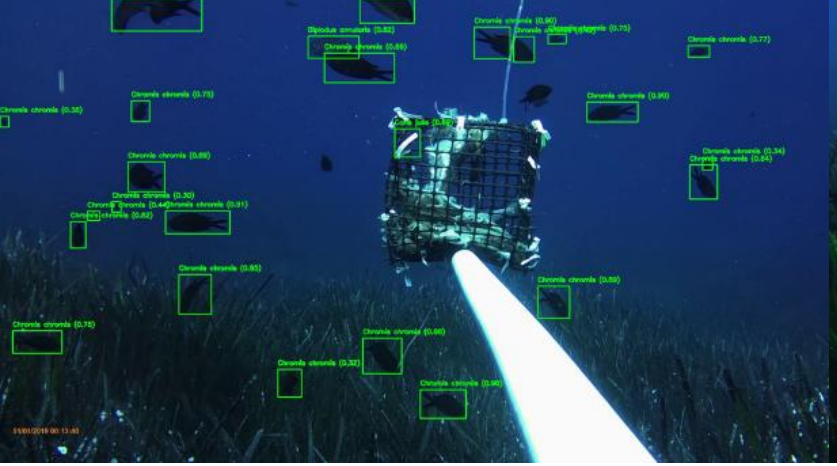


Automatic extraction and counting of fish from underwater videos using YOLO-based deep learning algorithms

Francesca Gallitto [1], Andrea Maria Lingua [1], Francesca Matrone [1], Filiberto Chiabrando [2], Xinchen Li [2], Silvia Secco [3,4], Alessandro Acierno [3], Massimiliano Scalici [3]

[1] Department of Environment, Land and Infrastructure Engineering (DIATI), **Politecnico di Torino**

[2] Department of Architecture and Design (DAD), **Politecnico di Torino**

[3] Department of Sciences, **University of Roma Tre**

[4] Department of Integrative Marine Ecology (EMI), **Genoa Marine Centre**

ISPRS Workshop Announcement: 3D underwater mapping from above and below, 2025

PRESENTATION OUTLINE

1. Problem definition, state of art
2. Methodology
3. Results
4. Conclusion

Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

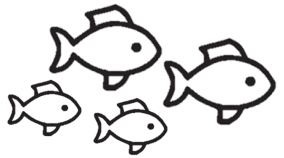
PROBLEM DEFINITION

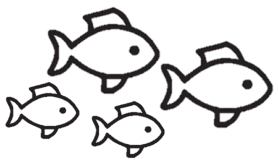
Underwater visual census (UVCs)

Real-time observation

Diver-Operated Video Censuses (DOVCs)

Post-dive data analysis





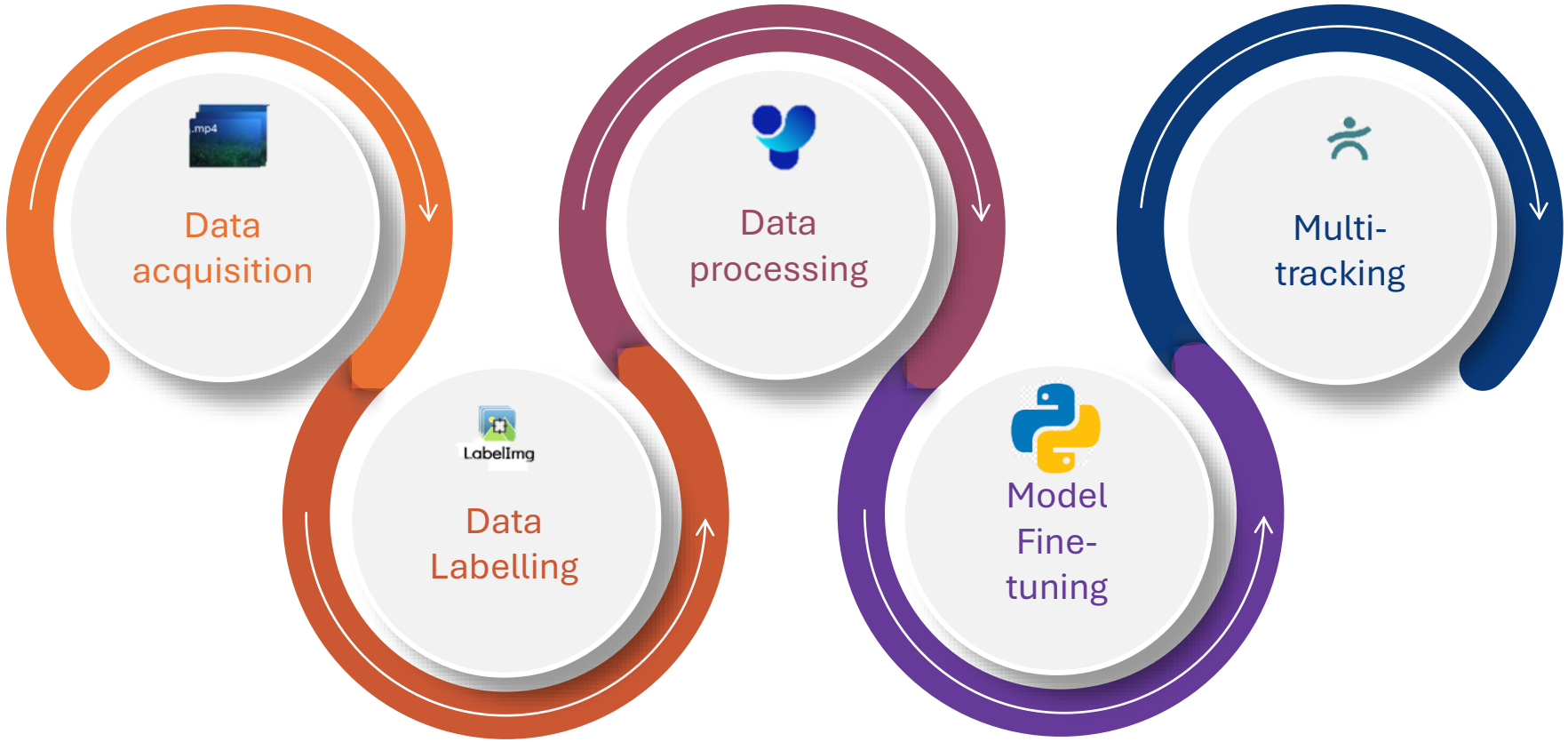
Negative aspects:

- observer bias;
- reduced accuracy in detecting cryptic or small-sized species;
- variability in diver experience and skill;
- extensive post-processing times for video analysis.

Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

METHODOLOGY

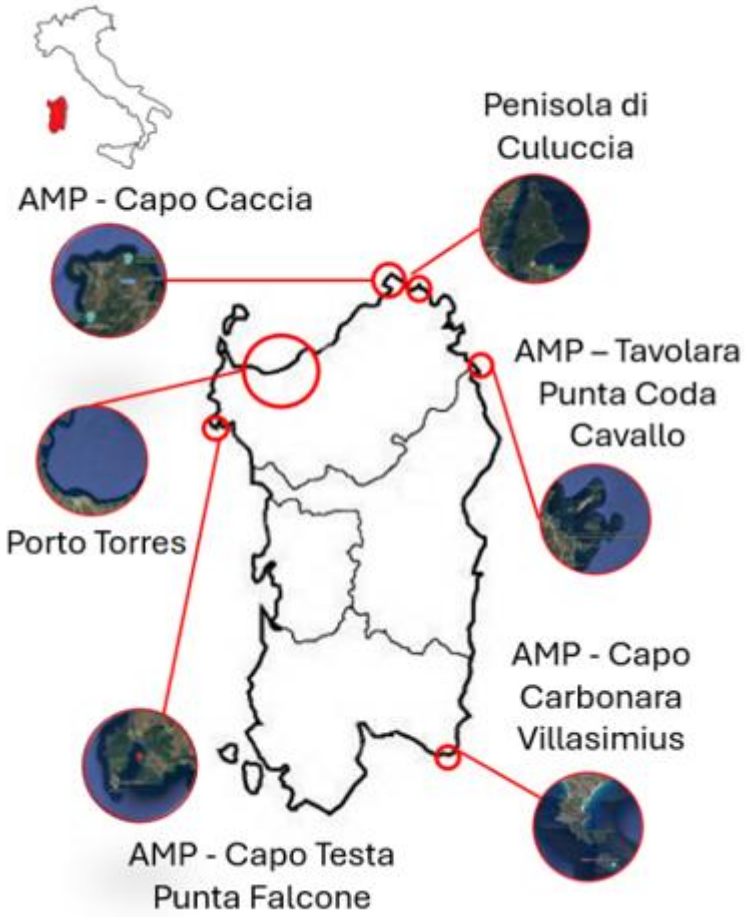
Proposed solution: integrated ***deep learning*** approach for multi-object tracking and species recognition from underwater videos



DATA ACQUISITION

Becam 4k Eis Action Camera

Data collected in the MPA Tavolara – Punta Coda Cavallo, specifically nearby Isola Rossa (C zone of MPA), during August 2024 by scuba operators, at 15 m depth. The procedure was carried out along a 50-m linear transect at a constant velocity of 12 m per min. The acquisitions were replicated 3 times



Politecnico di Torino
GEOMATIC Lab
G4CH
ROMA TRE UNIVERSITÀ DEGLI STUDI
SCIENZE Dipartimento di Eccellenza
FAIR Future Artificial Intelligence Research
POSEIDON
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
Finanziato dall'Unione europea NextGenerationEU

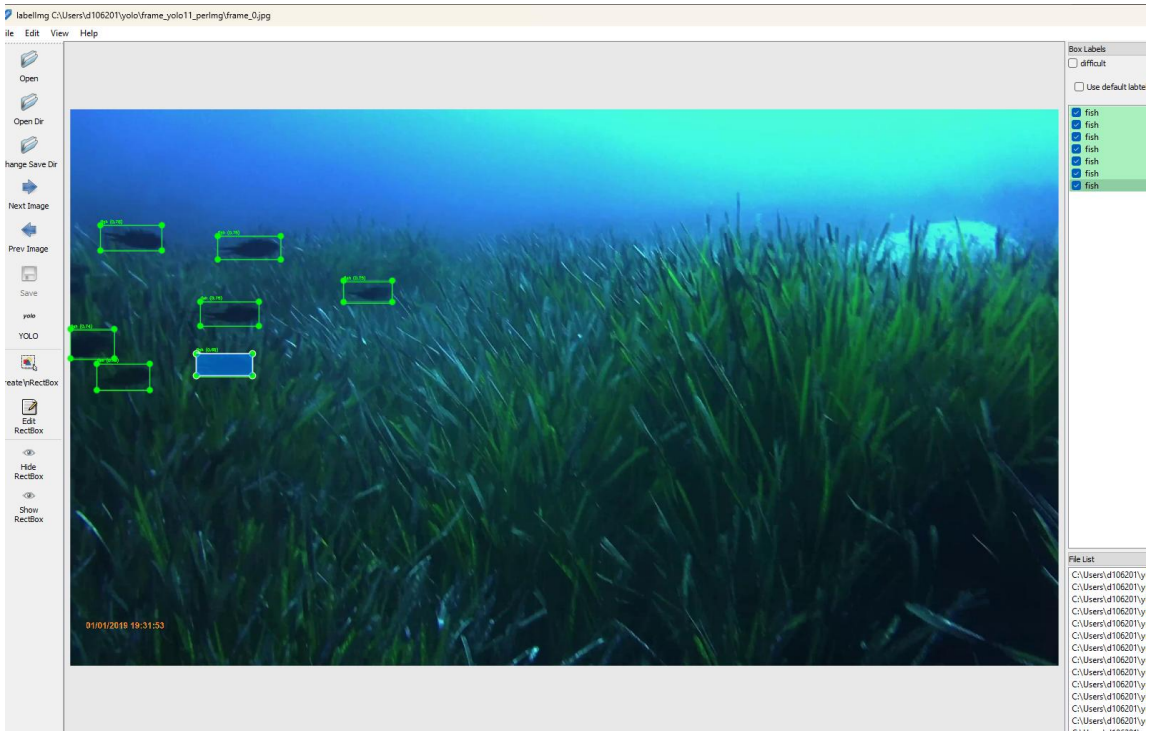
DATA LABELLING

Dataset: **SardinIA**

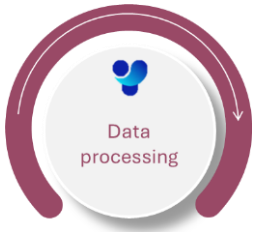
- 28 species of fish endemic to the Mediterranean Sea,
- total of 729 images
- 6 hours of labelling performing by two expert

Afish poly	*Diplodus sp-*	*Pomatous salator*	*Symphodus sp-*
Chromis chromis	*Diplodus vulgaris*	*Sarpa salpa*	*Labrid unid-*
Coris julis	*Epinephelus marginatus*	*Seriola dumerilii*	*Small*
Dentex dentex	*Lithognathus mormyrus*	*Serranus cabrilla*	*Taca*
Diplodus annularis	*Mugilidae prob Chelon*	*Serranus scriba*	*Spicara smaris*
Diplodus puntazzo	*Mullus sp-*	*Sparus aurata*	*Symphodus tinca*
Diplodus sargus	*Oblada melanura*	*Sphyraena sp-*	*Thalassoma pavo*

LabelImg, Tzutalin, 2015. Sofware. Open-source Git code. github.com/tzutalin/labelImg



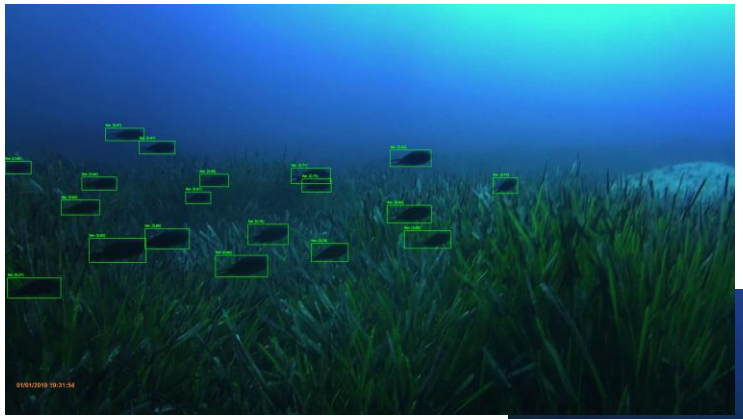
DATA PROCESSING



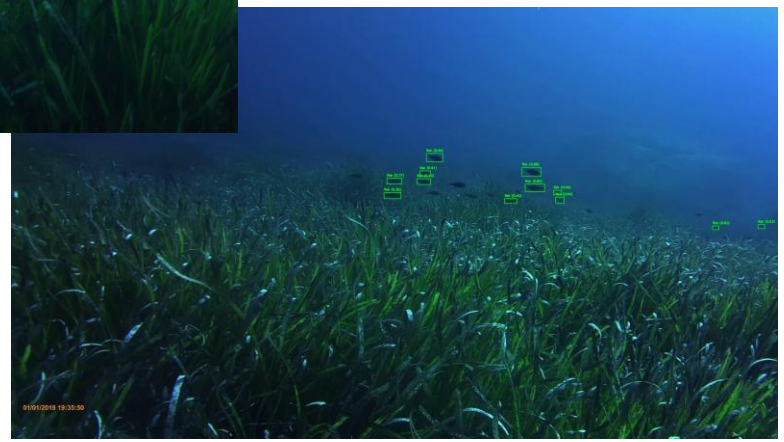
DeepFins

Jalal et al., 2025

YOLOv11-based model trained on fish species native to the Australian coasts



One single class



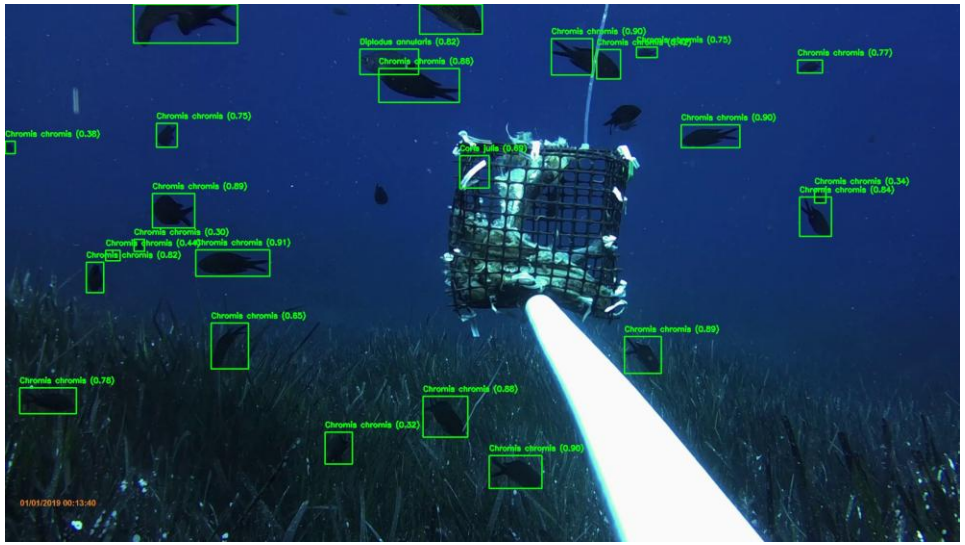
Small fish in the background were often missed

accuracy=0.71, precision=0.78,recall=0.68, F1 score=0.61

DeepEcomar

Catalan, 2023

Dataset of Mediterranean species, based on YOLOv5m



Absence of three species, *Spicara maena*, *Symphodus tinca*, and *Thalassoma pavo*, which are present, in some cases in high abundance.

accuracy=0.52, precision=0.31, recall=0.23, F1 score=0.20

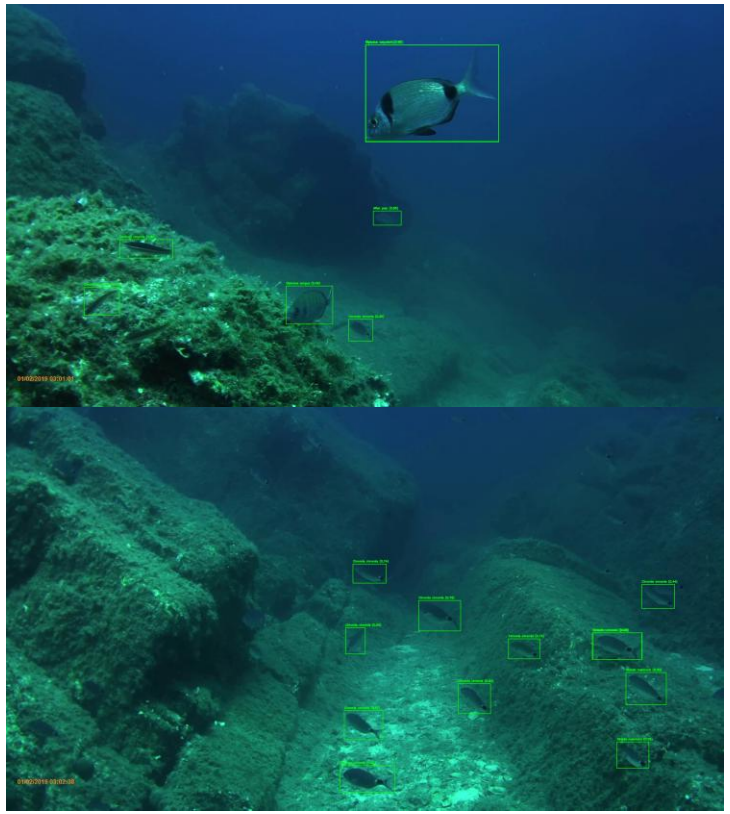
Politecnico di Torino
GEOMATIC Lab
G4CH
ROMA TRE UNIVERSITÀ DEGLI STUDI
SCIENZE Dipartimento di Eccellenza
FAIR Future Artificial Intelligence Research
POSEIDON
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
Finanziato dall'Unione europea NextGenerationEU

MODEL FINE-TUNING

!FISH SPECIES

YOLOv8 trained on SardinIA

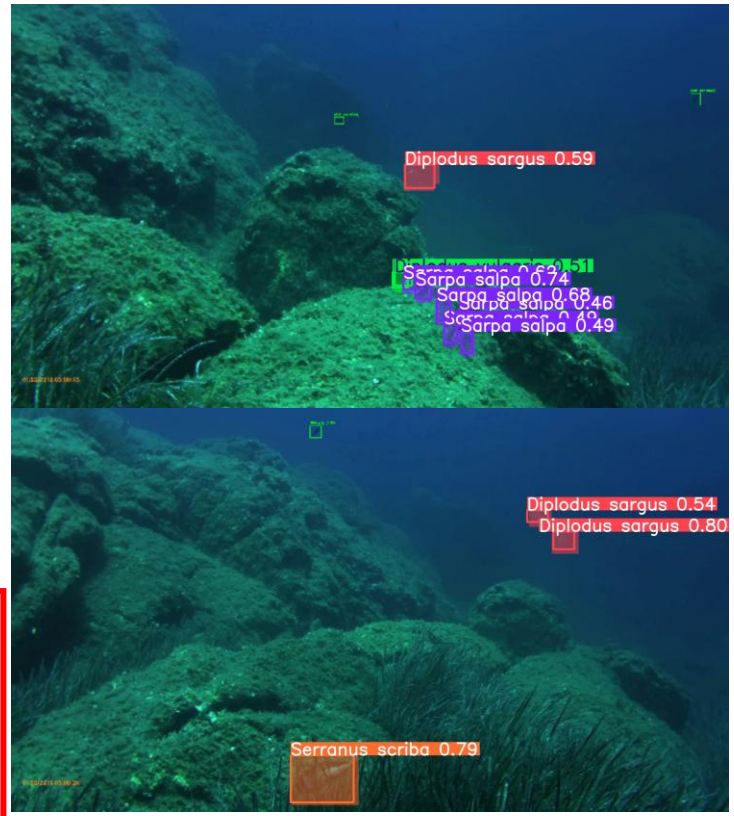
Epochs = 50, image size= 640, batch size = 16. Total of 0.592 hours.



Accuracy=0.84, precision=0.78, recall=0.69, F1-score=0.70

YOLOE trained on SardinIA

Epochs = 80, batch size = 16, image size = 640,



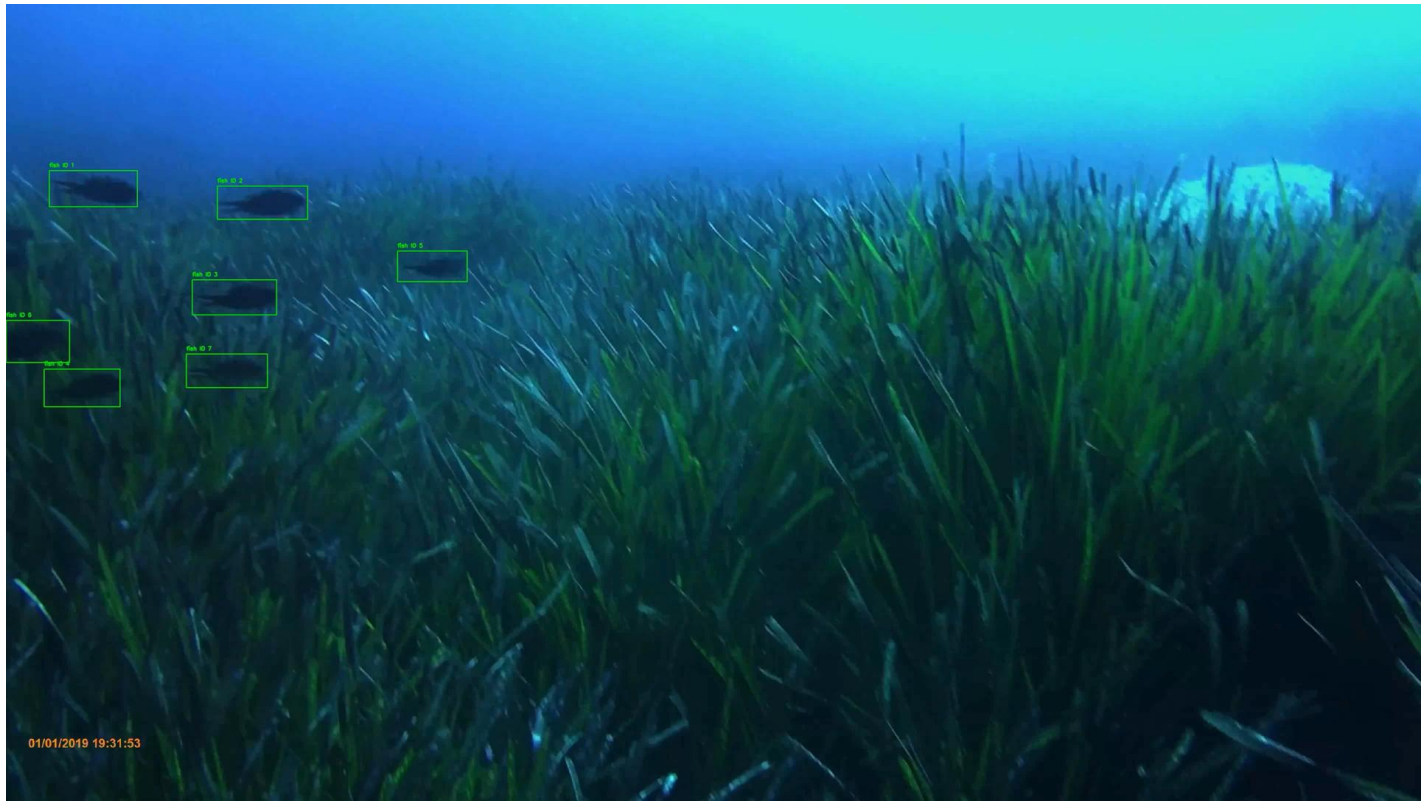
Accuracy =0.76, Precision = 0.86, Recall=0.86, F1-score = 0.86

Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

MULTI-OBJECT TRACKING

SAMURAI	ByteTrack	DeepSORT

Extends the original SORT algorithm by incorporating a deep appearance descriptor, which enhances its ability to re-identify objects after occlusions or long-term absence.



DeepSort and ByteTrack were tested, initialized as follows:

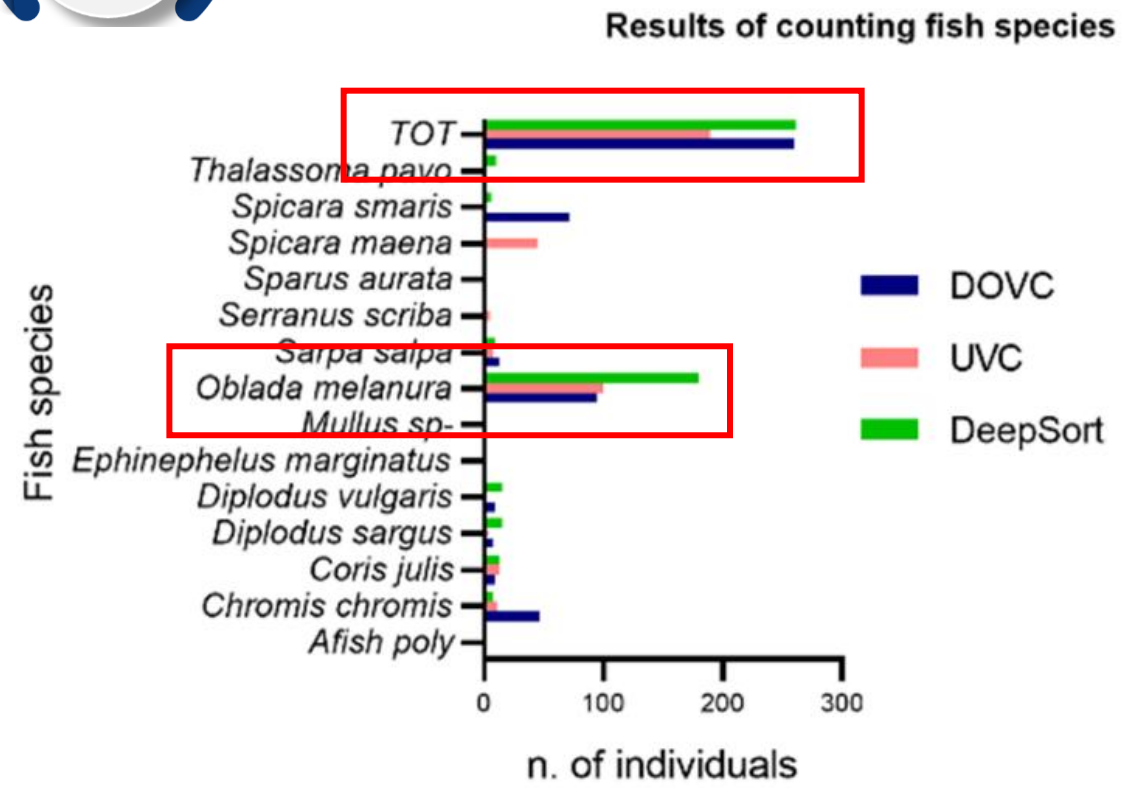
DeepSort: max_iou_distance=0.8, max_age=100, n_init=8, nn_budget=120;

ByteTrack: track_thresh=0.3, match_thresh=0.5, track_buffer=30, mot20=False

Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

RESULTS

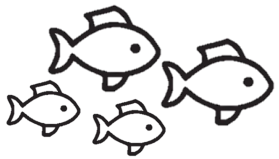
Strong reliability in overall abundance estimation.



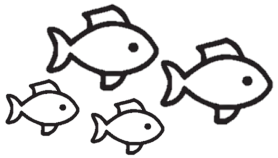
	DOVC	UVC	DeepSort
Afish poly	0	0	1
Chromis chromis	47	11	7
Coris julis	9	13	13
Diplodus sargus	8	3	15
Diplodus vulgaris	9	1	15
Ephinephelus marginatus	1	0	0
Mullus sp-	0	0	1
Oblada melanura	94	100	180
Sarpa salpa	12	8	9
Serranus scriba	2	5	2
Sparus aurata	2	0	2
Spicara maena	0	45	0
Spicara smaris	71	0	6
Thalassoma pavo	1	1	10
TOT	260	190	261

Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

CONCLUSION

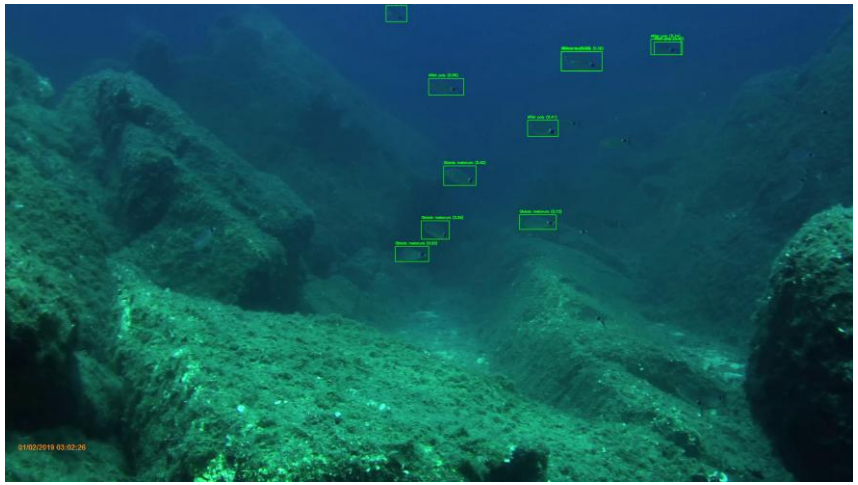


- ✓ Demonstrated the potential of deep learning techniques for automated monitoring of fish biodiversity in complex marine environments like the Mediterranean
- ✓ YOLOE model trained on a localized dataset (SardinIA) and the DeepSort multi-object tracker emerged as the most effective combination
- ✓ The developed system delivered performance comparable to traditional visual census methods, ensuring reliability in overall abundance estimation and accurate identification of dominant species



Future development

- Increase the dataset for very similar species and for very small-sized species
- Apply the methods in another videos
- Publish the SardinIA dataset



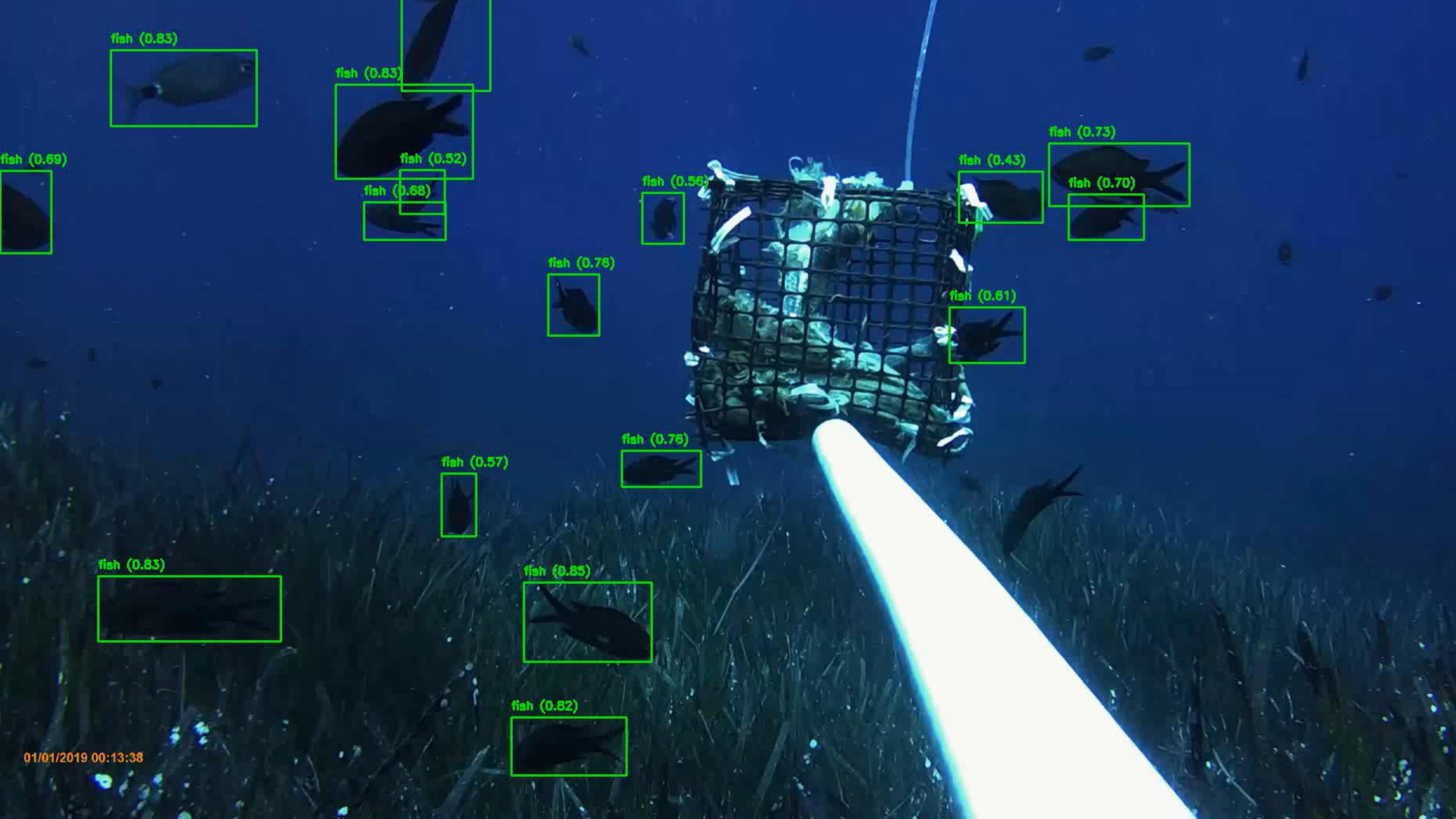
Politecnico di Torino · GEOMATIC Lab · G4CH · ROMA TRE UNIVERSITÀ DEGLI STUDI · SCIENZE Dipartimento di Eccellenza · FAIR Future Artificial Intelligence Research · POSEIDON · Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA · Finanziato dall'Unione europea NextGenerationEU

Thank you for you attention!

Automatic extraction and counting of fish from underwater videos using YOLO-based deep learning algorithms

Politecnico di Torino

francesca.gallitto@polito.it


fish (0.83)
fish (0.83)
fish (0.69)
fish (0.52)
fish (0.68)
fish (0.56)
fish (0.43)
fish (0.73)
fish (0.70)
fish (0.76)
fish (0.61)
fish (0.76)
fish (0.57)
fish (0.83)
fish (0.85)
fish (0.82)
01/01/2019 00:13:38