Hybridization of *Sebastes maliger, Sebastes caurinus, and Sebastes auriculatus* in the Puget Sound Basin, Washington

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Photo by Jade Leutenegger

Importance of Hybridization

Evolution – Genetic diversity & speciation

African cichlids (Cichlidae family)

- Ancestral hybridization
- Model of rapid speciation
- Species-rich group
- Intraspecific variation

Speciation Reversal Theory (Seehausen et al. 2007)

- Speciation occurs by way of divergent adaptation in heterogeneous environments
- Loss of habitat heterogeneity allows for more interspecific gene flow
- Genetic homogenization reduces biodiversity

Importance of Hybridization

Conservation

- –Introduced species
  - • Secondary contact of introduced species
  - • Native Cutthroat Trout (*Oncorhynchus clarki*) – endangered native populations
  - • Rainbow trout (*O. mykiss*) - out of basin hatchery stocking

- –Altered habitats
  - • Mississippi River dikes changed natural water flow
  - • Pallid sturgeon (*Scaphirhynchus* albus) - endangered
  - • Shovelnose sturgeon (*S. platorynchus*) – large abundance

Research Organisms

Copper Rockfish

Sebastes caurinus

Brown Rockfish

Sebastes auriculatus

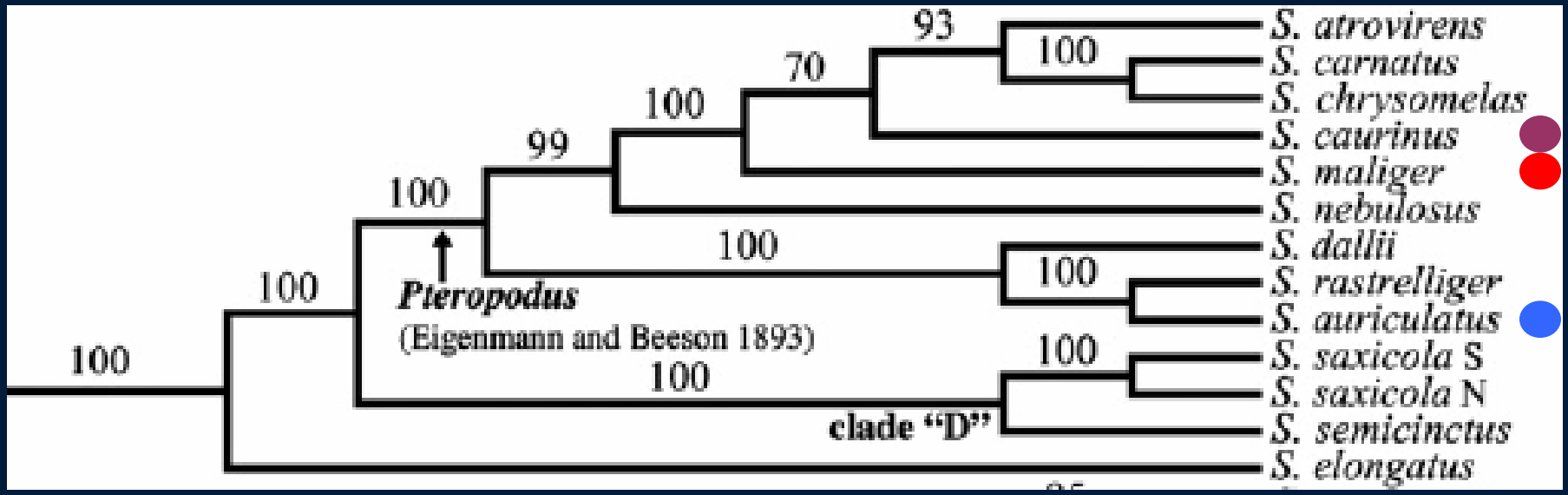
Quillback Rockfish

Sebastes maliger

- Closely related species
- Demersal adults associated with substrate structure
- Near shore species
- Long lived (30-55 yrs.)
- Pelagic juvenile life history
- Internal fertilization & live bearers

Photos: http://wwww.jongrossphotography.com

Genetic Phylogeny



- *Sebastes* is a species-rich group with over 65 species in the NE Pacific Ocean

- Copper, quillback, and brown rockfish closely related (Pteropodus sub genus)

Quillback

Brown

Copper

J Hyde & R Vetter 2007

Puget Sound Hybrids

- Previous genetic work identified hybrids in Puget Sound (L. Seeb, V. Buonaccorsi, and others)
- Puget Sound is a unique and changing environment where a species interaction such as hybridization is important to quantify

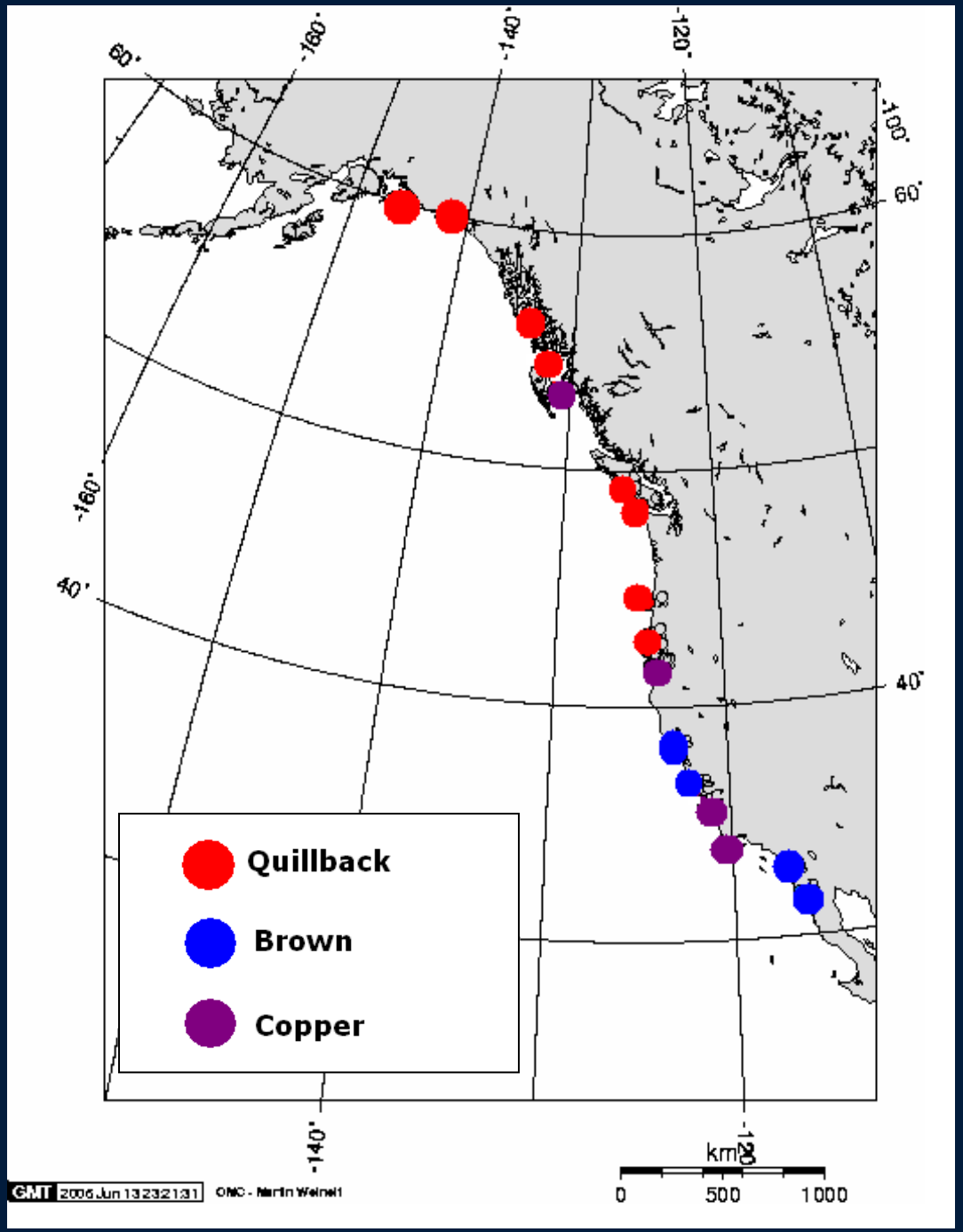
Research Questions

- Where and how much hybridization is going on in Puget Sound copper, quillback, & brown rockfish ?
- Is there a direction to interspecific introgression
  - Is there a species bias in hybrids?
  - Is there evidence of female (or male) mediated gene flow?
- Can we estimate the timing of hybridization events?

Coastal Samples

- SWFSC collection
- Coastal range represented in samples

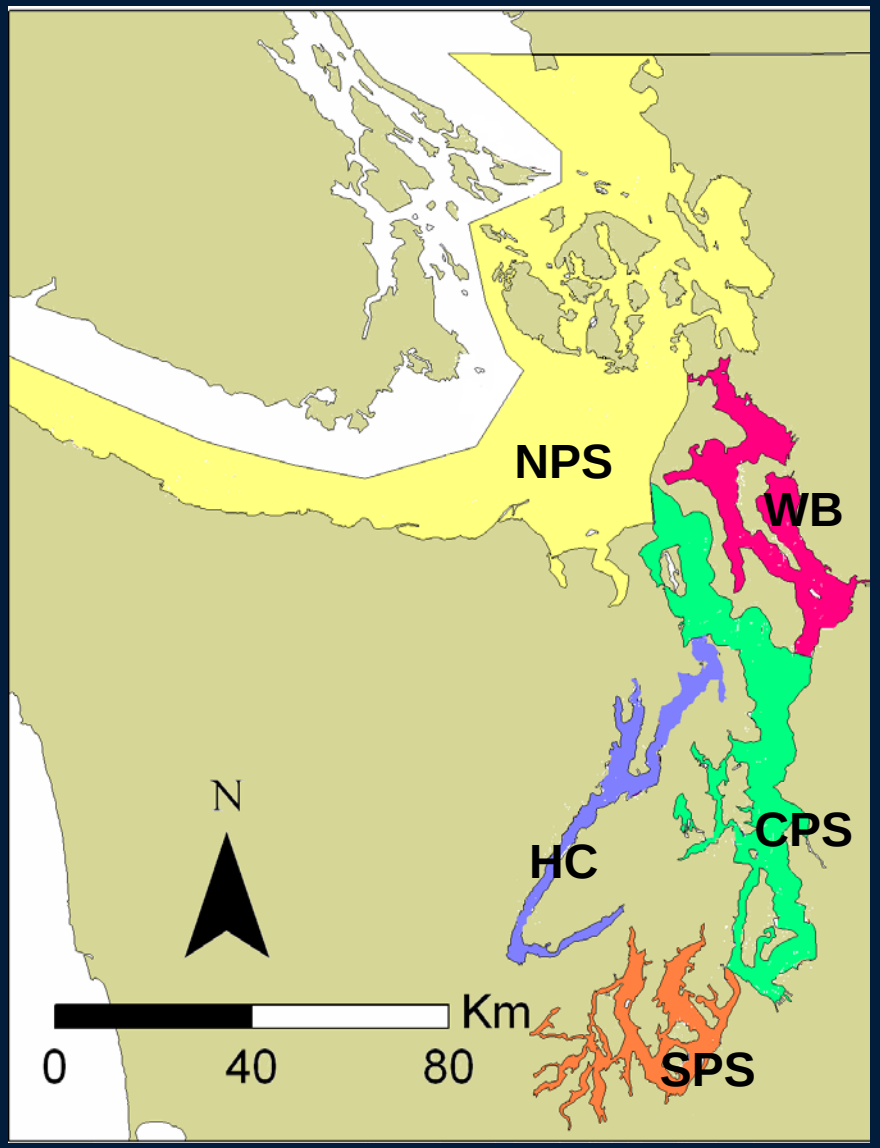
Species	N
Brown	*13*
Copper	*12*
Quillback	*16*
Total	*41*



Puget Sound Samples

Species	N
Brown	*24*
Copper	*33*
Quillback	*40*
Total	*97*

- North Puget Sound (NPS)
- Whidbey Basin (WB)
- Hood Canal (HC)
- Central Puget Sound (CPS)
- South Puget Sound (SPS)



Morphological species ID

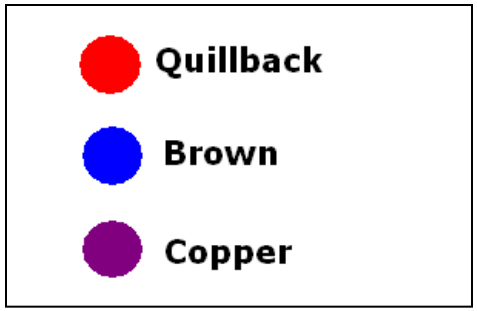
2002 WDFW Groundfish Survey – Wayne Palsson

Analysis Methods

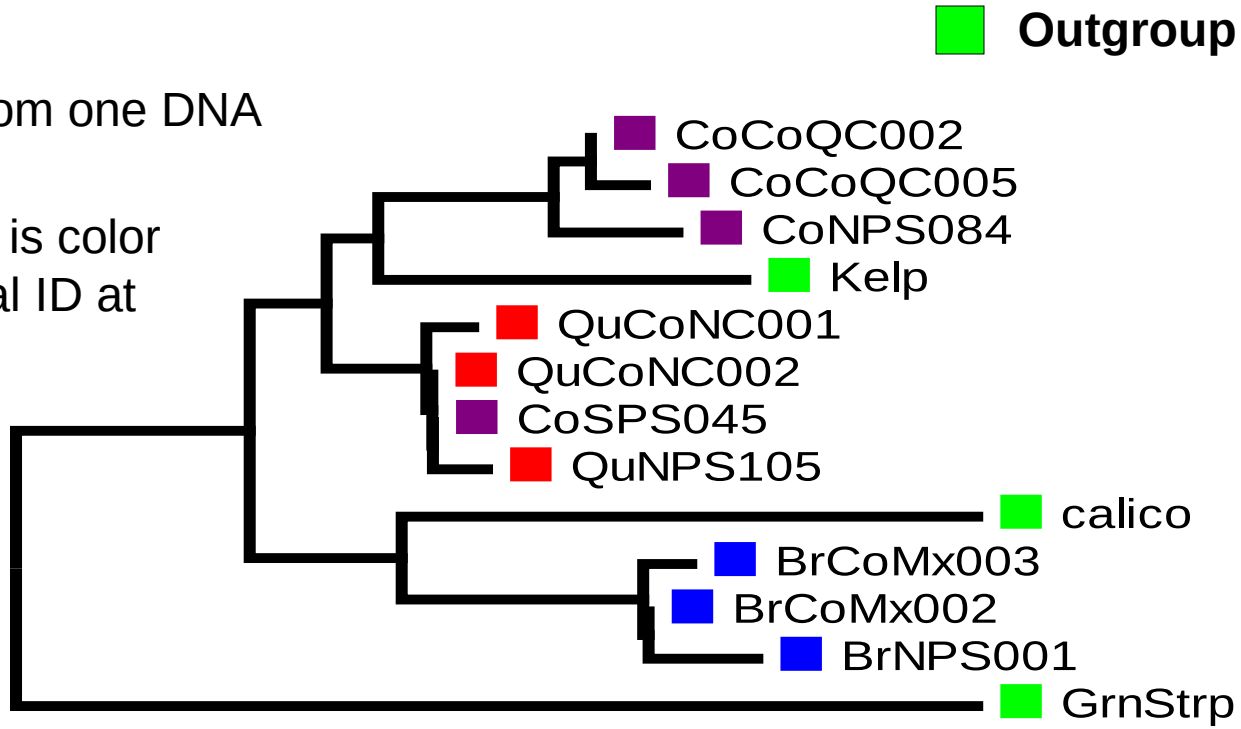
- Sequence 5 DNA markers
  - One mtDNA (maternally inherited) & 4 nuclear DNA markers (bi-parentally inherited)
- Phylogenetic analysis using mutation model implemented maximum likelihood (ML)
  - ML haplotype trees used to identify species specific groups (clades)
- Identification of hybrid:
  - Mismatch of DNA & morphological ID at one or more markers

Using trees to evaluate DNA introgressive hybridization

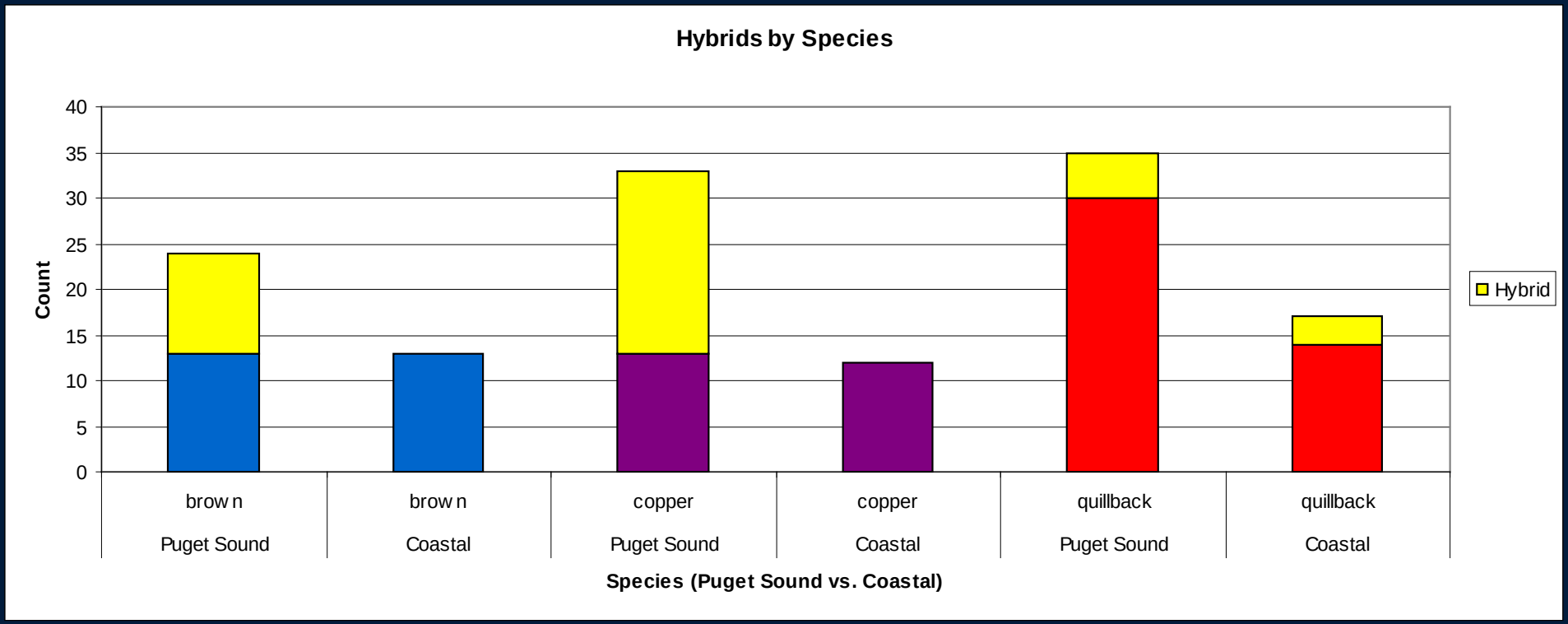
- More DNA markers are required to detect later generation hybrids
- Misidentified specimen : All DNA markers ≠ *morphology*
- Hybrid : on or more DNA marker ≠ morphology



- Partial tree results from one DNA marker
- Individual fish in tree is color coded by morphological ID at collection



Results: Hybrid counts



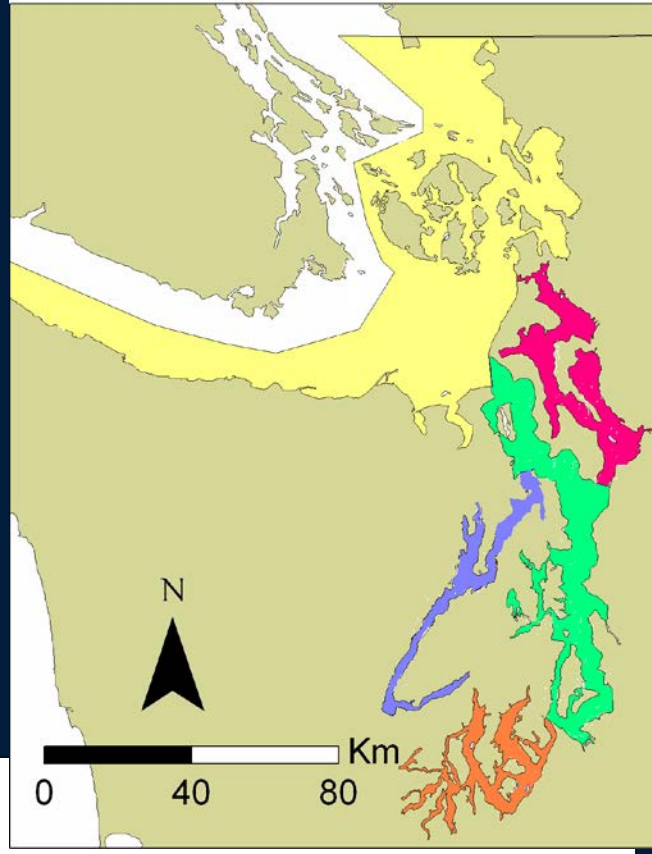
Brown **Copper** **Quillback**

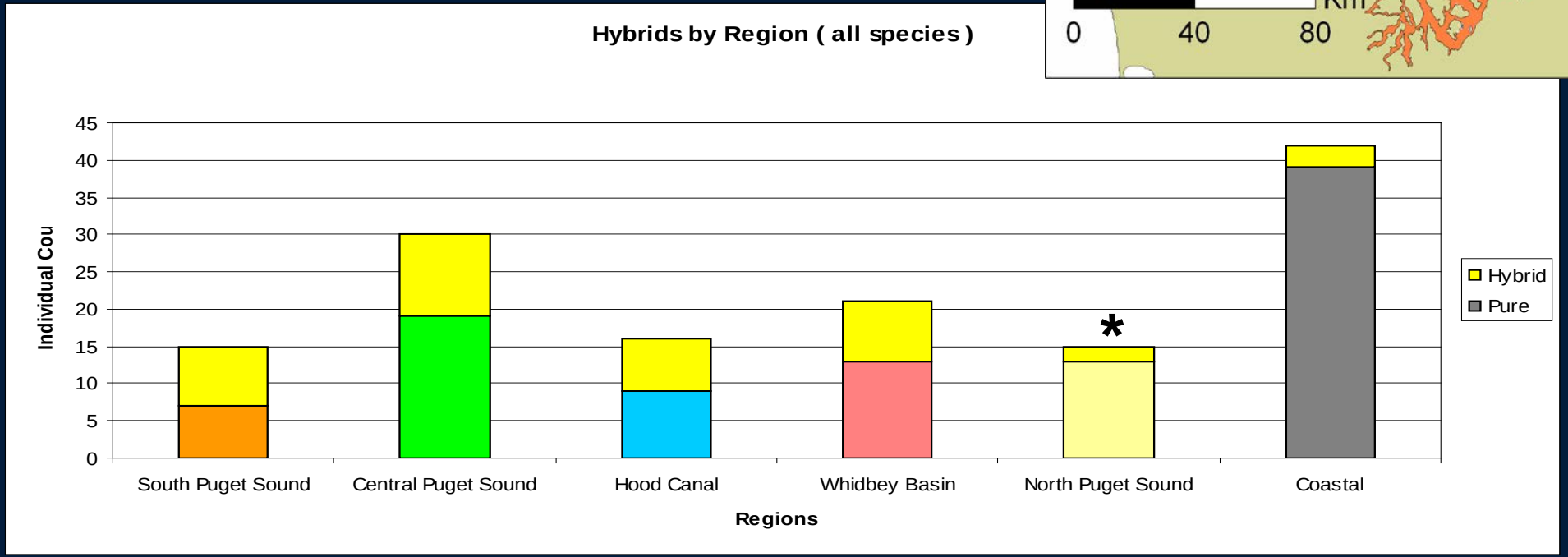
- ✓36 hybrids were identified in Puget Sound
- ✓Most were collected as copper or brown
- ✓2 quillback hybrids were identified on the coast
- ✓Fewer Puget Sound quillback were identified as hybrids

Results:

Hybrid counts by region – 3 species combined

- ✓ North Puget Sound - fewer hybrids
- ✓ North Puget Sound ~ coastal
- ✓ No differences among PS regions
- ✓~1/2 to 1/3 of samples were hybrids south of Admiralty Inlet



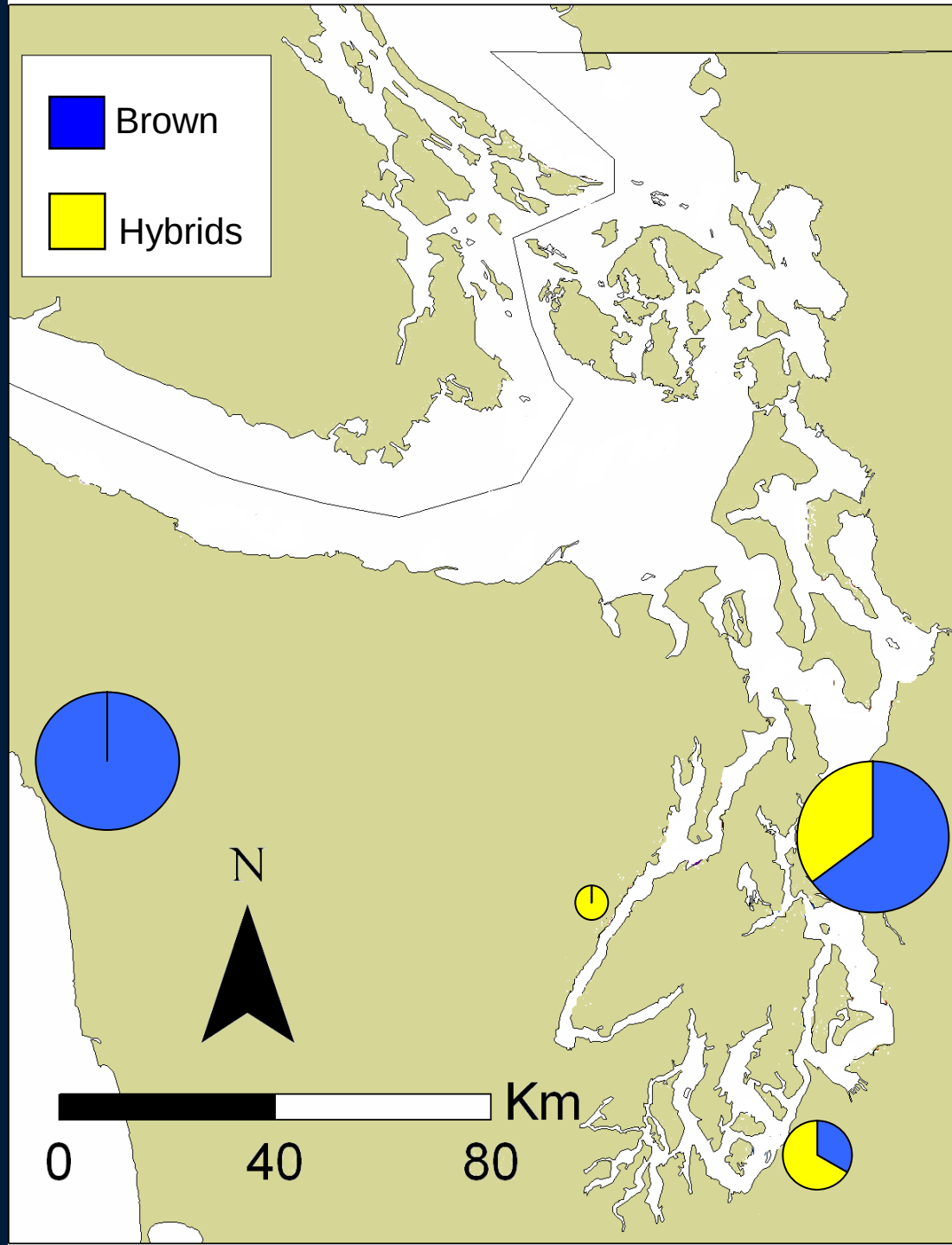


Results

Brown Rockfish

46% of Brown Rockfish in Puget Sound were hybrids (N = 24)

Zero from the coast (N=13)

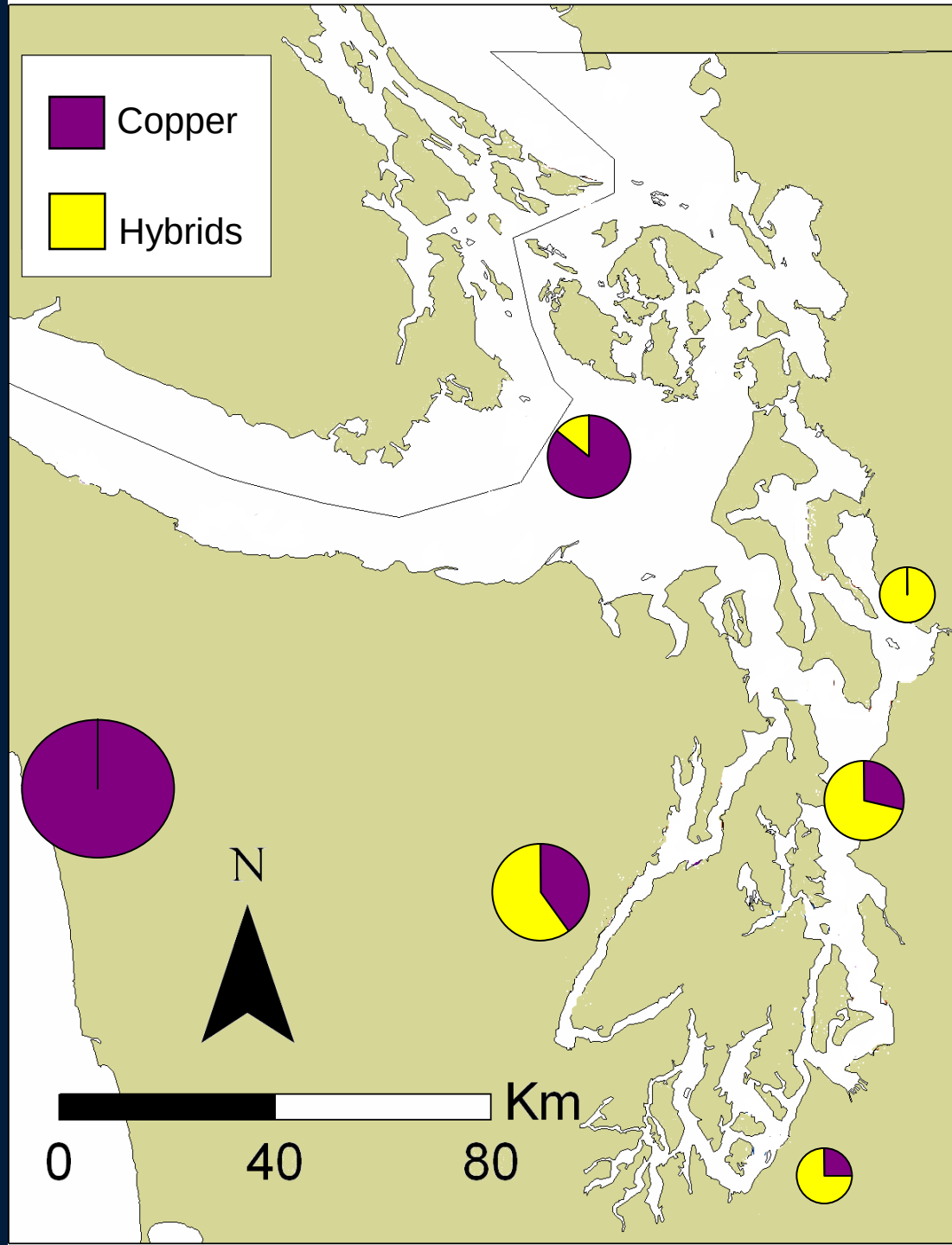


Results

Copper Rockfish

61% of Copper Rockfish in Puget Sound were hybrids (N = 33)

Zero from the coast (N = 12)

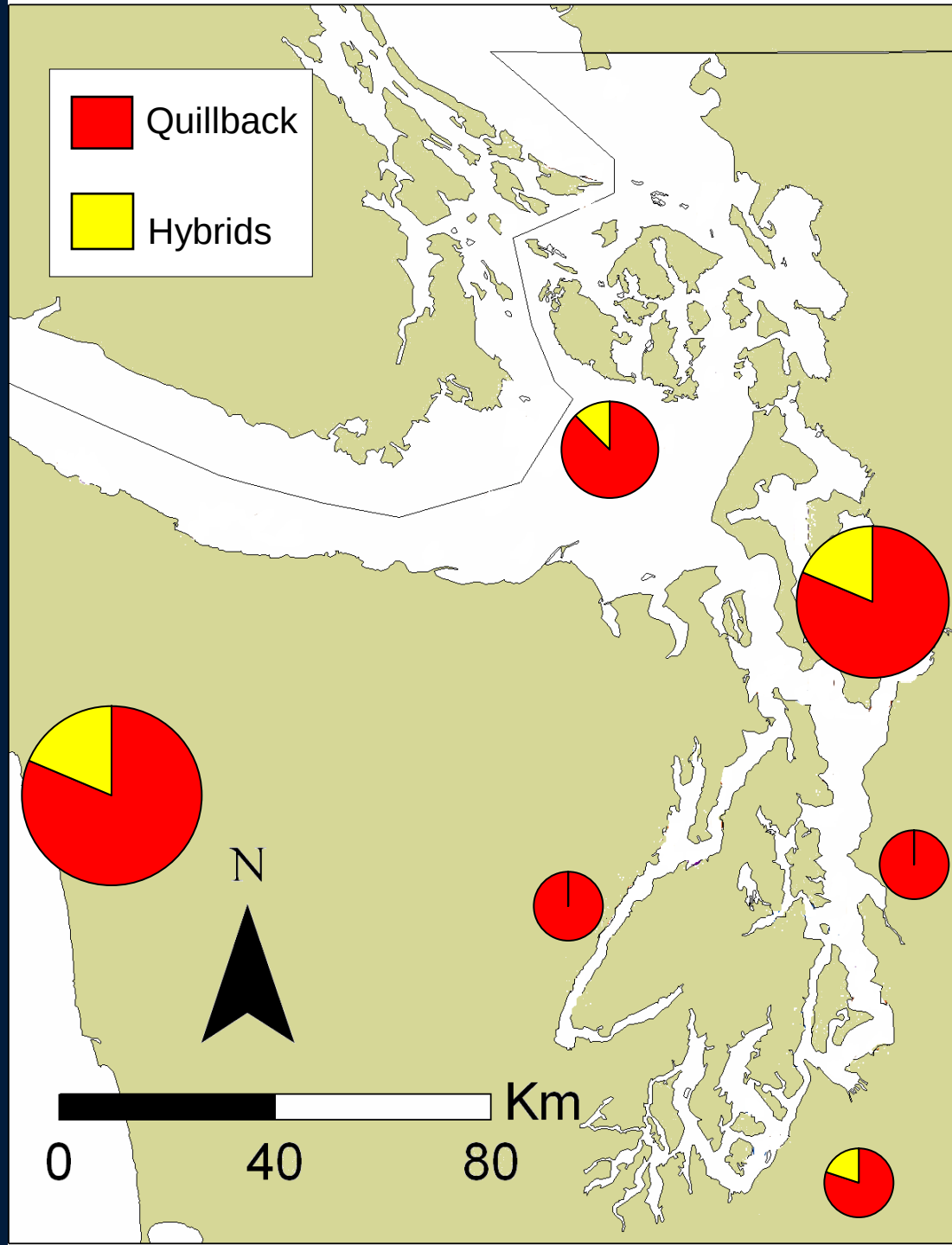


Results

Quillback Rockfish

14% of Quillback Rockfish from Puget Sound were hybrids (N = 40)

13% from the Coast were hybrids (N=16)

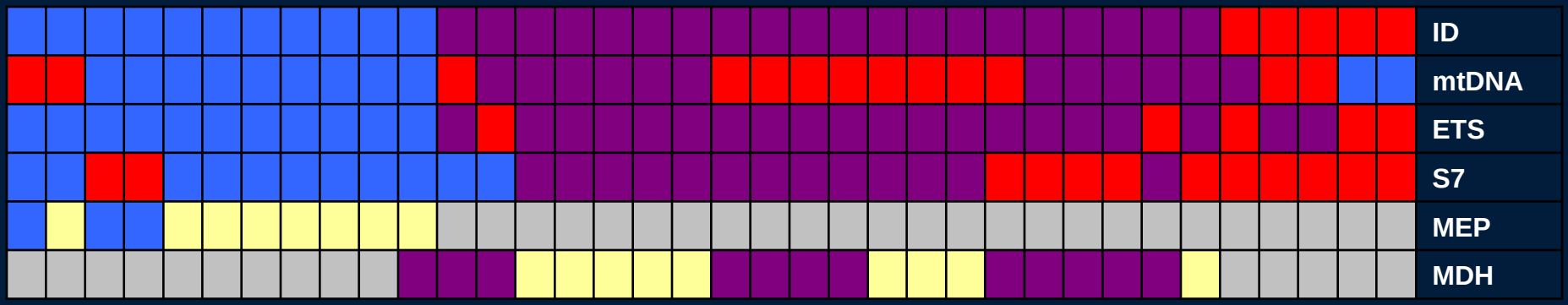


Detailed Results for hybrids

Brown
Copper
Quillback
Marker cannot resolve
Marker ≠ collection ID

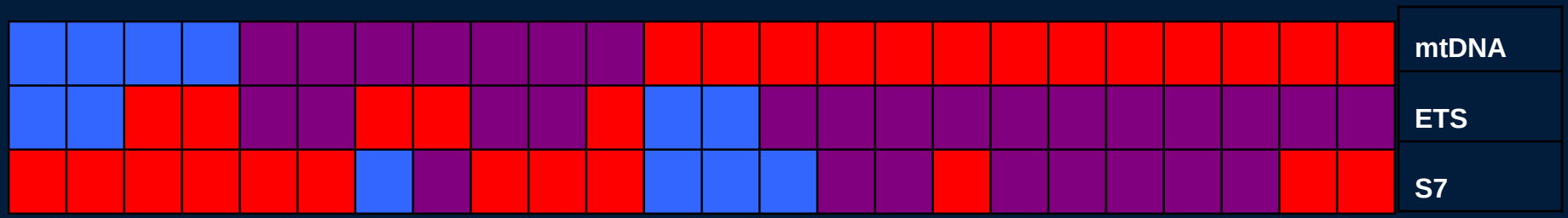
Species direction of hybridization

- Species bias in hybrids



Male/Female direction of hybridization

- sex bias in hybrid mating (mtDNA ≠ nDNA)



Summary of Results

- *One third of our Puget Sound copper, quillback, and brown rockfish samples were hybrids*
- *All hybrids were later generation hybrids (no F1s)*
- *A few hybrids were found with mixed ancestry from 3 species*
- *No hybridization in coastal copper and brown rockfish were detected.*
- *Both coastal quillback and Puget Sound quillback samples had a lower incidence of hybrids.*
- *Most of the hybridization is between copper/quillback*
- *No evidence of sex bias in hybrid mating*

What does this mean?

Management – How do we protect species hybrids or species with hybrids?

Evolution – Hybridization may be a natural process in post glacial fjord populations.

Conservation – Impact of hybrids on depleted stocks and their ability to recover

- Do nearshore habitat alterations impact species hybridization?

- Is there a potential for speciation reversal?

Thank you

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