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Net-pen culture of *Seriola dumerili* in Mediterranean: implications for the sustainable management

Tanja Šegvić Bubić

Igor Talijančić, Iva Žužul, Luka Žuvić, Leon Grubišić, David Izquierdo-Gomez
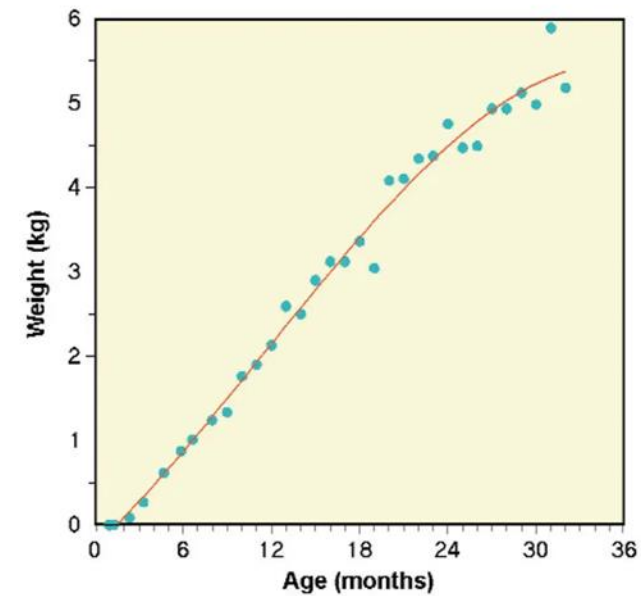
Introduction

- A good candidate for diversification - desirable production traits!
  - Fast growth
    - Growth rate 10x higher then the European seabass
    - Can reach 6 kg in 2.5 years of farming
  - Exellent flesh quality and global market
  - Strong potential for export
    - congener species are produced commercially elsewhere
  - Suitable for products with added value
    - Due to large size can be marketed as whole or as processed food

- To cope with climate change, the greater amberjack provides an opportunity to fill emerging niches in marine warm water cage culture.
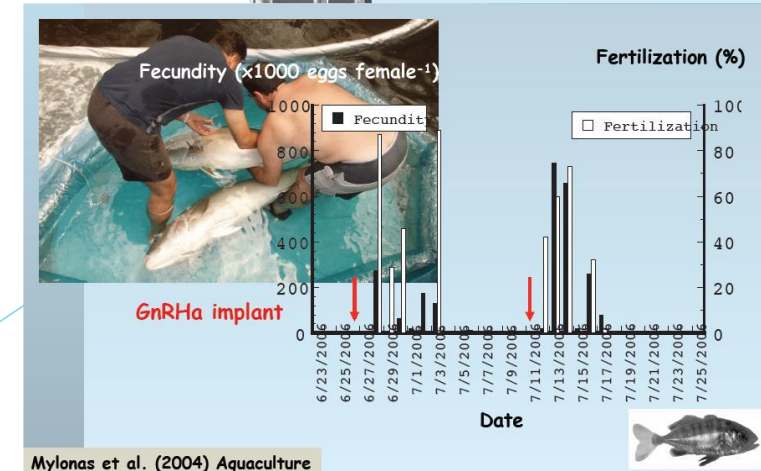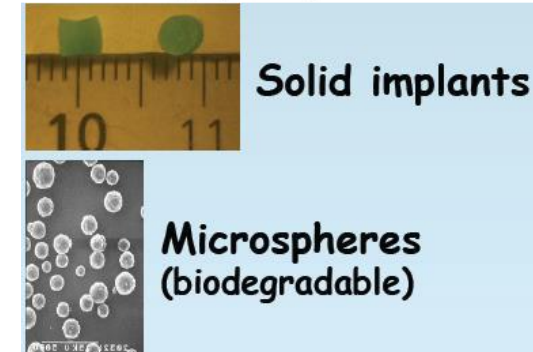
Greater amberjack farming in the Mediterranean ....

- Started in the 80s with capture-based activities using wild juveniles
  - Fish of cc 90 g reached cc 1kg in a year, standard culture condition in cages
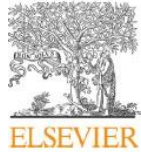 - Feeding on fresh fish passing quickly to artifical feeds

Hatchery-produced individuals ????

- major bottlenecks for the development industrial production:
  - broodstock reproductive dysfunctions, suboptimal feed formulations, disease outbreaks and/or fingerlings supply

- EU project FP7 Diversify, Greek project MAGIATIKO and the Spanish SERIOLA project
  - fully controlled captive life cycle has only recently been established
  - Commercial farming in the EU is still very low, with Greece (21 t) and Spain (18 t) as the main producers

Solid implants

Microspheres (biodegradable)

Fecundity (x1000 eggs female⁻¹) Fertilization (%)

GnRHa implant

Mylonas et al. (2004) Aquaculture

Fisheries Research

Two seas, two lineages: How genetic diversity is structured in Atlantic and Mediterranean greater amberjack *Seriola dumerili* Risso, 1810 (Perciformes, Carangidae)

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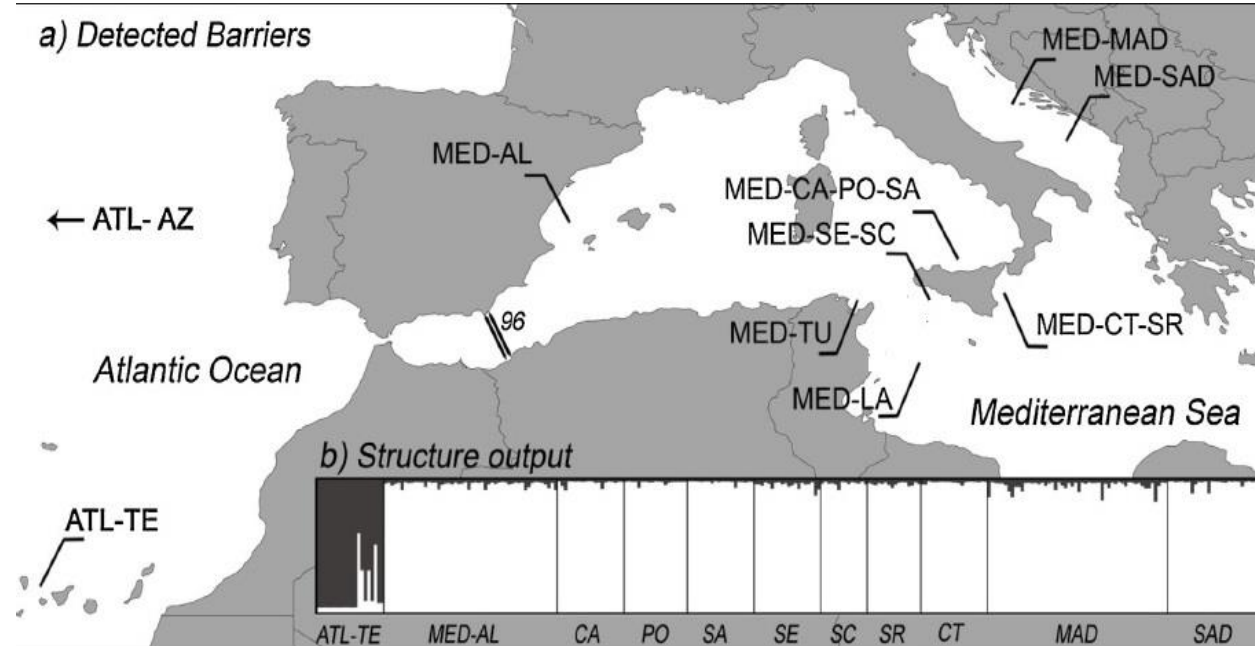
ABSTRACT

The vastness of the ocean and our limited ability to observe and monitor the organisms therein make molecular markers particularly useful tools in the ... of the ecology and evolutionary biology of fish. Nowadays, due to increased demand of fish foo... focused on new candidate species for aquaculture, such as *Seriola* species. Here, ... microsatellites loci and three mitochondrial (mt)DNA genes (16S, ... amberjack, *Seriola dumerili*, det... sumably arisen by the oceano... species. Still, an absence of he... was noted, although an obse... clades, with no spatial divisi... Pleistocene or Holocene co... In addition, some prelimina... been recently recognized as ...

• From a management perspective, *S. dumerili* from the Med and eastern Atlantic should be considered and managed as two separate, genetically distinct stocks or management units

• with industry expansion, we recommend the use of locally derived broodstock, where possible, to achieve maximum stocking success and to minimize potential disruption of locally adapted populations through fish escaping from farms

Commercial juvenile production in the Europe

▶ Production of fingerlings is still low, with FuTuna - Spain supplies its own market and other Mediterranean countries

▶ No information about size and genetic origin of broodstock

▶ New projects in Spain are initiated - RAS hatchery with production capacity of 5 million seriola fry and 15,000 tons by 2027

Storm Gloria: giant waves smash into the west Med

- Escape of millions of fish into the wild

escaped Seriola at fish market

wild Seriola at fish market

➤ Problem??? Escaped vs. wild fish – competition for space and trophic resources
  ➤ represent a potential vector of diseases and parasites
  ➤ impact on genetic diversity of local fish populations through hybridization
 ➤ Fitness reduction

Aims:
- ► exploring the morphological and/or genetic traits as proxies for origin discrimination of *S. dumerili*
- ► evaluating the potential implications of escaped *S. dumerili* into the ecosystem

- ➢ data set of **492 samples**: the Balearic and the Adriatic Sea
- ➢ two sets:
- • *historical dataset* from 2013 to 2018 collected prior to the development of commercial aquaculture
- • *contemporary dataset* from 2020 to 2021 from wild and farmed stocks in recent years + *escaped fish after storm Gloria*

- • *Microsatellite genotyping- 15 loci*
- • *Geometric morphometrics – 20 landmarks*
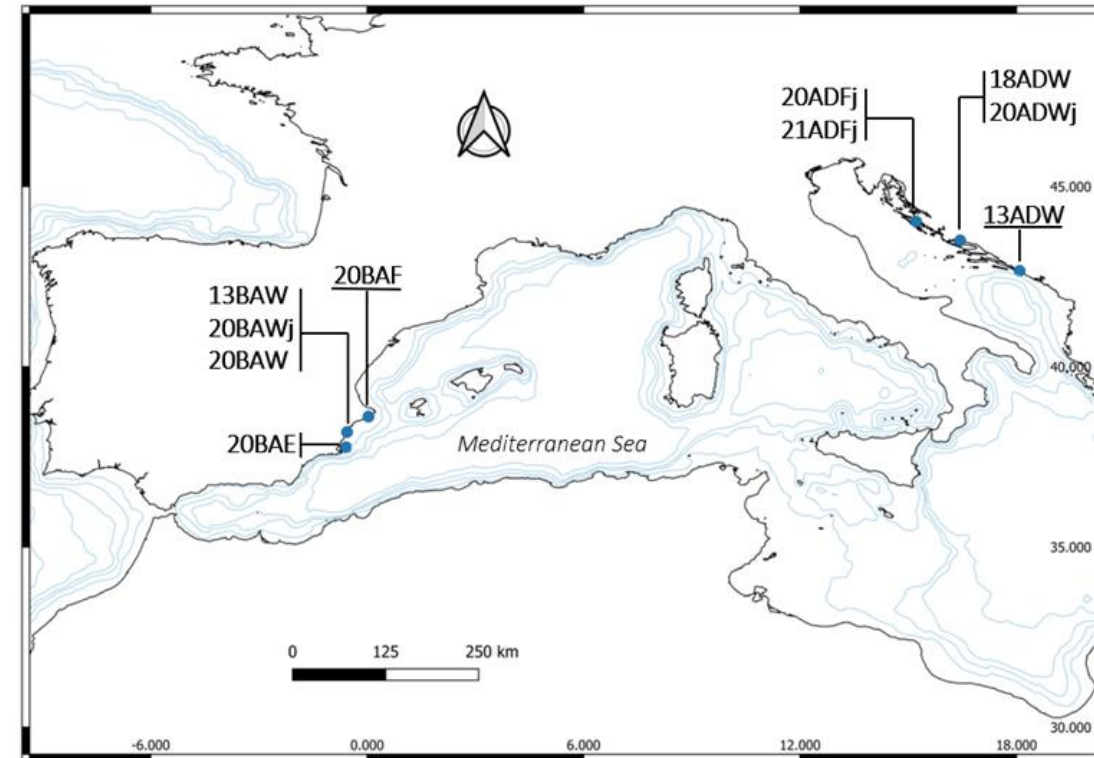
Results

Pop ID	Ar	Ho	He	F_{IS}	NE
Wild					
Overall	6.8[a]	0.66±0.2[a]	0.66±0.2	-0.014[a]	1078(685,2327)
Escapees					
20BAE	6.2±2.6	0.74±0.2[*]	0.72±0.2	-0.026	13(12,15)
Farmed					
Overall	4.6[b]	0.70±0.3[b]	0.65±0.3	-0.138[b]	9(8,10)
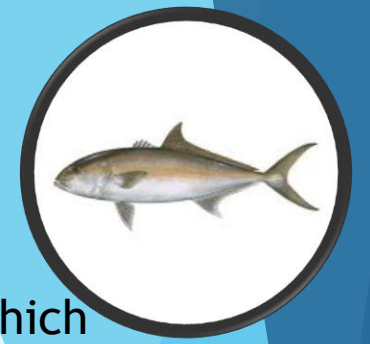
The extent to which diversity is lost depends on hatchery protocols , including the number, size , and source of broodstock , as well as spawning methods
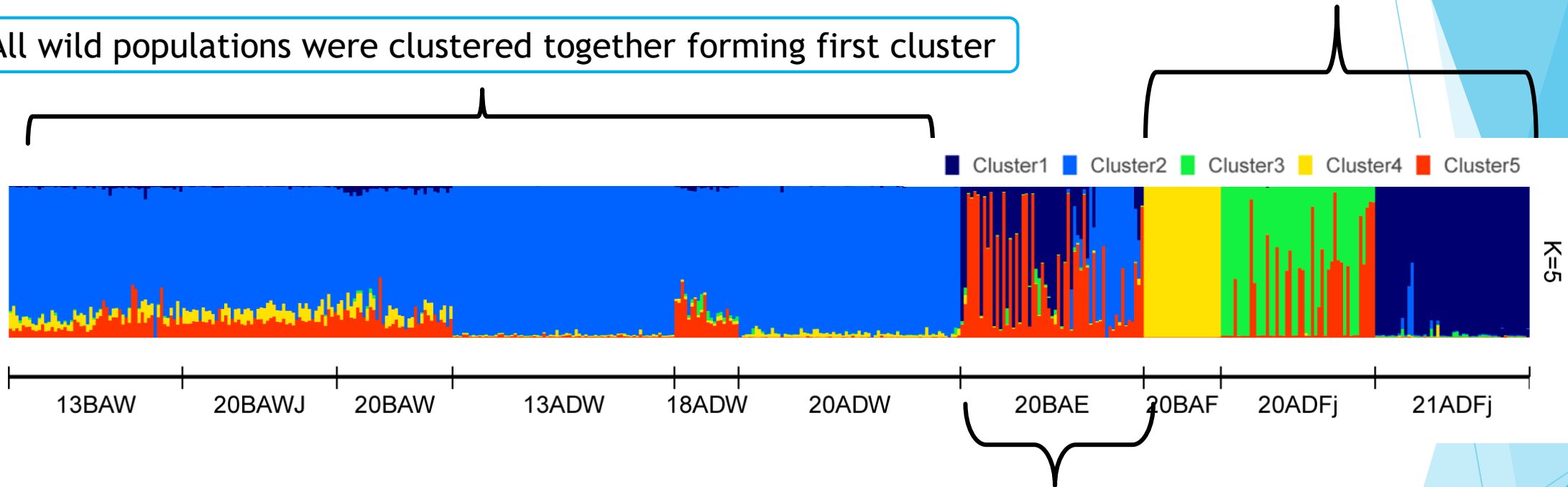
➢ <u>farmed populations</u> :

  ➢ significantly lower allelic richness (4.6 vs. 6.8) than wild populations

  ➢ significantly lower inbreeding coefficient (FIS)

  ➢ very low effective population sizes - NE values

➢ global genetic differentiation estimated across all ten populations **was 0.053** *demonstrating a moderate level of differentiation among pelagic marine populations*

➢ **<u>high FST differentiation index of 0.114</u> was observed among farmed populations** and was significantly different from the low index observed in the wild populations (0.008).

Results – Structure analysis

Farmed populations were assigned to a separate cluster

All wild populations were clustered together forming first cluster

Cluster1 Cluster2 Cluster3 Cluster4 Cluster5

K=5

13BAW 20BAWJ 20BAW 13ADW 18ADW 20ADW 20BAE 20BAF 20ADFj 21ADFj

The escaped fish were highly admixed, with some individuals assigned to the farmed-origin clusters, while other individuals were assigned to the wild-origin cluster

Results – Geometric morphometrics

PC1 -

PC1 +
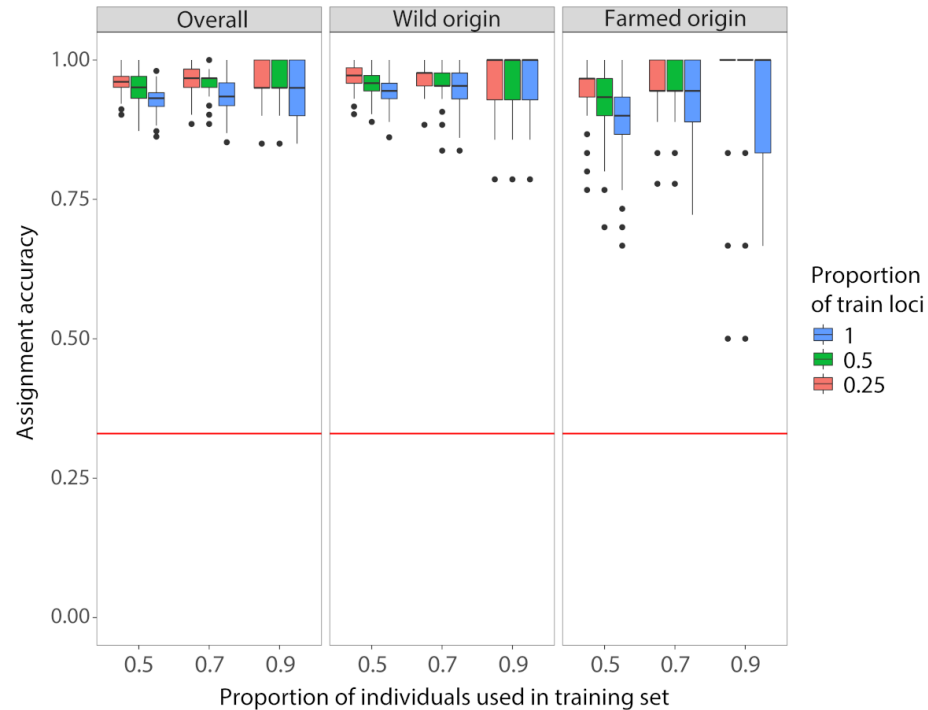
Wild fish

Farmed fish

PC2 -

PC2 +
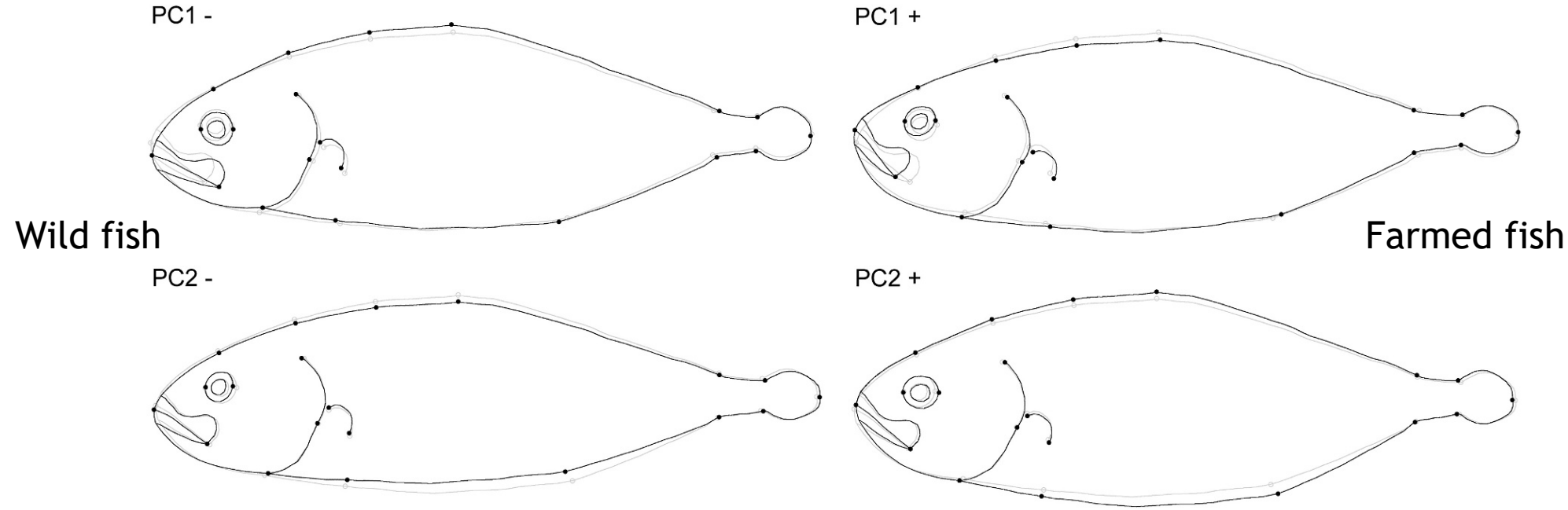
- general body shape differentiation was mainly determined by mouth position and head profile shape along bgPC1 and body height along bgPC2

- overall classification accuracy of 82.21% using PCA jackknife (leave-one-out) cross-validated classification

Results – assignment of escaped fish

R package assignPOP (Chen et al., 2018) using morphometric, genetic and their combined datasets in a supervised machine learning framework


A) assignment accuracies estimated via Monte-Carlo cross-validation and linear discriminant analysis methods, with sampling of three subsets of high FST loci plus geometric morphometrics data, crossed by three levels of training individuals, with 99 iterations.
B) escapee origin assignment with all morphometric data and 7 loci used for the test

CONCLUSION

▶ Genetic and morphological differences between wild and farmed S. dumerili exist

▶ The genetic management for the production of S. dumerili fingerlings is poor

  ▶ the breeding population size **should be large enough** (min. 30–50 per generation - due to unequal sex ratios and biased reproductive success, broodstock of 100–200 individuals is recommended for breeding programmes)

▶ Escaped S. dumerili was detected both in landing ports and first selling points

  ▶ dispersion behaviour of escaped fish - acoustic telemetry and mark and recapture studies

  ▶ Trophic studies during the feralisation process of escaped fish

▶ A risk of genetic introgression from farmed S. dumerili over wild populations exists

  ▶ better-quality standards of Mediterranean fish farms, e.g., Norwegian standard: NS 9415

  ▶ development of meteorological models to predict the risk of escape events due to storms, strong winds and waves

▶ The development of adaptive contingency plans to prevent, mitigate and control the potential negative effects of escape events in the wild are strongly recommended
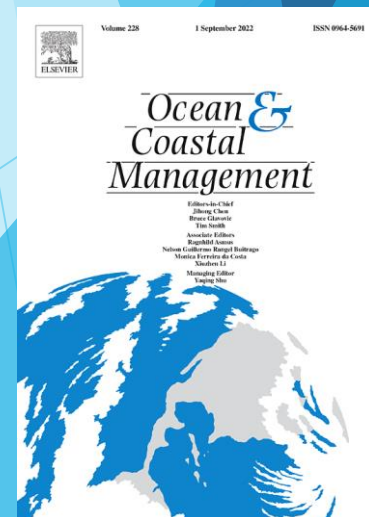
Culture of *Seriola dumerili* in a marine ecosystem: Insights from genetic and morphometric fish traits and implications of escape events

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