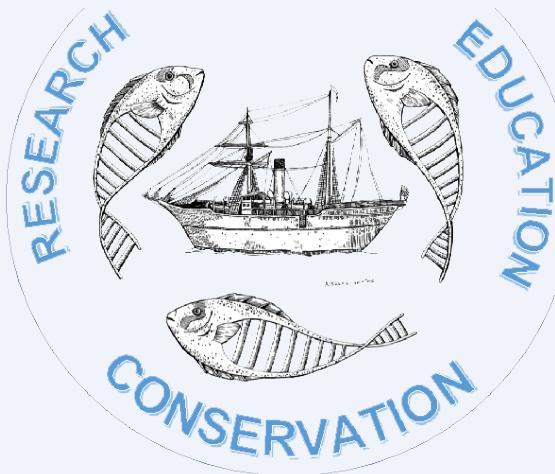


Partnerships for International Research & Education: Centennial Genetic and Species Transformations in the Epicenter of Marine Biodiversity



The Philippines PIRE Project

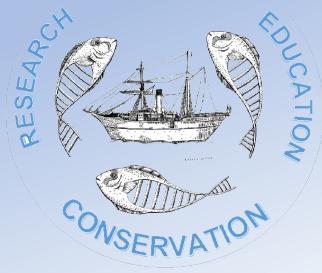


ASU Arizona State University



Smithsonian Institution
NATIONAL MUSEUM of NATURAL HISTORY





OVERARCHING RESEARCH QUESTION

What **genetic** and **species** level changes have taken place over the past **century** of intense fisheries **exploitation** and **habitat degradation** in the Philippine global epicenter of marine biodiversity?

Genetic component made possible by the 1908-1909 voyages of the *USS Albatross*



Historical Background of the *USS Albatross* voyage to the Philippines

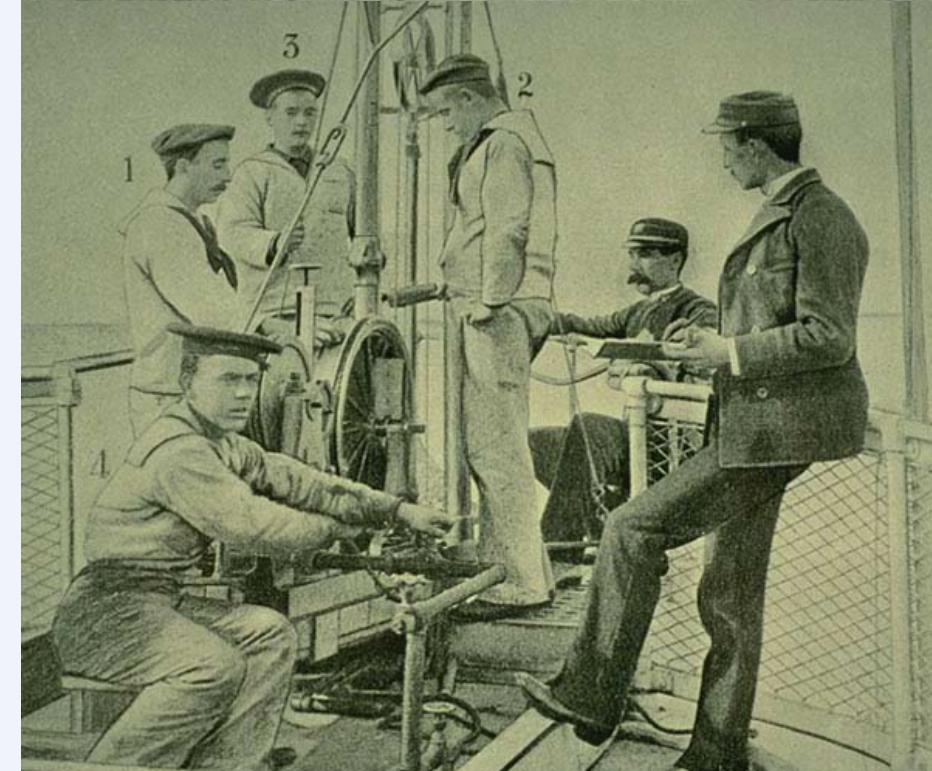
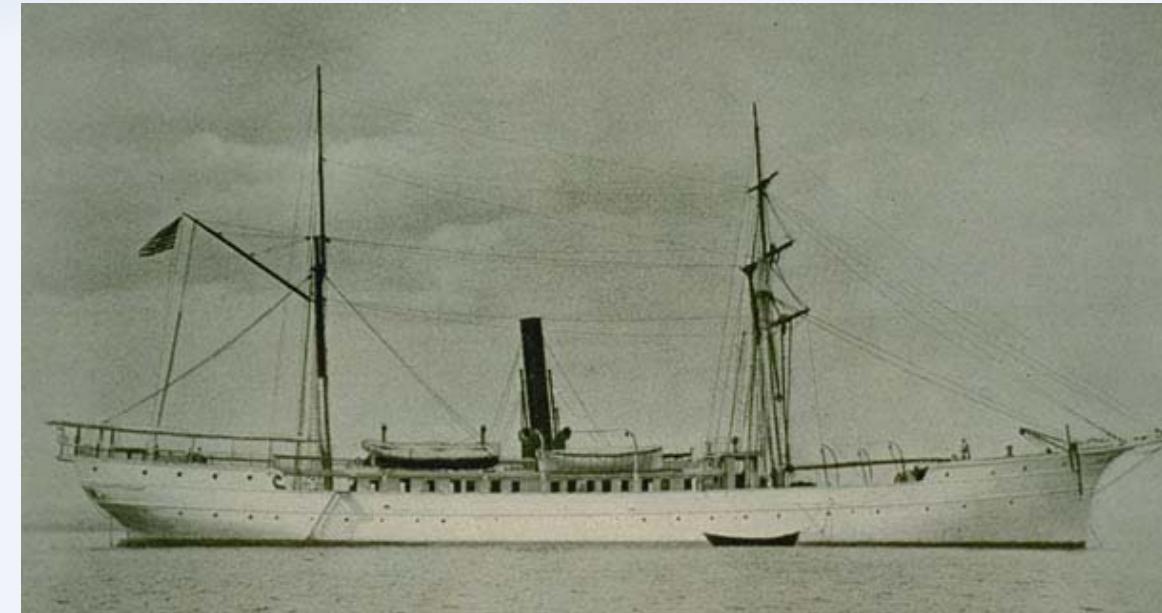
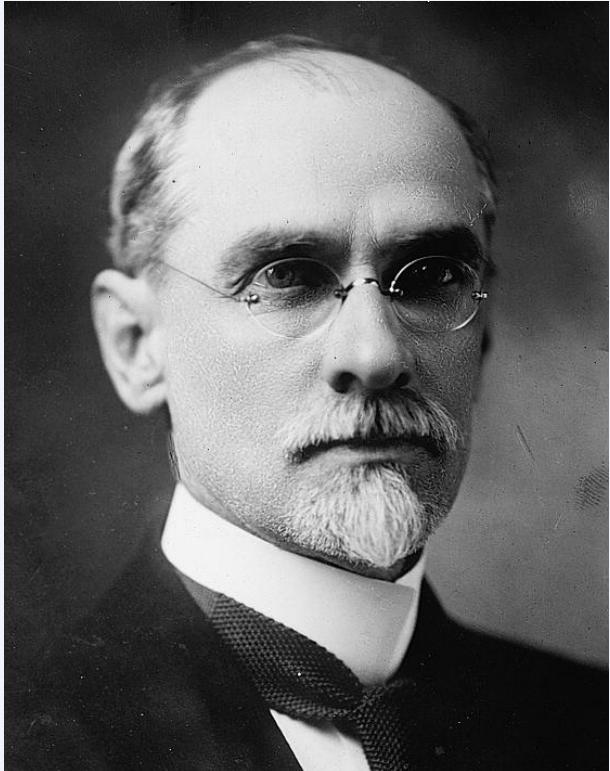
- Battle of Manila Bay May 1, 1898
- Philippines purchased from Spain for \$20 million, December 1898



The *USS Albatross*

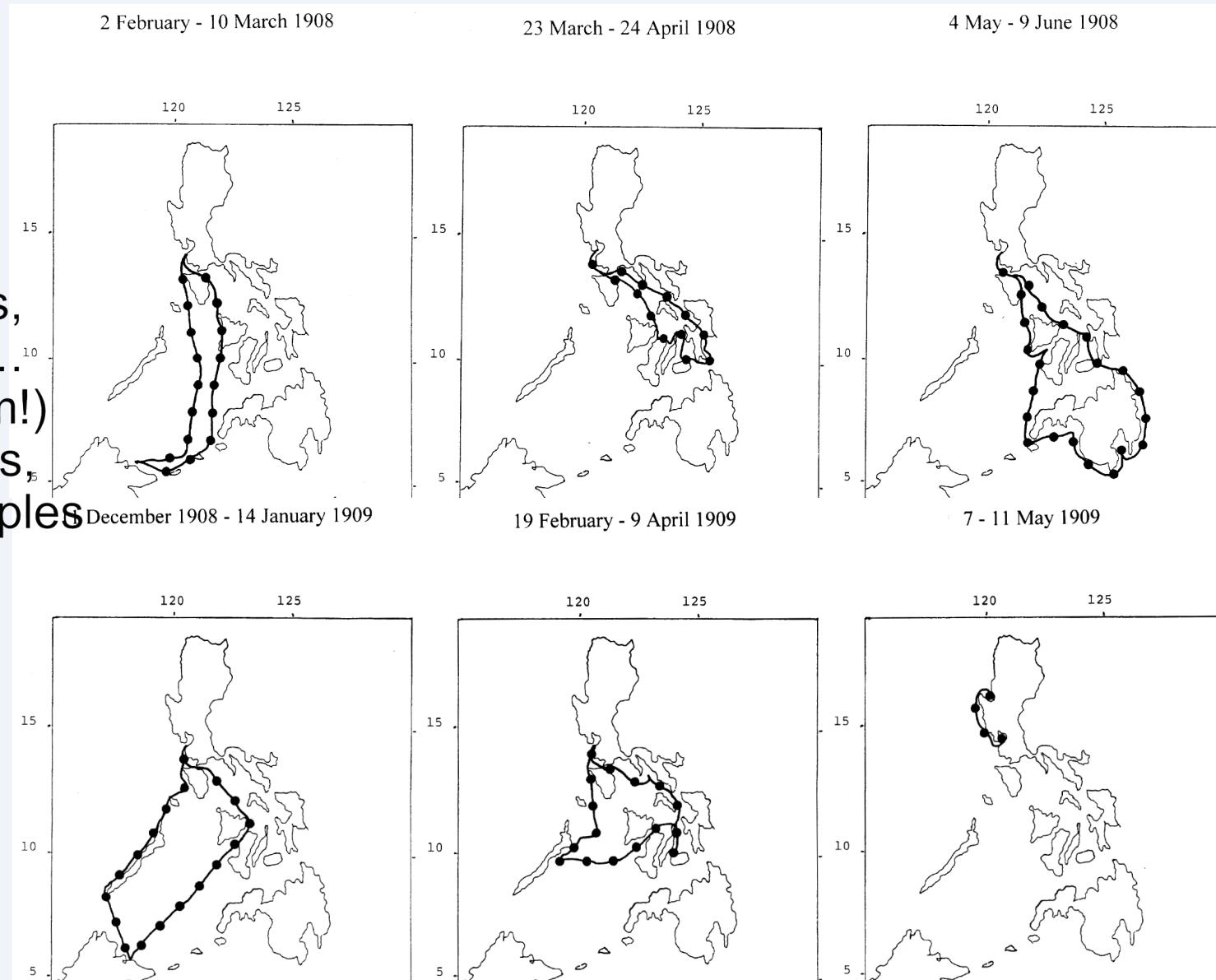
Philippine expeditions: 1908-1909

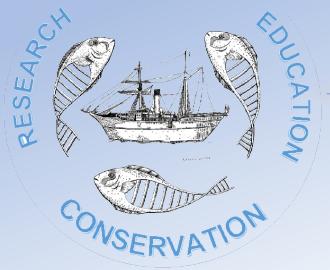
- Survey newly owned colony
- Headed by Hugh M. Smith, Ichthyologist & Deputy Director of Bureau Fisheries
- Paul Bartsch, Zoologist US National Museum, 4 other scientific staff, ~ 65 crew



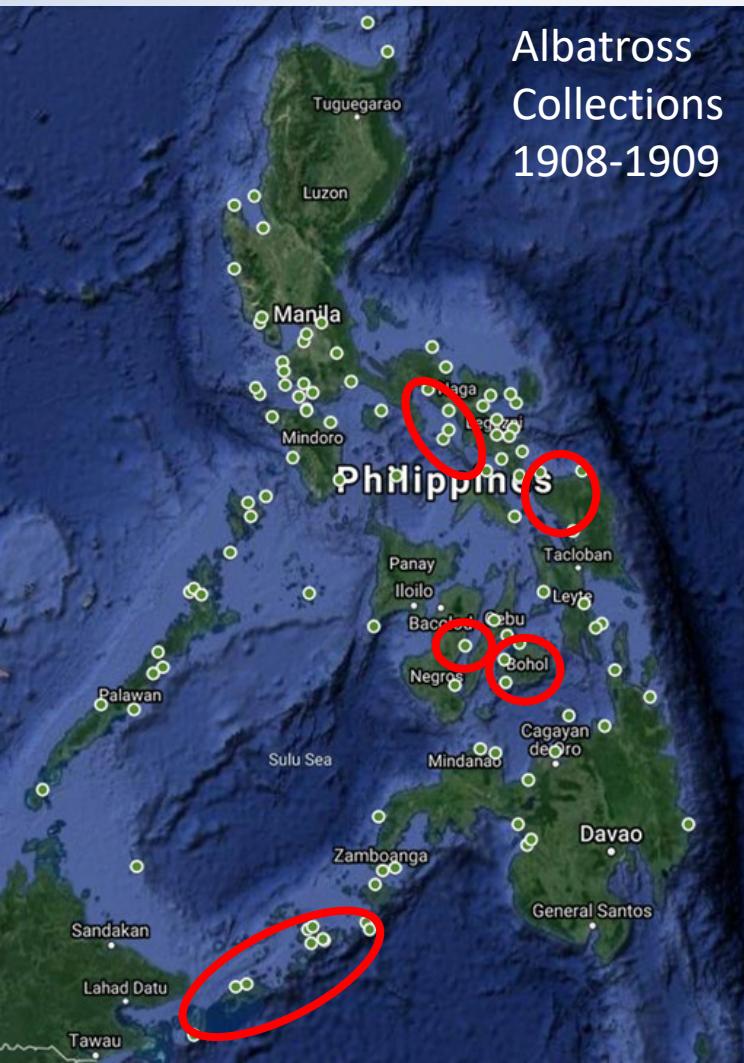
The USS Albatross Philippine expeditions: 1908-1909

- 10 cruises
- ~ 100,000 specimens
- > 79,000 fish specimens
- > 27,400 fish lots
- Many lots with >20 specimens
- Bottom trawls, dynamite, pelagic nets, light/dip net, gill net, traps, handlines....
- Preserved **ethanol** (high powered rum!)
- Target: 20 species, 500 SNPs/species, RAD sequencing, population size samples





Duplicating Albatross Collections



USS Albatross lots w/ n>15

- 135 candidate lots
- 58 lots in pipeline mid 2021:
 - 28 species, 37 localities

Contemporary duplicates mid 2021

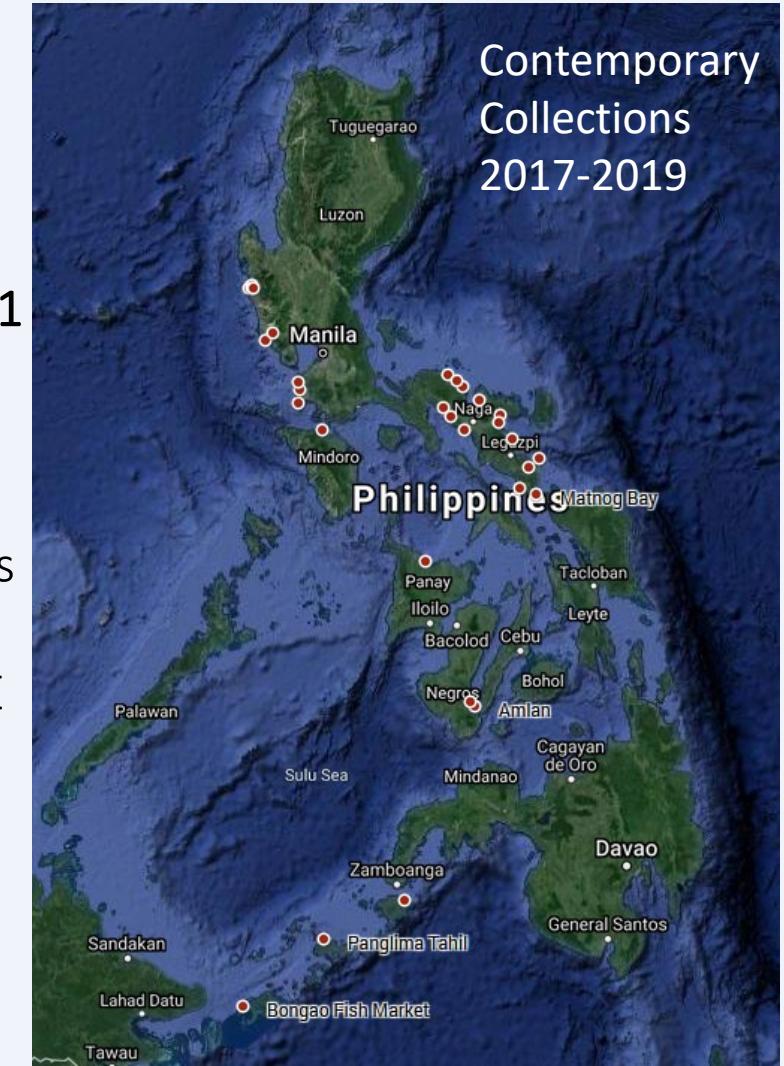
- 68 lots
- 23 species
- 29 localities
- COVID-19 hiatus

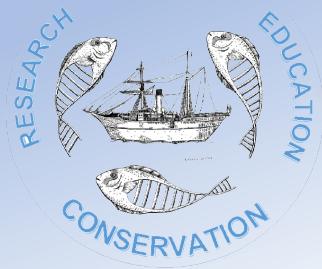
End 2021, 2022 expeditions:

Negros, Sulu A., Bohol, N&E
Samar, Ragay Gulf

Near Future: Palawan, Puerto
Galera, Bolinao, Romblon

Future: E. Leyte, Mindanao, N.
Luzon, Bicol 2, & misc.



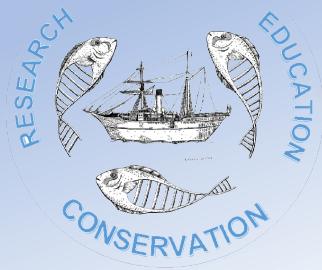


Unlocking Historical Genomes

- Precious genetic information is locked in museum specimens
- Formalin vs ethanol preserved
- Not much literature addressing NGS on old Ethanol preserved specimens like the Albatross collection
- Focus is on mitigating negative effects of DNA degradation
- RAD is most popular NGS method for non-model species, but sensitive to fragmented DNA common with historical specimens
 - In pilot we obtained 500 SNPs

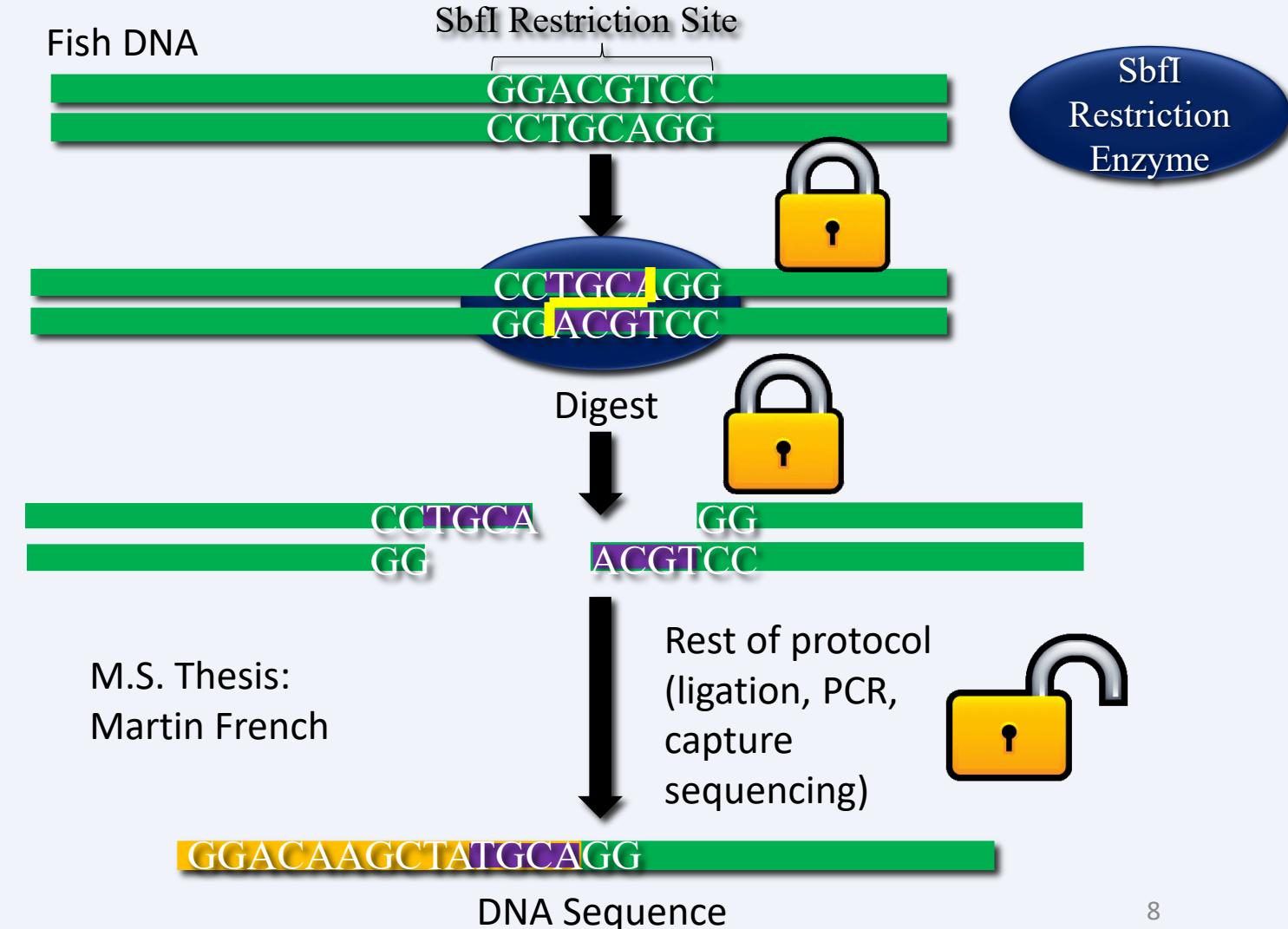


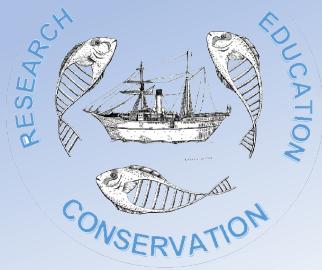
Ethanol preserved samples at the London Natural History Museum 2. Martin French, 2019.



Unlocking Historical Genomes

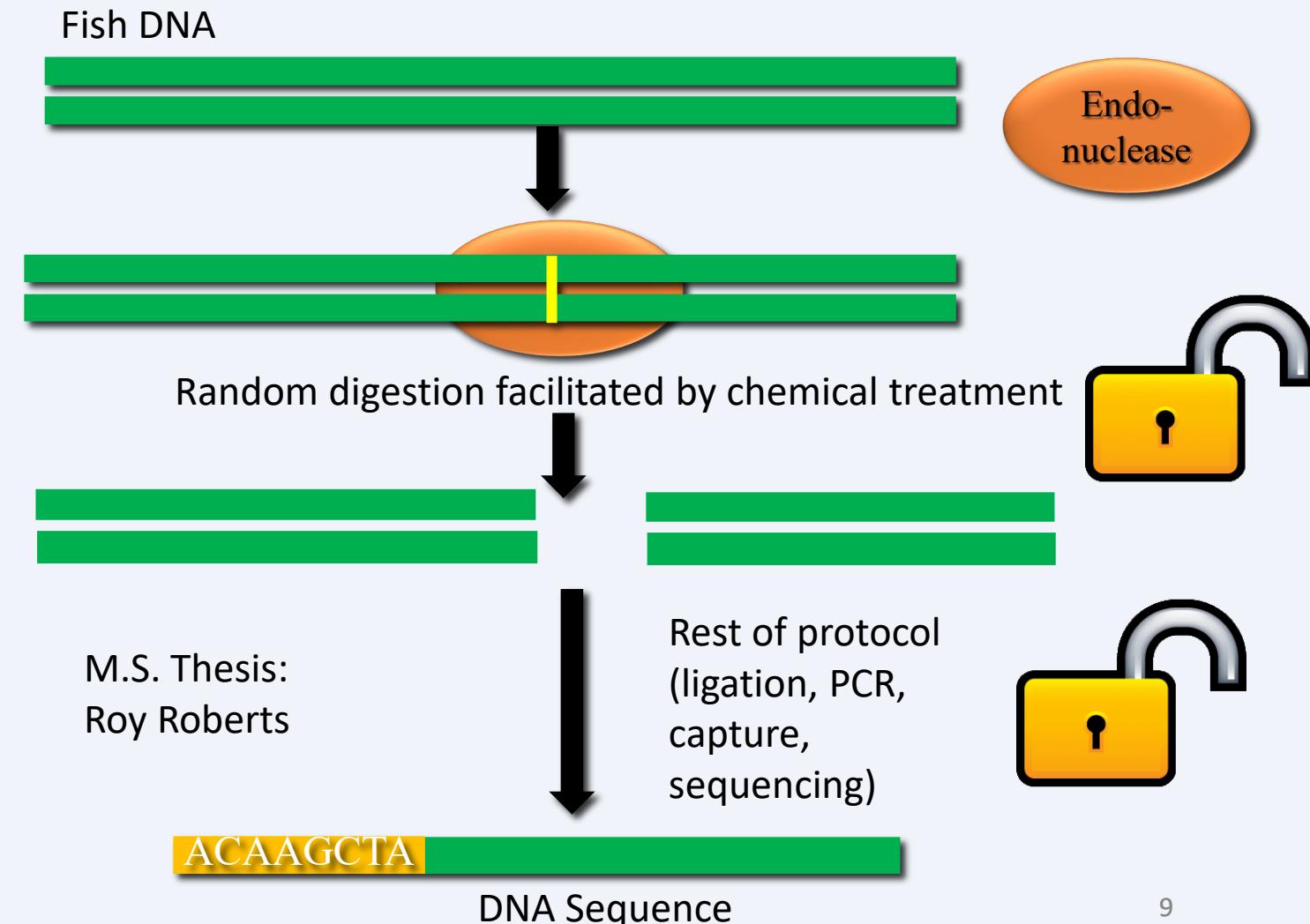
- RAD protocol too sensitive
- Enzyme-modifying contaminants inferred to be inhibiting sequencing success
- Inhibited and/or altered specificity of restriction enzymes & other enzymes

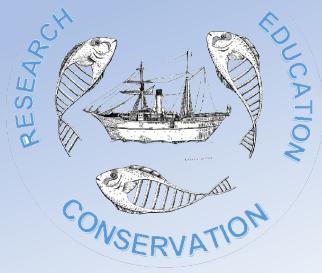




Unlocking Historical Genomes

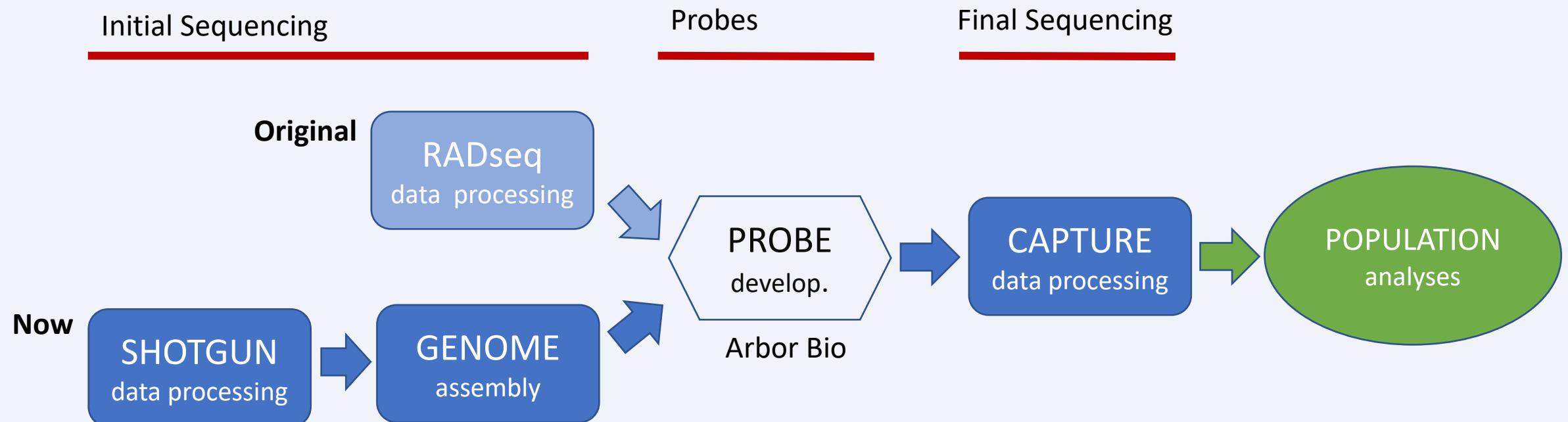
- Solution: Simple shotgun sequencing + target capture
 - Not sensitive to fragmented DNA
 - Avoids most severe effects of contaminants
- Tested effects of additional measures to mitigate DNA degradation
- Targeted sequences captured
 - **Success with 4/4 species**
 - **Historical & Contemporary**
 - **2000-40,000 SNPs**

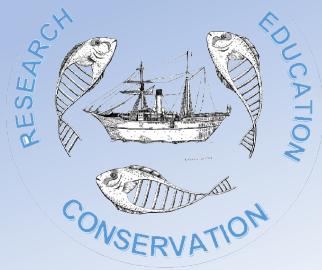




Unlocking Historical Genomes

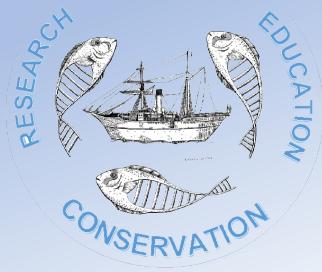
Bioinformatics | Genome assembly





Preliminary Genetic Results to Date

- Potential for lots of cryptic species diversity
- Have several species through time to enable temporal comparisons
- Slight to substantial decrease in genetic diversity consistent with reduction in population size but need to confirm
- Modeling also supports reduction in population sizes



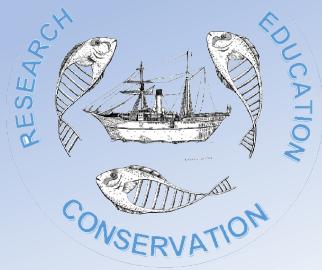
Research Plan and Future Activities

Q1. To what extent has genetic diversity been lost from marine fishes in the Philippines, and are some species more susceptible than others?

- Allele frequencies and diversity
- Effective population size
- Bottleneck signatures
- Signatures of selection



Equulites laterofenestra



Research Plan and Future Activities

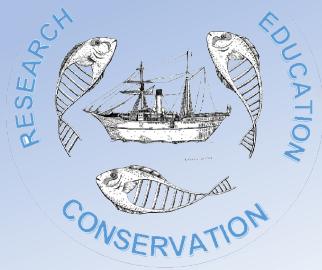
Q1. To what extent has genetic diversity been lost from marine fishes in the Philippines, and are some species more susceptible than others?

Targeted by commercial fisheries

- | | |
|----------------------------------|---------------------------------------|
| <i>Equulites laterofenestra</i> | <i>Sphyraena obtusata</i> |
| <i>Gazza minuta</i> | <i>Spratelloides gracilis</i> |
| <i>Spratelloides delicatulus</i> | <i>Salarias fasciatus</i> |
| <i>Doboatherina duodecimalis</i> | <i>Taeniamia zosterophora</i> |
| <i>Hypoatherina temminckii</i> | <i>Plotosus lineatus</i> |
| <i>Siganus spinus</i> | <i>Herklotichthys quadrimaculatus</i> |
| <i>Leiognathus equula</i> | <i>Halichoeres miniatus</i> |
| <i>Taeniamia biguttata</i> | <i>Gerres oyena</i> |

Not targeted by commercial fisheries

- | |
|---------------------------------------|
| <i>Atherinomorus endrachtensis</i> |
| <i>Ambassis urotaenia</i> |
| <i>Periophthalmus argentilineatus</i> |
| <i>Ambassis buruensis</i> |



Research Plan and Future Activities

Q2. Do overfishing and habitat loss reduce gene flow between marine populations?

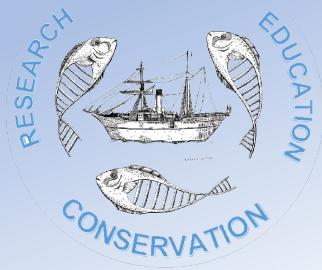
**Already
have**

Pelagic/Semi-pelagic species:

- *Hypoatherina temminckii*
1 - - 2 - - 3
- *Doboatherina duodecimalis*
1 - - 2 - - 3
- *Spratelloides delicatulus*
1 - - 2 - - 3
- *Spratelloides gracilis*
1 - - 3

Relative
Fishing





Research Plan and Future Activities

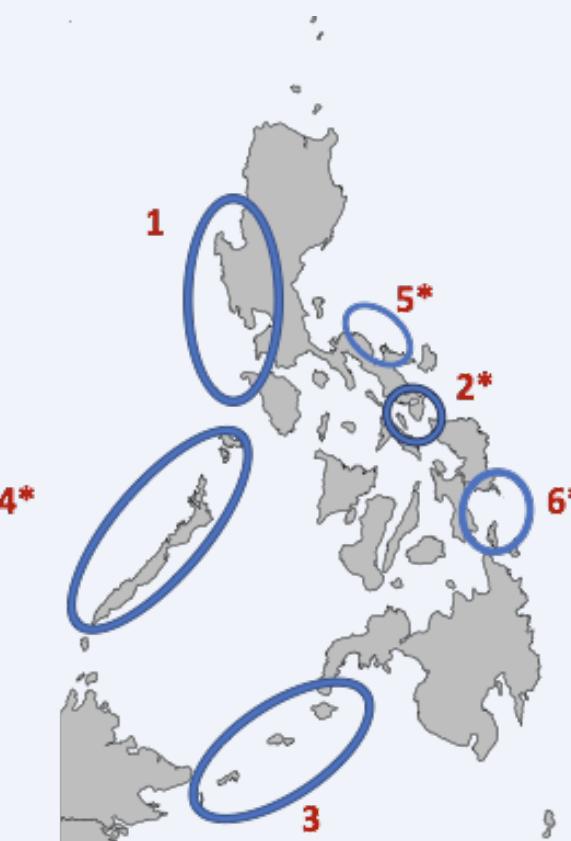
Q2. Do overfishing and habitat loss reduce gene flow between marine populations?

Hope to have

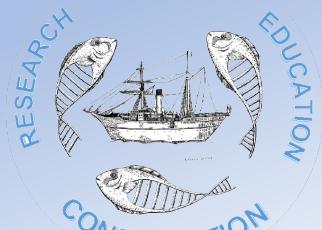
Pelagic/Semi-pelagic species:

- *Hypoatherina temminckii*
1 - 2 - 3 - 4*
- *Doboatherina duodecimalis*
1 - 2 - 3 - 4* - 5*
- *Spratelloides delicatulus*
1 - 2 - 3 - 4* - 5*
- *Spratelloides gracilis*
1 - 2* - 3 - 4* - 6*

Relative Fishing



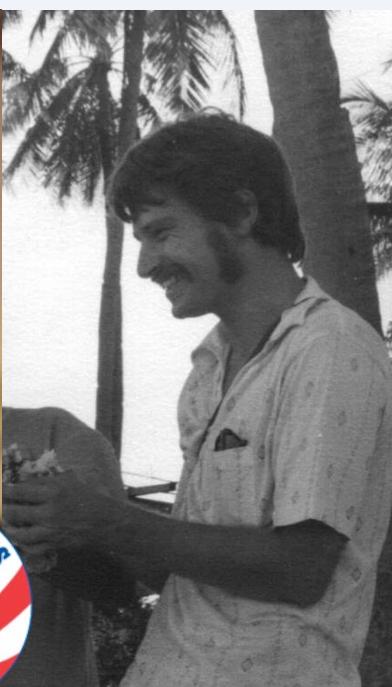
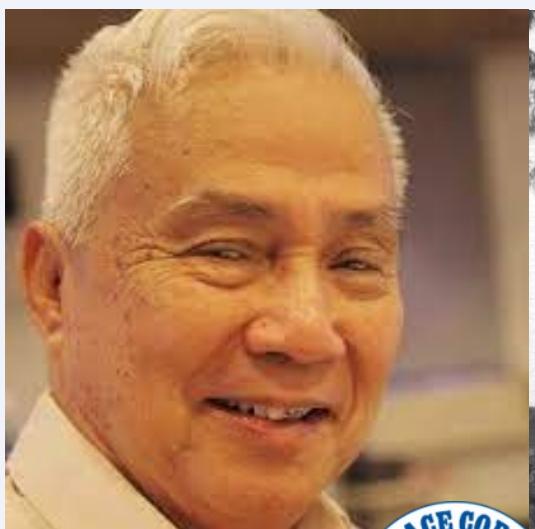
* = extra collections



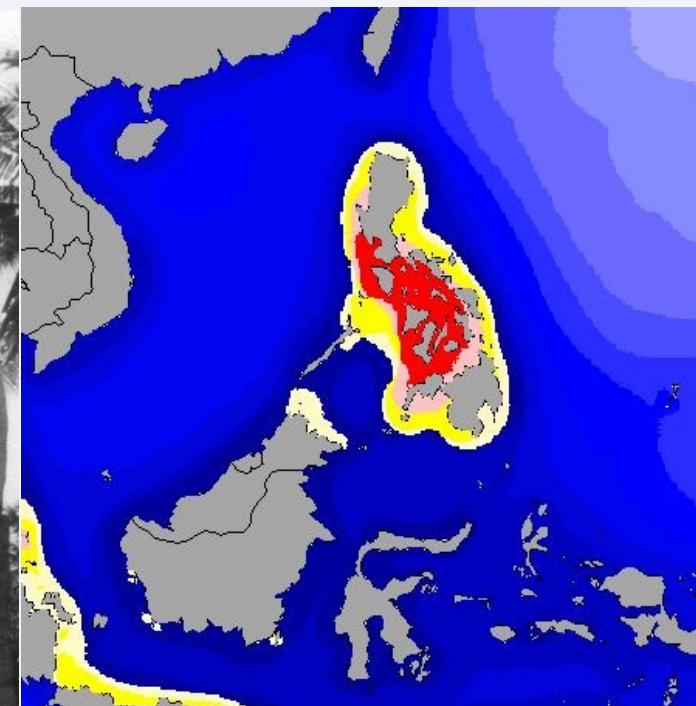
OVERARCHING RESEARCH QUESTION 2

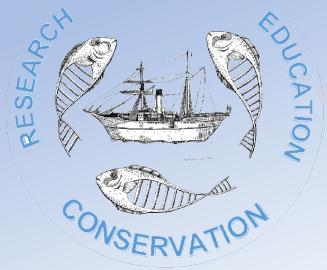
What **genetic** and **species** level changes have taken place over the past century of intense fisheries exploitation and habitat degradation in the Philippine global epicenter of marine biodiversity?

Species component made possible by the 1977-1978 Smithsonian expeditions: decadal vs. century changes



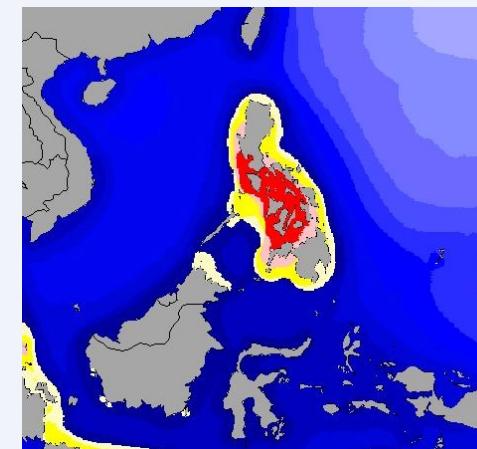
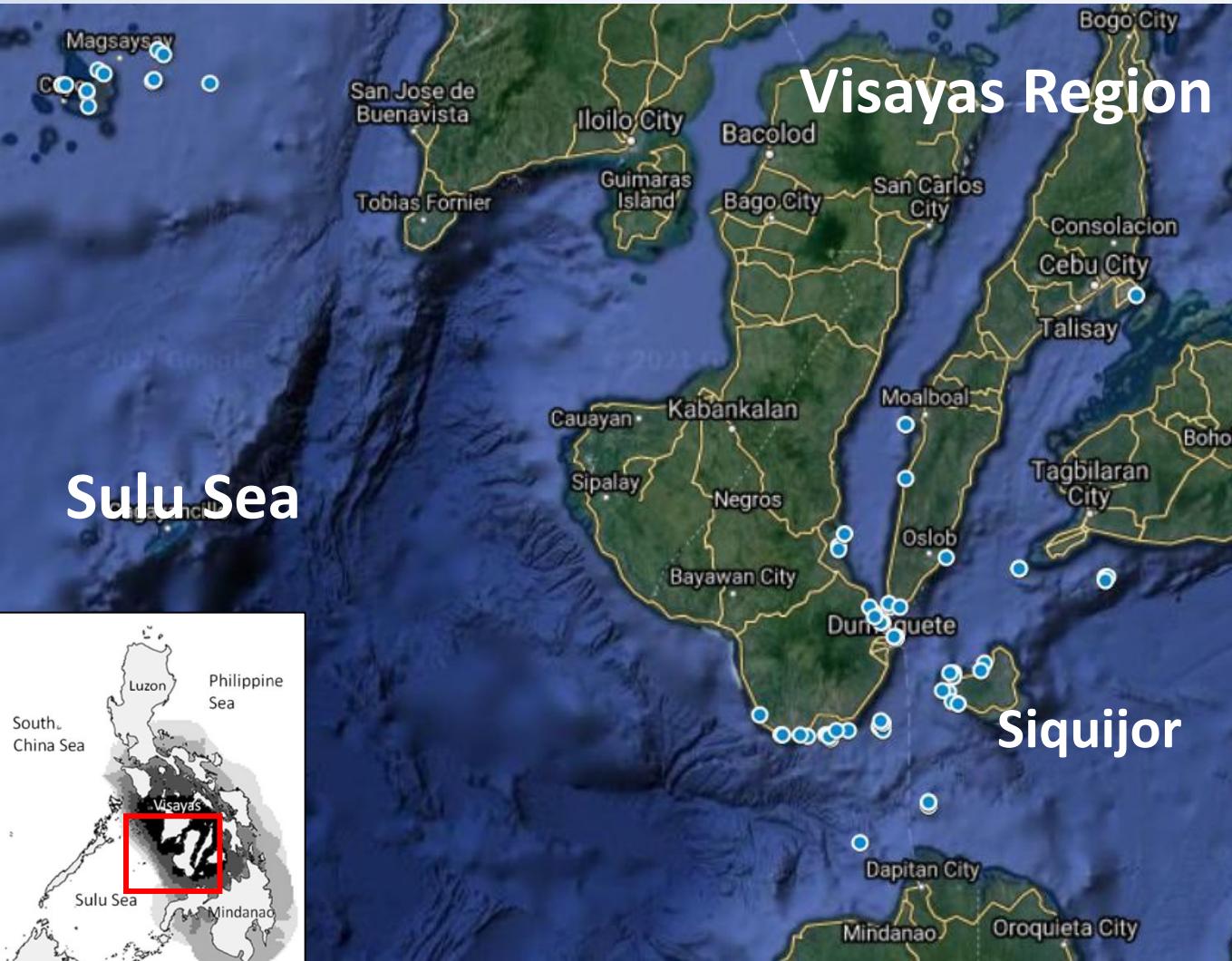
Smithsonian

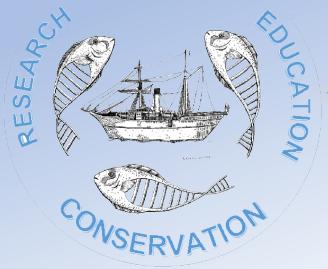




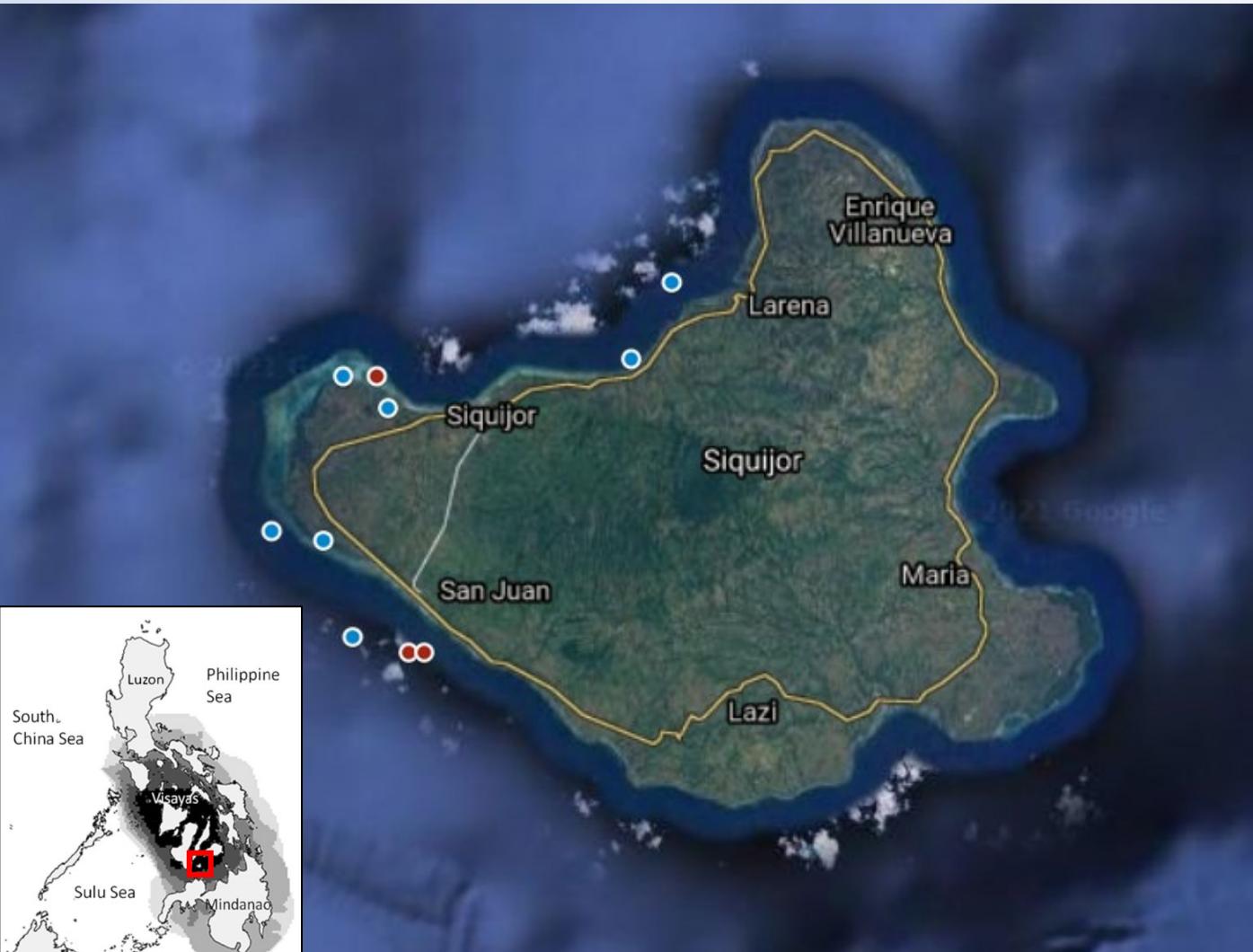
Decadal Biodiversity Changes

- Smithsonian Institution (SI)
 - 1978-1979
 - $n = 71$
- Rotenone stations used to identify changes in species richness
- Visayas Region
 - "center of the center of marine shore fish biodiversity" (Carpenter & Springer 2005)
 - "epicenter of conservation adversity" (Nañola *et al* 2010)

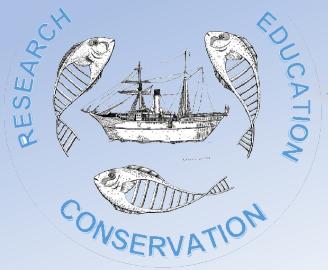




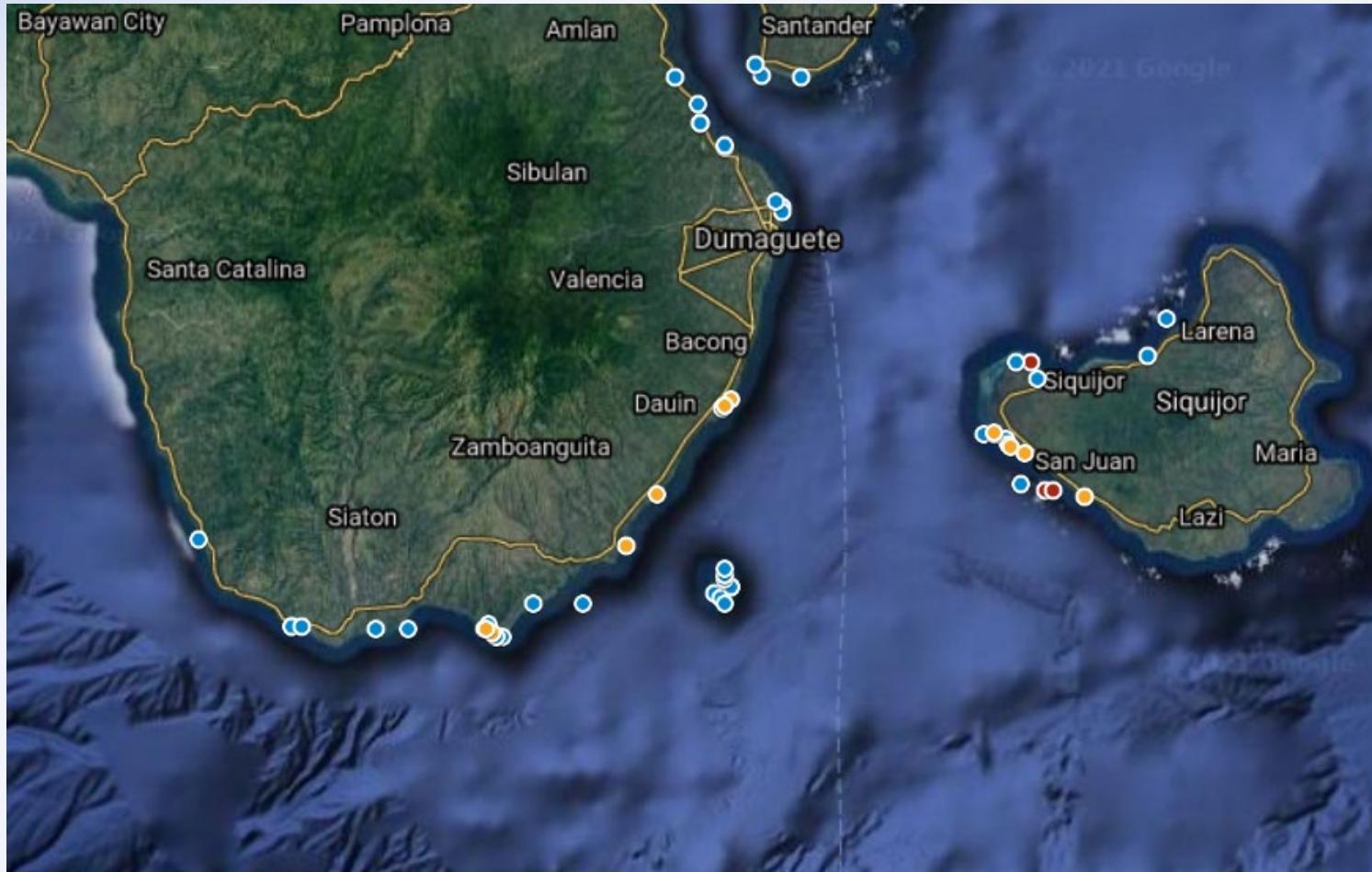
Decadal Biodiversity Changes



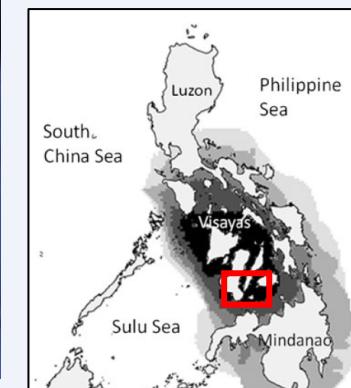
- **Smithsonian Institution (SI)**
 - 1978-1979
 - $n = 71$
- **Silliman University (SU)**
 - 2019
 - $n = 3$

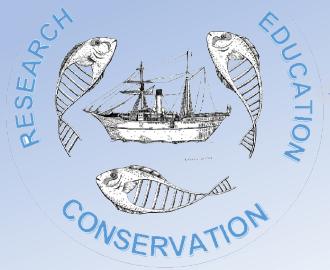


Decadal Biodiversity Changes



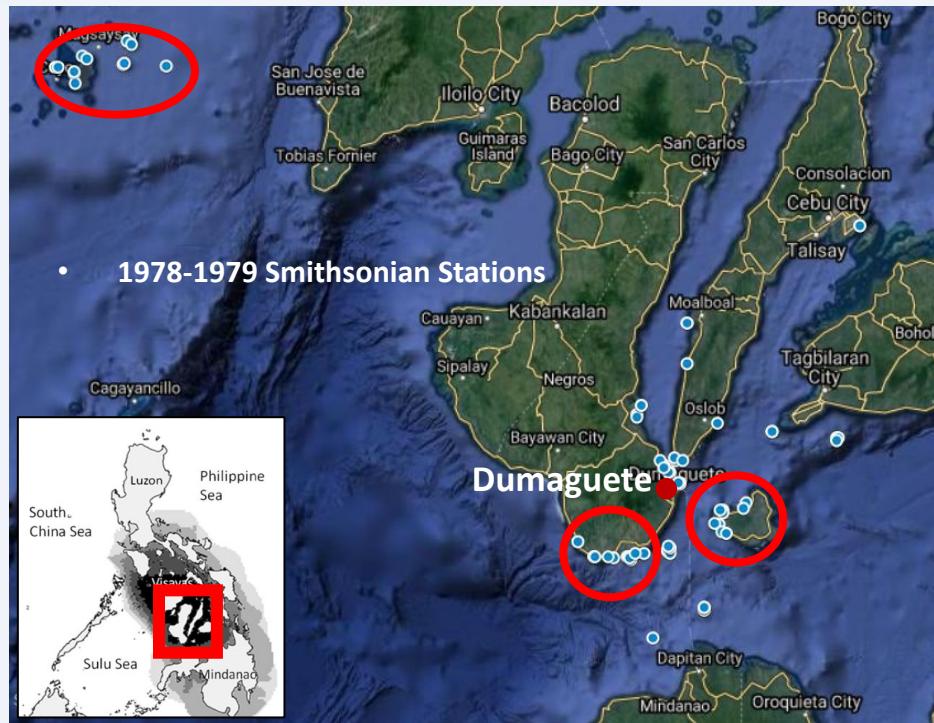
- **Smithsonian Institution (SI)**
 - 1978-1979
 - $n = 71$
- **Silliman University (SU) 2019**
 - 2019
 - $n = 3$
- **California Academy of Sciences (CAS)**
 - 2016
 - $n = 13$





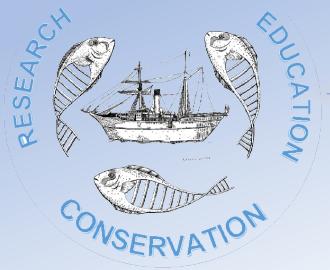
Decadal Biodiversity Changes

Research Plan and Future Activities: Field Work

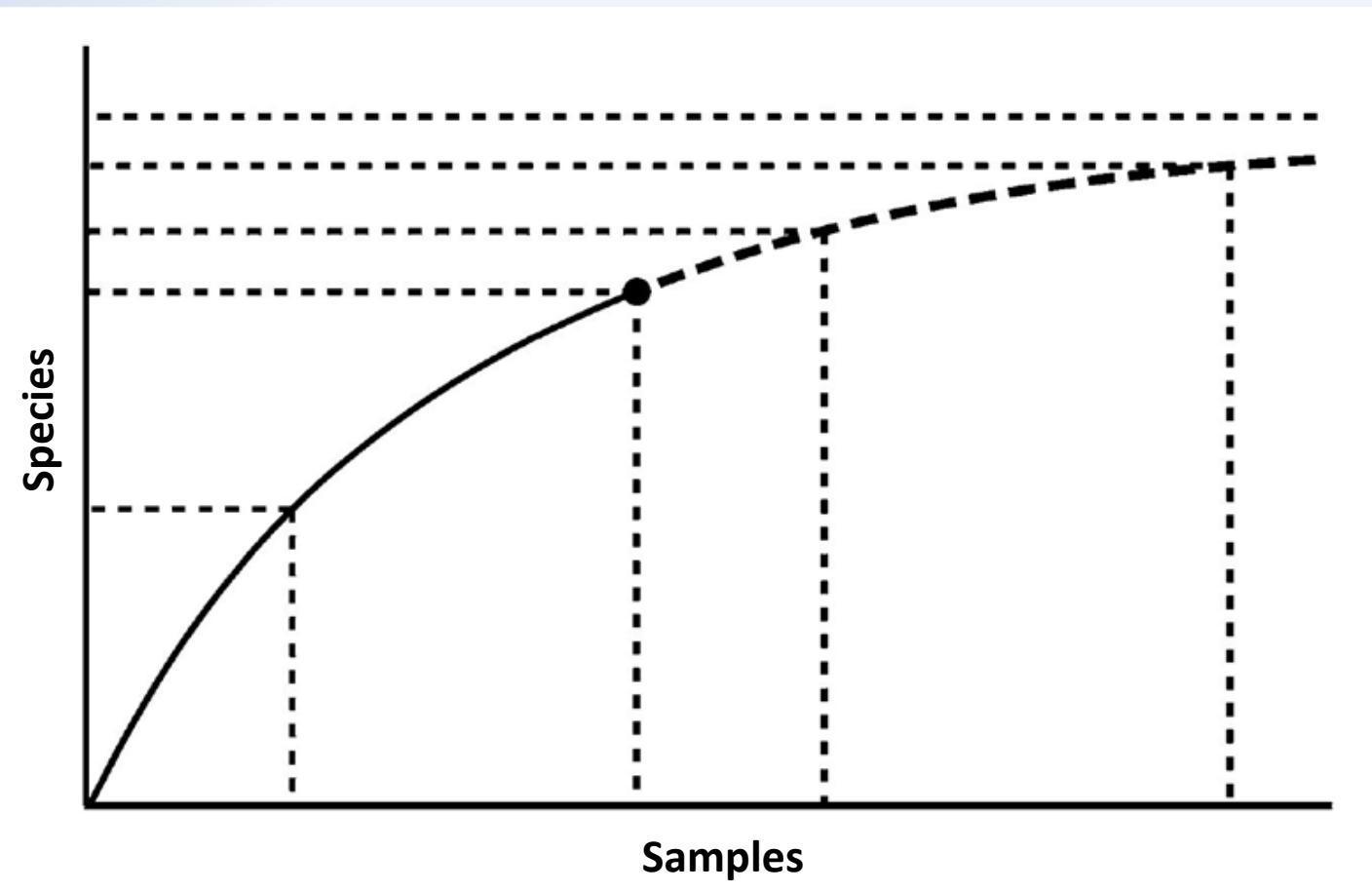


Plan was

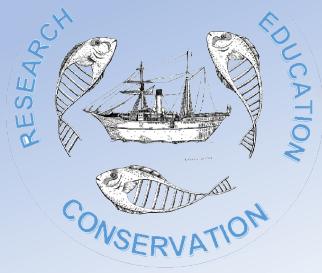
- 17 sites: May-June 2022
 - 18 sites: May-June 2023
- 2022 accomplishments so far
- 24: Cuyo done, Siaton done, Siquijor done



Decadal Biodiversity Changes

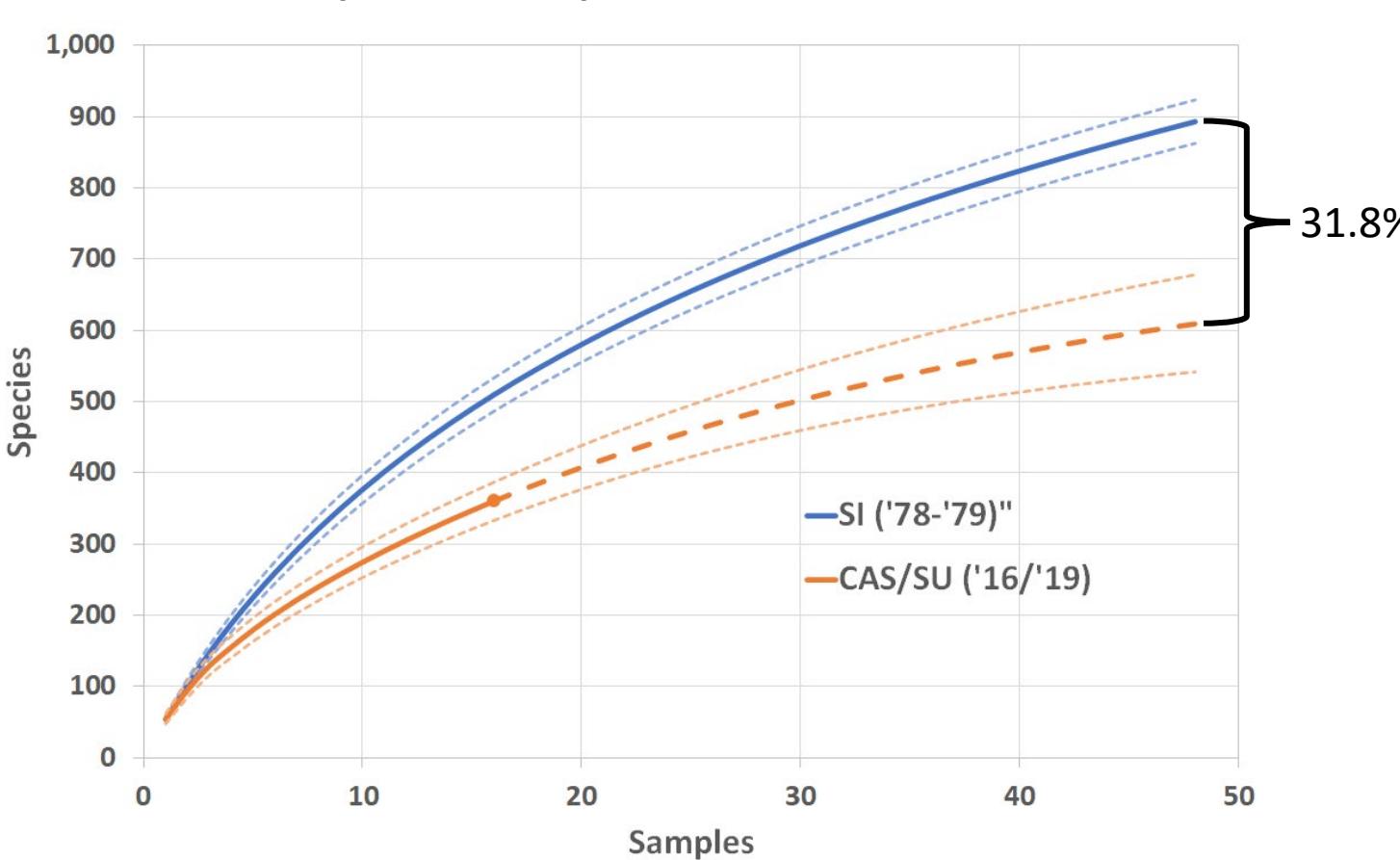


- Species richness increases non-linearly with
 - area sampled
 - # of individuals encountered
 - # of samples collected
- Sample- & individual-based abundance data used to create species accumulation curves
 - Interpolation
 - Rarefaction
 - Extrapolation

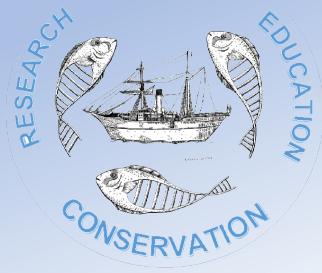


Decadal Biodiversity Changes

Sample-based species accumulation curve

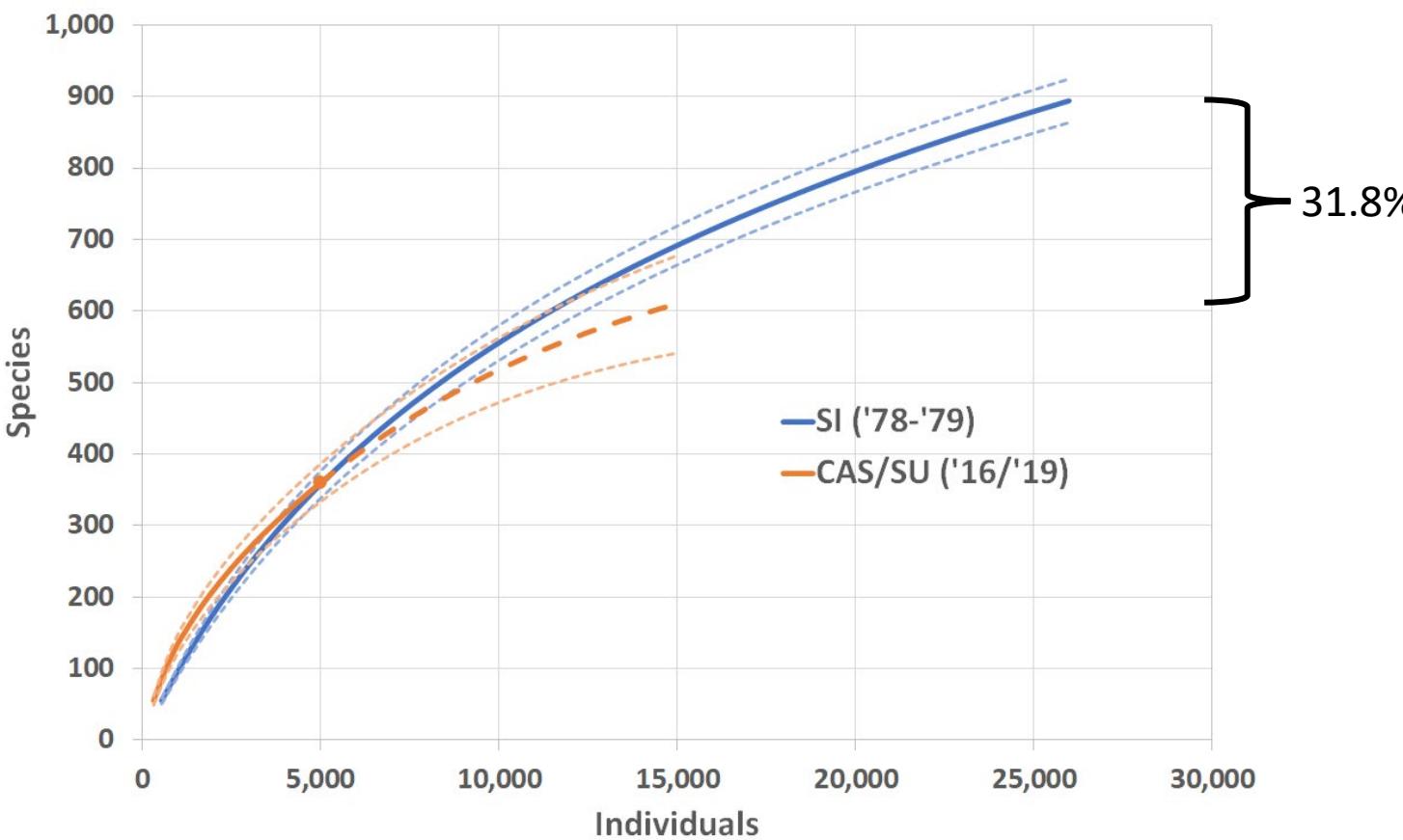


- **Smithsonian Institution (SI)**
 - 1978-1979
 - $n = 71$
- **California Academy of Sciences/ Silliman University (CAS/SU)**
 - 2016/2019
 - $n = 16$
- 31.8% reduction in species richness between 1978-1979 and 2016/2019 surveys
- **8.3% reduction/decade**

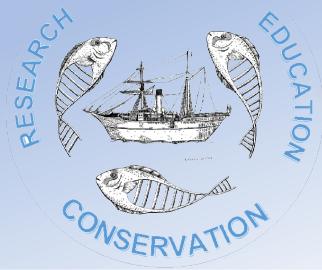


Decadal Biodiversity Changes

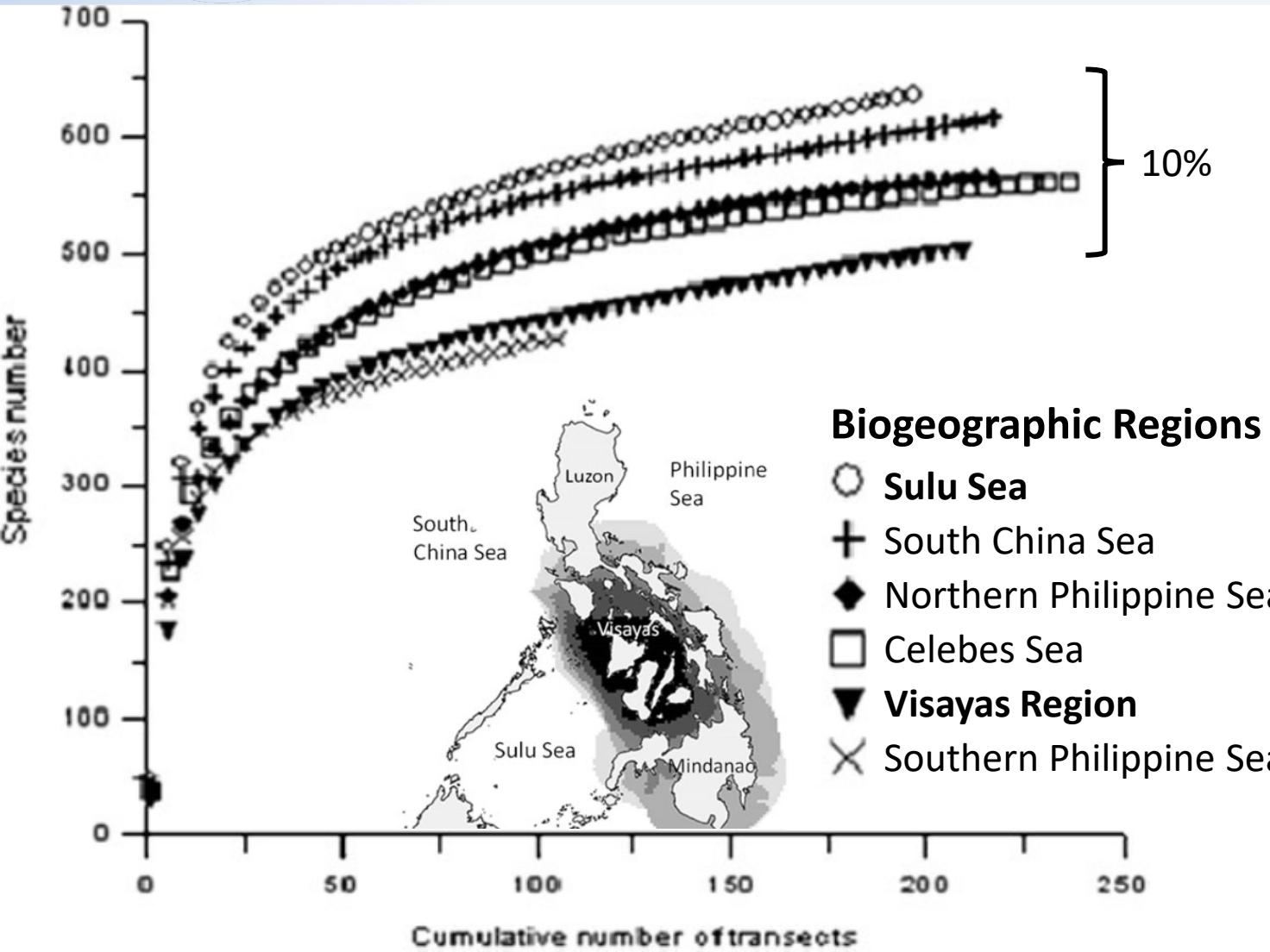
Individual-based species accumulation curve



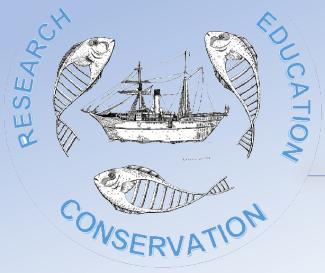
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Decadal Biodiversity Changes

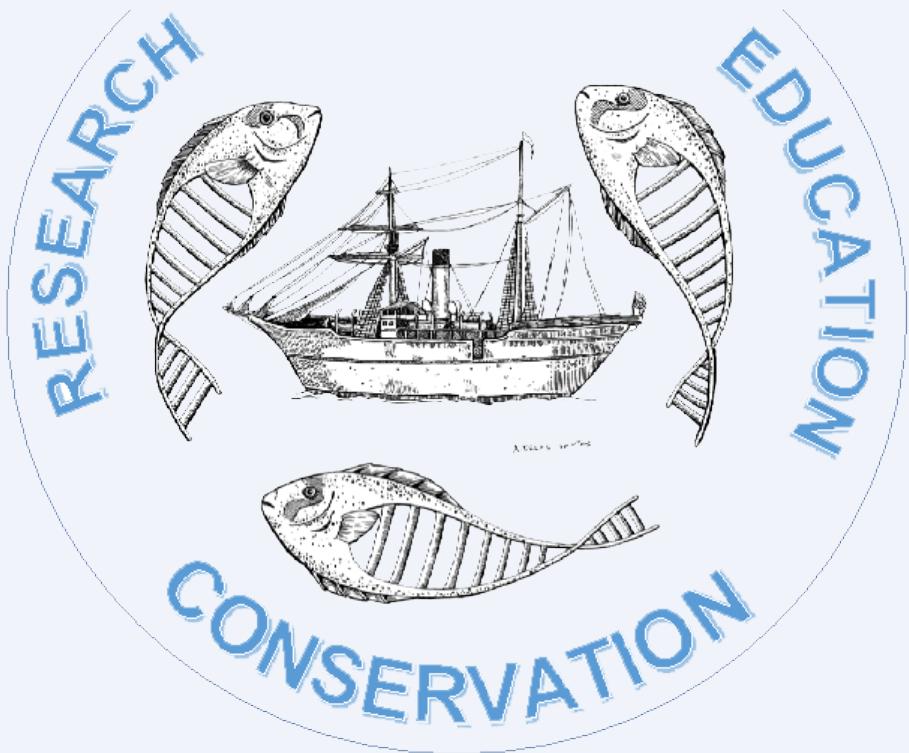


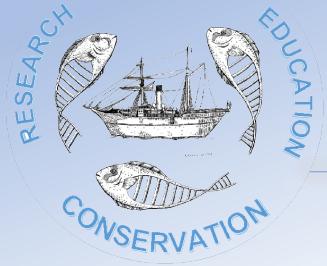
- 8.3% reduction/decade
- Nañola *et al* 2010
 - 10% reduction in species richness in the Visayas Region vs. the Sulu Sea
 - **2% reduction/decade**
 - Methodological difference
 - Fish visual census survey vs rotenone survey



Questions?

The Philippines PIRE Project





Introductions

Please introduce yourself

- Institution and PI
- Your current & future project(s)
- Something interesting about yourself

The Philippines PIRE Project

