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Phone App for early discrimination of migrating female European eels to support and manage the wild population

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The European eel

- Catadromous fish
- Teleost fish of the order Anguilliforms, family Anguillidae
- Colour
- Size

Figure1: *Anguilla anguilla* (http://natura.provincia.cuneo.it)

Distribution

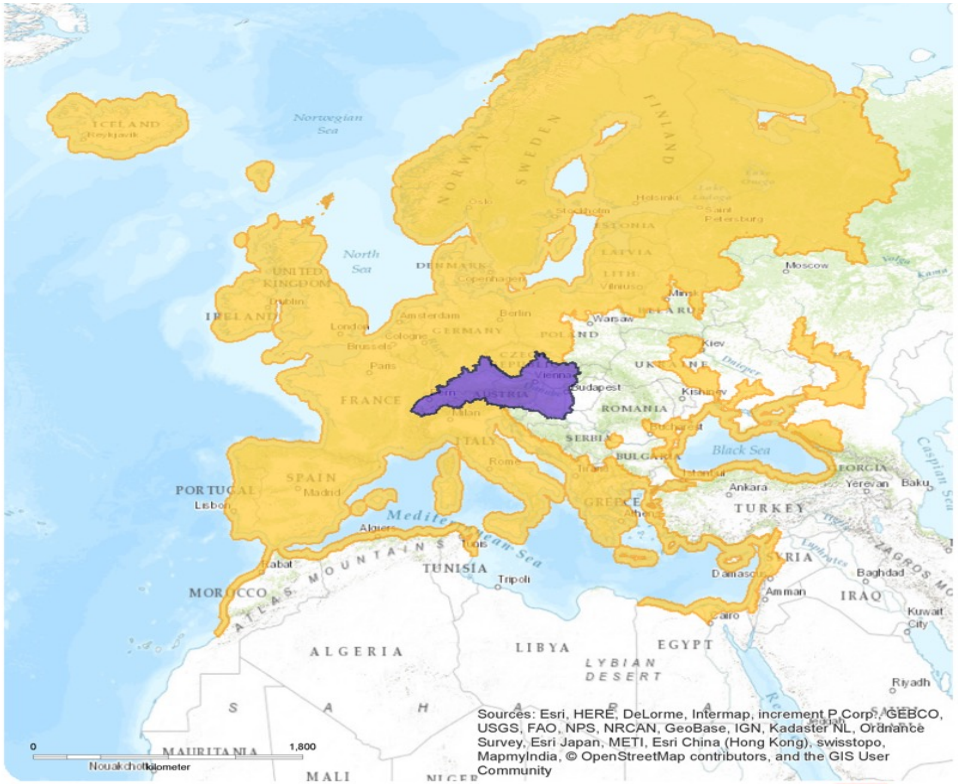


Figure 2: in yellow the distribution of the European eel.

Life cycle

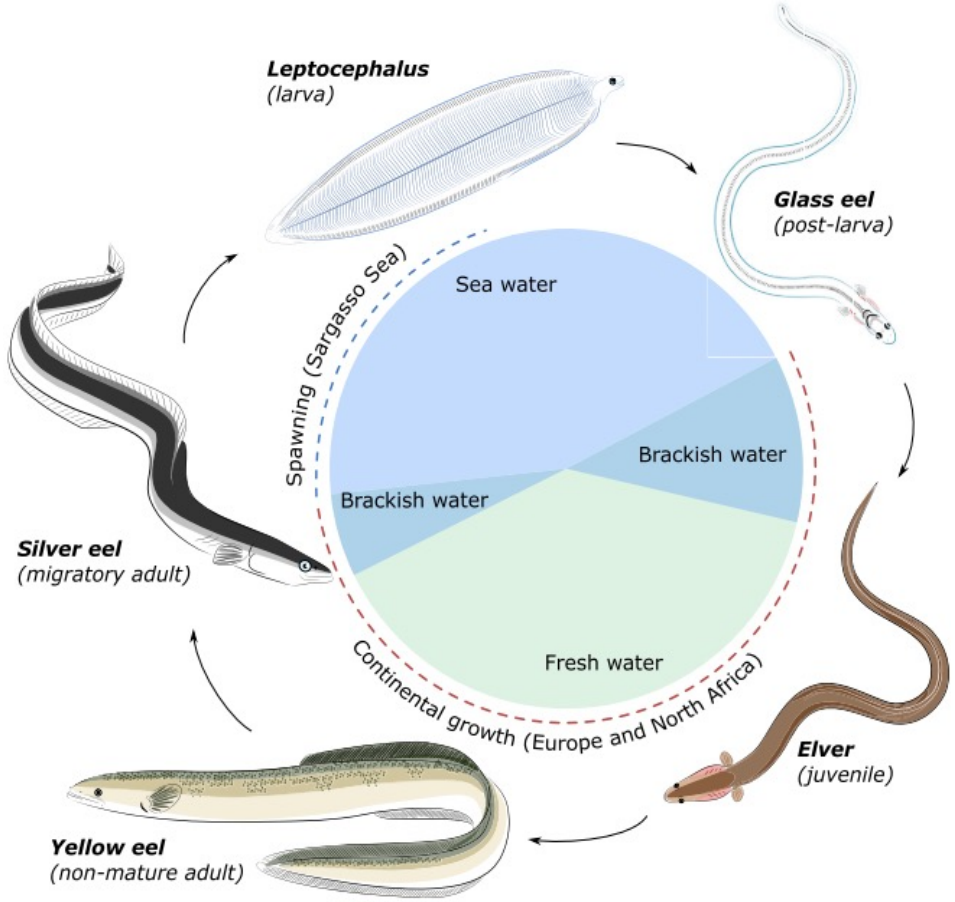


Figure 3: Life history of the European eel *(A. anguilla)* from Cresci (2020).

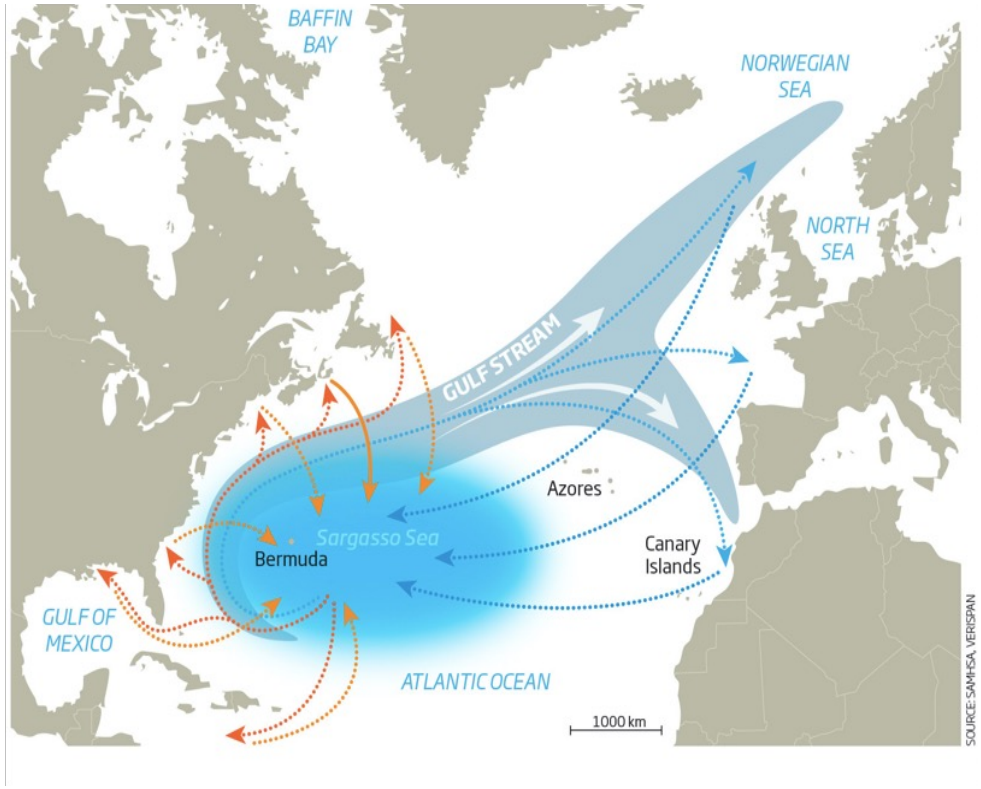
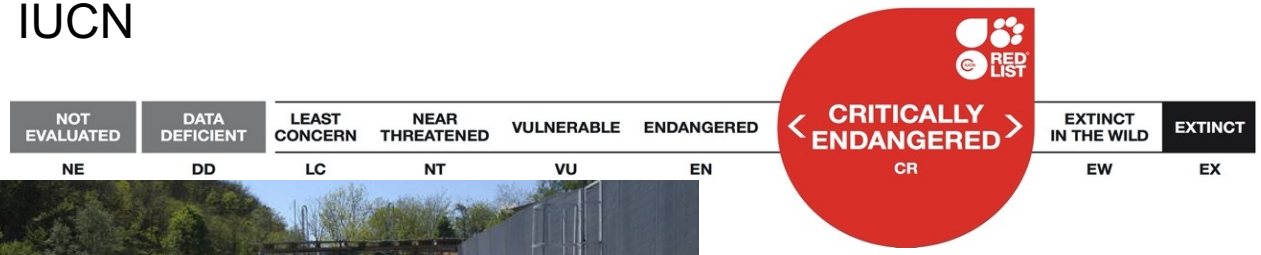


Figure 4: American (orange) and European (blue) eels migrate to the Sargasso Sea in the north Atlantic to breed, then their growing spawn use Gulf Stream to float and swim back (dotted lines) https://rivistanatura.com

Decline and Conservation

- The stock is at an historical minimum and is currently outside safe biological limits, and fisheries are not sustainable (ICES,2020)
- Is now classified as “critically endangered” according to IUCN



- Overfishing
- Oceanic modification of the North Atlantic drift
- Parasites (e.g.*Anguillicola crassus*)
- Pollution by domestic and industrial effluents
- Poaching and illegal export to Asia
- Habitat destruction

Maturity

- Data on maturation stage is needed to monitor silver eels escapement, asses population trends, and provide data as a proxy for spawining stock biomass
- One of the most obvious is the change of the livery that passes from a yellowish coloration (yellow- eel/resident) to the migratory one characterized by a silvery coloration (silver-eel/migrant)

No-invasive methods to know maturation status :

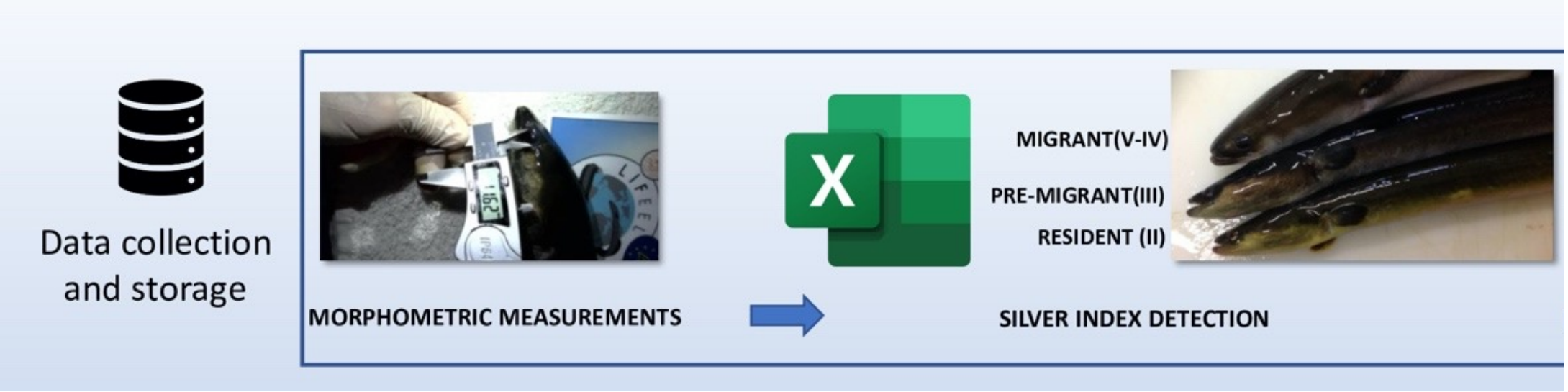
- Eye index (EI) Developed by Pankhurst et al. 1982
- Silver index (SI) Developed by Durif et al. 2005

Migrant eel

Pre-migrant eel

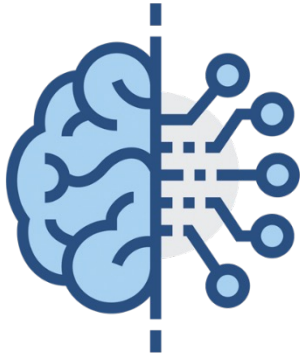
Resident eel

Maturity

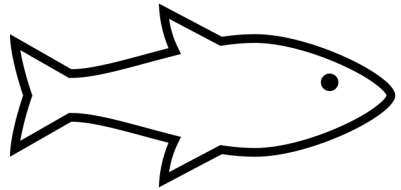


- Data not quick and easy to use
- Calliper or ichthyometer
- Operator’s subjectivity

Machine learning technology



- In the last years machine learning is used increasingly in different fields.
- This technology can extract highly dimensional features and indepth information into data, thus offering a solution for **smart** aquaculture and introducing the fishing industry into a new era
- A commonly used approach is to train a machine learning algorithm by showing examples of desired inputs and outputs, rather than programming a set of rules for all possible inputs



The aim

The aim of this study is to create a mobile phone App that, by simply taking a picture from a device, can give the user a real-time indication of the sexual maturation stage of eels and how near they are to actively migrating downstream.

FREEL

Materials and methods

1) SAMPLING

- **1852** eels were sampled in different *Valli* (closed lagoon) of North Adriatic sea using the «lavoriero» (downstream trap)

Materials and methods

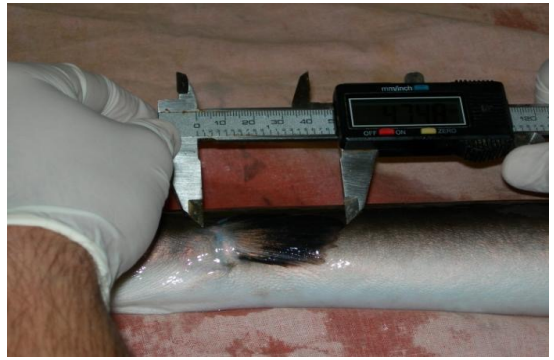
Eels were anesthetized in a water bath (10 l) where 2 ml of 1:10 solution of clove oil dissolved in ethanol (70%) were added

- Measured and sampled to obtain an external indicator of their maturation status according to Durif et al. 2005
- Eye index was also calculated *EI = 100*(((EDh + EDv) *0.25)2 *(10* BL)-1)*

Body weight (**BW)**

Total length (**BL**);

Pectoral fin length (**PFL**)



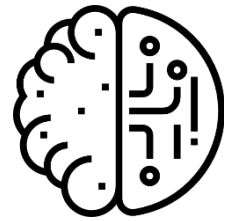
Silver index

I-II	Resident
III	Pre-migrant
IV, V	Migrant

Horizontal eye diameter (**EDh**)

Vertical eye diameter(**EDv**)

Materials and methods



EELS IMAGES DATASET

CONVOLUTIONAL NEURAL NETWORK

CNN MODEL TRAINING

CLASSIFICATION

PERFORMANCE EVALUTATION (TP,TN,FP,FN)

- The training was carried out in **Tensorflow** using photos **(n = 280)** The architecture used is **Efficientdet**
- Photos were obtained from 70 animals for each silver index using a fiducial marker
- A test dataset was created which allowed us to use a **supervised learning approach**
- The performance of the model was calculated using a **confusion matrix.**

FIDUCIAL MARKERS

PHOTO CAPTURE

Results and discussion

	SI-II	SI-III	SI-IV	SI-V
BL (cm)	59.46±6.96	69.93±6.31	84.30±5.39	65.91±7.56
BW (g)	386.07±137.32	646.83±202.48	1331.92±257.41	538.20±174.99
Edh (mm)	5.85±0.79	7.79±0.85	9.65±1.19	9.42±1.31
Edv (mm)	5.40±0.69	7.37±0.79	8.99±1.07	8.89±1.15
EI (%)	4.29±0.99 →	6.52±1.14 →	8.28±1.93 →	9.96±2.09
PFL (mm)	26.60±3.25	33.11±3.26	38.30±3.46	35.76±4.23

- **EI** remains by far the value that best expresses the transition from resident to migrating eel
- A **threshold value** was identified below which the eel is sexually immature, an intermediate value that intercepts a 90% migrating eel, and finally, a value above which the eel is sexually mature and ready for ocean migration

Freel 1

10:33

Dettaglio

Anguilla # 6

app_flutter/freel/
CAP2221960723286452815.jpg

Result

Resident

Coordinates

BOTTOM OVERFLOWED BY 38 PIXELS

1 CENTESIM
2 CENTESIM
5 CENTESIM
10 CENTESI
20 CENTESI
50 CENTESI
1 EURO
2 EURO

10:32

Dettaglio

Anguilla # 8

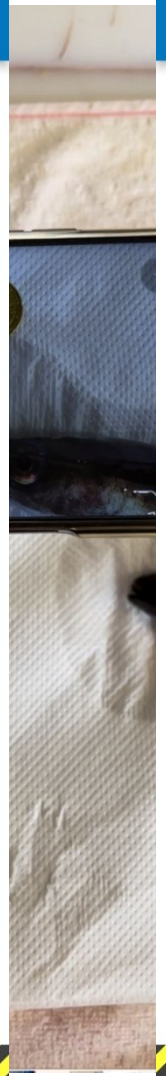
app_flutter/freel/
CAP5386643606067039229.jpg

Result

Migrant 90%

Coordinates

BOTTOM OVERFLOWED BY 38 PIXELS

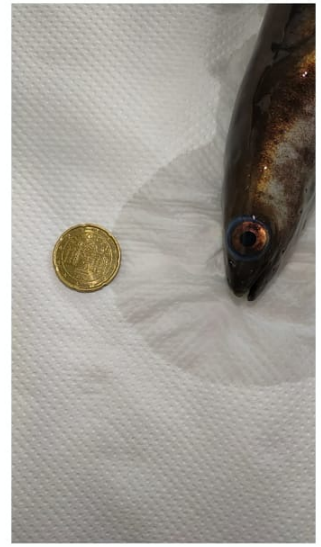


10:31

Dettaglio

Anguilla # 3

app_flutter/freel/
CAP7796078507022512705.jpg



Result

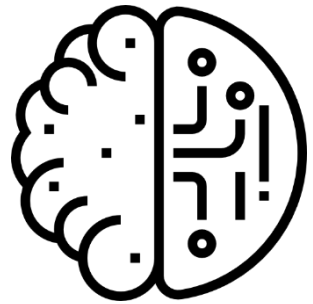
Migrant

Coordinates

BOTTOM OVERFLOWED BY 38 PIXELS


10:14
Freel 1.0_TEST
FREEL
Salviamo

Results and discussion



		Predicted Class	
		Positive	**Negative**
Actual Class	**Positive**	*TP* (True Positive) = 263	*FN* (False Negative) = 2
	Negative	*FP* (False Positive) = 1	*TN* (True Negative) = 14

The first tests carried out on a small sample of images, but despite this, the results are still positive

In particular, **ACC** is 98%, **SNS** is 99.89%, and **PRE** is 99.24%

For the future, it will be useful to compare different algorithms to see which one performs best

However, what will make the algorithm usable for all, will be the training with a larger dataset that will not only consider the morphometric and photo data of European eels of the north Adriatic but also data from **different European migration sites**

Conclusion

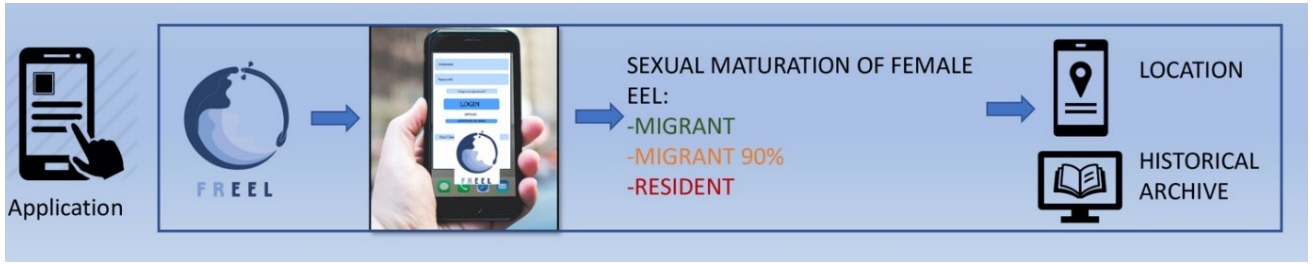
This study allowed us:

a) to identify a single parameter to discriminate the sexual maturity of the eel and thus to know the female with a migratory instinct

b) to use this parameter as a proxy to develop an easy and user-friendly app for all management operators

c) archive and location functions were added

d) tool for stock management to know any changes in the migration period



Thanks For The Attention

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