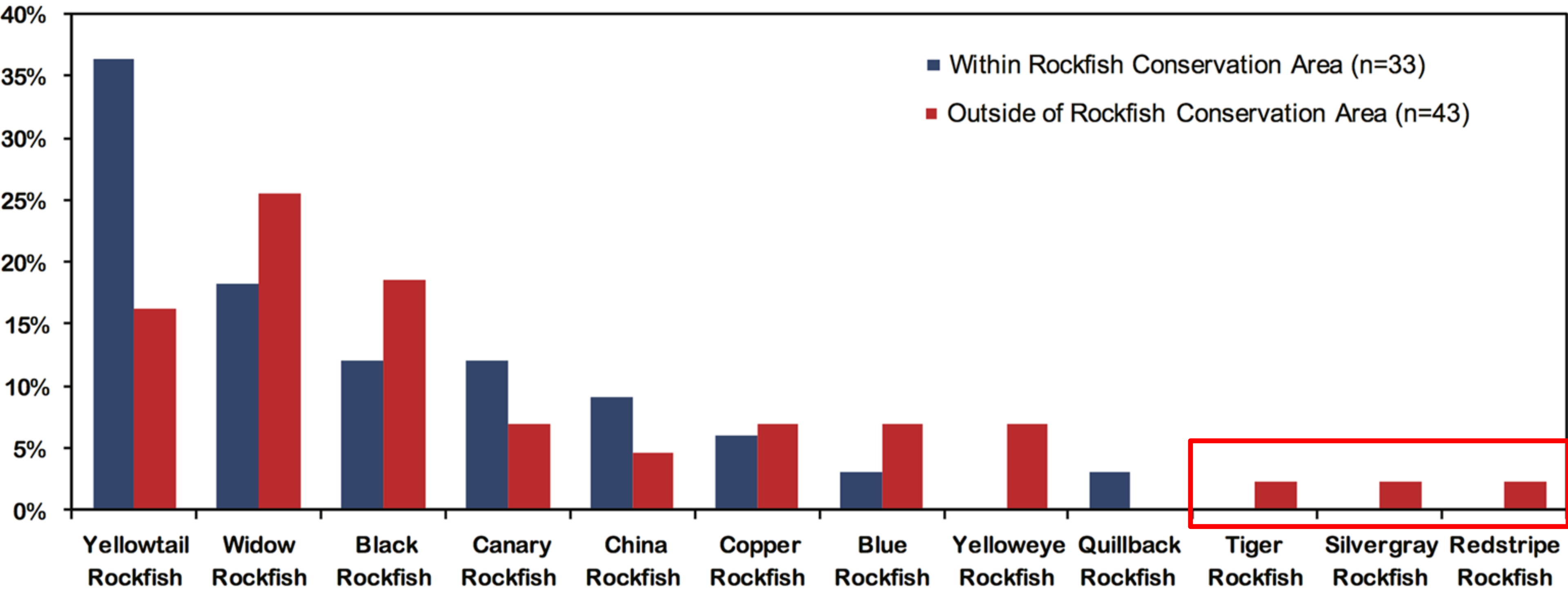
Antonia T. Rodrigues, Iain McKechnie, Dongya Y. Yang

Published: February 13, 2018 • https://doi.org/10.1371/journal.pone.0192716

# At least twelve different rockfish species utilized during the past 2,500 years



# Four species found only at sites where commercial and recreational fishing continues.



# Shifting baseline:

*Change in reference (i.e. baseline) against which a system's state is measured, which itself may represent significant change from an even earlier state of the system.*

**Pauly, Daniel. (1995) "Anecdotes and the shifting baseline syndrome of fisheries", Trends in Ecology & Evolution.**

- Paper brought major attention to this idea for viewing how our reference points for 'intact' populations and ecosystems shifts over time (cited >1800 times!)
- Idea is now popularized to discuss intergenerational change in views/relationship with nature.

# 15 min break