Co-funded by
the European Union

SHORT-TERM CONTRACT FOR THE PILOT PROJECT TO TEST THE USE OF STEREOSCOPIC CAMERAS DURING THE FIRST TRANSFER AND THE AUTOMATION OF VIDEO FOOTAGE ANALYSIS

Technical Report for Objective 1: test the use of stereoscopic cameras during the first transfers of Bluefin tuna

P. Muñoz-Benavent, J. Martínez-Peiró, G. Andreu-García, S. Morell-Monzó, V. Puig-Pons, and V. Espinosa. Universitat Politècnica de València (UPV)

Tests were conducted to evaluate the use of stereoscopic and conventional cameras during the first transfers of bluefin tuna from purse seine vessels to transport cages in the Mediterranean and Adriatic during the 2024 fishing season, and from traps to transport cages during 2025. The technical feasibility of estimating weight at this early stage was confirmed. Length measurements were obtained from stereocamera recordings by marking the snout and fork tail points of individuals (32%, 21%, 45%, and 73% for four transfers in the Mediterranean, 65% for one transfer in the Adriatic, and 85%, 35%, and 79% for three transfers from a trap), while fish counts were determined from monocamera recordings. In two Mediterranean transfers, estimated weights could be compared with subsequent transfers to farm cages. Average lengths of 201.9 and 210.5 cm were recorded in first transfers, compared with 192.6 and 207.4 cm in second transfers (authorities' estimates) and 210.1 and 215.2 cm at harvesting. Discrepancies between first and second transfers are likely due to differences in sampling, operator variability, and software, whereas differences with harvesting reflect fish growth in cages and the selective nature of harvesting. Regarding fish counting, a variation attributed to operator subjectivity and the difficulty of enumerating overlapping schools. Time requirements for manual counting ranged from 1.5 to 4 hours per transfer (10.5 hours in total), while manual length estimation required 1.3 to 9.5 hours per transfer (19 hours in total). The application of software and artificial intelligence for automatic estimation of fish number and weight will be reported separately under Objective 2 of the Pilot Project.

1. Description of the work carried out during the tests

The pilot project has two independent objectives: a) to test the use of stereoscopic cameras during the first transfers from purse seine vessels or traps to towing cages in order to be able to estimate at this stage the weight of the captured bluefin tuna (BFT). b) to test the use of available software and artificial intelligence to automatically determine the number of individuals and their weight. This report primarily focuses on the first objective, although results from the second are also included.

The primary mission during the tests was to:

- Assess whether stereoscopic cameras, in combination with conventional cameras, allow successful video recording of first transfers under real conditions.
- Evaluate the accuracy in determining the number of individuals and their average size at first transfer (from purse seiner or trap to transport cage) and compare these results with those obtained during second transfers (from transport cage to farm cage), using both automatic analysis software and current manual methods.

The work included testing the system in at least three transfers in the following scenarios:

- First transfer from a purse seiner to a transport cage in the Mediterranean.
- First transfer from a trap to a transport cage.
- First transfer from a purse seiner to a transport cage in the Adriatic.

The first transfer from a purse seiner scenario, both in the Adriatic and Mediterranean, was addressed during the 2024 campaign, whereas the first transfer from a trap scenario was addressed in the 2025 campaign. The specific work carried out in each scenario is detailed in the following subsections.

1.1. First transfers from purse seiners to transport cages in the Mediterranean

UPV coordinated with ICCAT and Balfegó Tuna, the company collaborating in the campaign, to organize the recordings. The agreements were as follows:

- UPV equipment (stereocameras and laptops for recording) will be placed on Nuevo Atxarre (a Balfegó Tuna auxiliar boat), from where the transfers will be recorded. UPV personnel will be transported to Nuevo Atxarre by the Spanish Army's Alborán patrol vessel, with a 2-hour margin before transfers begin.

- Divers will be in charge of recording the first transfers with three stereocameras and two monocameras. The setup replicates that used for transfers from transport cages to farm cages, using a monocamera for counting and a stereocamera for sizing. However, the lateral stereocameras are duplicated, and a ventral stereocamera is added to test the feasibility of that view. The positioning is depicted in Figure 1:

  - SC1 and SC2: Two stereocameras positioned 2-3 meters away on each side of the gate, capturing the fish from a lateral view (see Figure 2) at distances ranging from 2 to 12 meters.
  - SC3: One stereocamera positioned 2-3 meters below the gate, capturing the fish from a ventral view (see Figure 3).
  - MC: One monocamera, positioned 4-5 meters away from the gate, providing a lateral view and covering the entire gate.

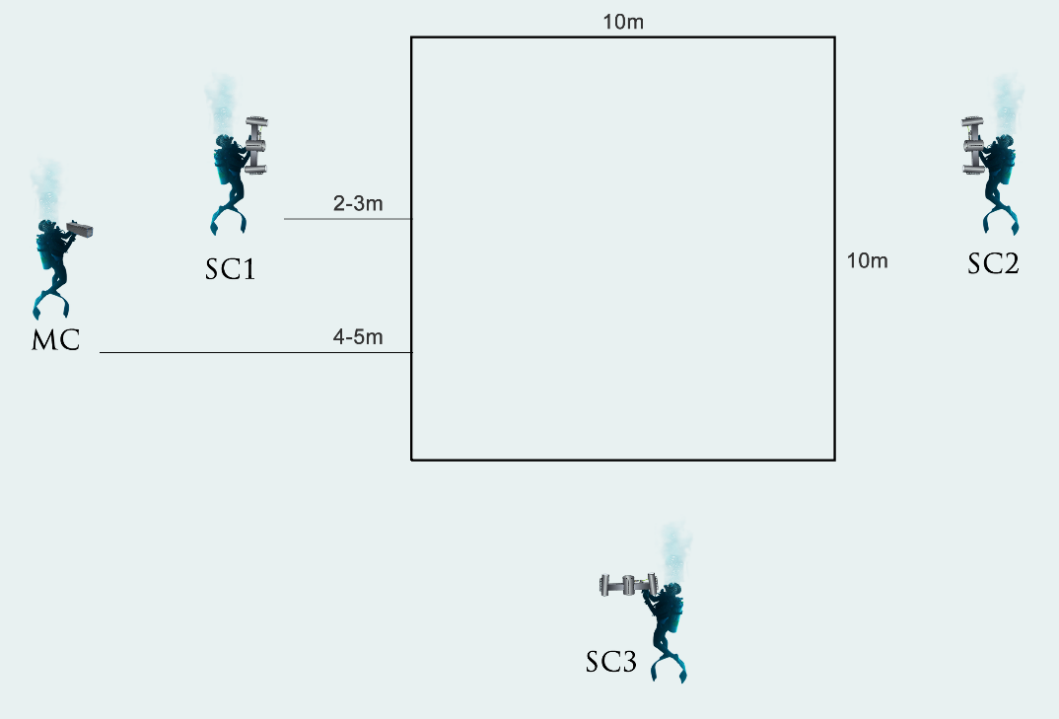

Figure 1. Positioning of monocamera (MC) and stereocameras (SC1, SC2, and SC3) during first transfers from purse seiners to transport cages in the Mediterranean.

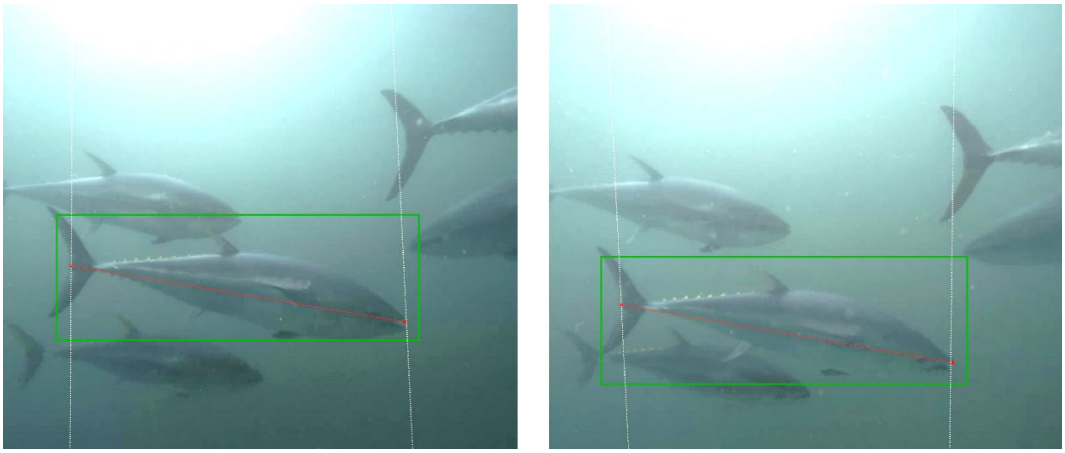

Figure 2. Stereoimage to be obtained from lateral views (SC1 and SC2 stereocameras).

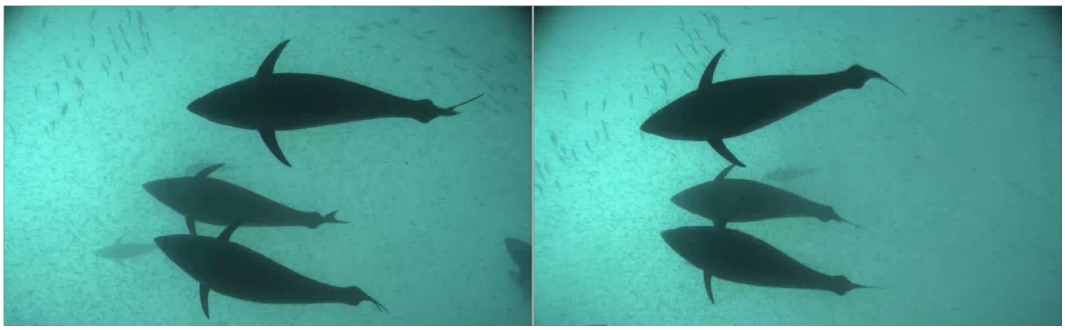

Figure 3. Stereoimage to be obtained from the ventral view (SC3 stereocamera).

A diary of onboard experiences is presented in Annex 1, and Table 1 summarizes the recorded transfers. Two first transfers (M1-2) were recorded with the full setup but for the last two transfers (M3-4) the ventral view was discarded due to operational constraints. This view was previously used with success by our team for studying the evolution of the fattening progress in farm cages, but Balfegó Tuna explained that keeping the ventral stereocamera in position during transfers was difficult for the divers and caused significant delays. Figure 4 shows the images recorded with monocamera (MC) and stereocameras (SC1, SC2 and SC3) with the proposed setup. The videos of all transfers can be downloaded from the links provided.

Transfer ID	M1	**M2**	M3	M4
Transport cage	ESP010R (with another transfer)		ESP014R	ESP008R
Date and time	20240604 17:23 – 18:34	20240605 10:46 – 11:52	20240611 10:07 – 10:57	20240613 07:05 – 08:16
Video duration (min)	71	66	50	71
Video duration transferring (min)	7	12	10	14
Number of cameras	2 lateral SC 1 ventral SC 1 MC	2 lateral SC 1 ventral SC 1 MC	2 lateral SC 1 MC	2 lateral SC 1 MC
Video links	Link	Link	Link	Link

Table 1. First transfers from purse seiners to transport cages recorded in the Mediterranean. SC: stereocamera; MC: monocamera.

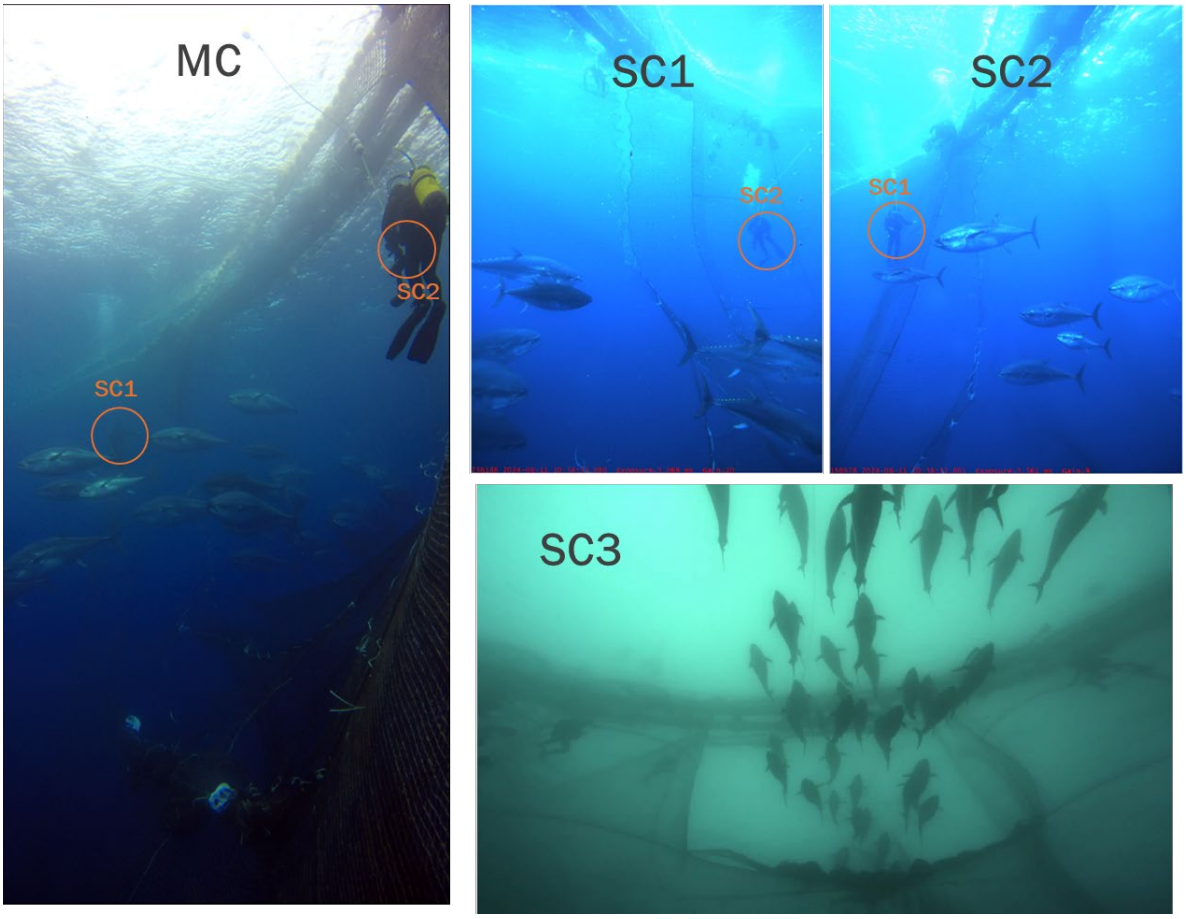

Figure 4. Images of first transfers from a purse seiner to a transport cage recorded in the Mediterranean with one monocamera (MC), two stereocameras to record the lateral view of the fish (SC1 and SC2) and one stereocamera to record the ventral view of the fish (SC3). The position in the cage of the two divers holding the SC1 and SC2 stereocameras can be observed in the images of different cameras (highlighted in orange).

1.2. First transfer from purse seiners to transport cages in the Adriatic

UPV coordinated with ICCAT and Croatian Ministry of Agriculture to coordinate the recordings. The agreements were as follows:

- Only stereocameras SC1 and SC2 will be used due to the size of the gate and the fish.
- Tests will occur late in the season when most of the quota would already be captured, as requested by operators.
- All first transfers from one purse seiner to transport cages will be recorded whenever possible.
- Only one operator, Jadran Tuna, will participate.
- Two patrol vessels equipped for diving and use of cameras will organize the transport of the project team. The transfers will be recorded from the patrol vessel.
- Fisheries inspection will provide two divers, which will hold the stereocameras for transfers recording.

The recording setup could not meet our initial idea of mimicking the setup of transfers from transport cages to farm cages, as in the Mediterranean, since the gate sizes are very different. The size of the transfer gate during the first catch is determined by the opening of the purse seine net, which is typically 14x6 meters but can vary between 15x5 meters and 13x7 meters depending on weather and oceanographic conditions at the time of transfer. This contrasts with the smaller transfer gates (approximately 4x3.5 meters) used for transfers from transport cages to farm cages, which are optimal for size estimation with stereocameras. However, the smaller gates are difficult to use for first transfers because they increase the likelihood of fish mortality, especially for smaller tuna, which are particularly sensitive to initial contact with the nets or other environmental disturbances. On the other hand, the desirable outcome of the project is to develop a technical solution and methodology

to determine the number of individuals and biomass, preferably using a single video record. Given these conditions, two possibilities were agreed upon with the operators:

- Reduce the transfer gate to 7x6 meters and use one stereocamera to record smaller catches of up to 500 fish, with an average weight of 8-10 kg.
- For larger catches, record the transfers using two stereocameras, one on each side of the gate, with each stereocamera covering half of the gate (approximately 7x6 meters).

Conducting these two types of experiments would allow us to compare the results and provide recommendations. The first alternative would be ideal for the project's outcome and for future implementations, as it would only require one stereocamera. The second alternative, however, would involve higher costs.

Unfortunately, during our 17-day stay in Croatia, only one transfer was recorded, due to a lack of catches caused by unfavorable weather and sea conditions. Furthermore, the tests were conducted later in the season, when most of the quota had already been captured, as requested by the operators. UPV remained in Croatia until 15 July, the last authorized day of the fishing season.

Figure 5. Positioning of monocamera (MC) and stereocameras (SC1, SC2, and SC3) during first transfers from purse seiners to transport cages in the Adriatic.

A diary of the on-board experiences is presented in Annex 1, and a summary of the recorded transfer is presented in Table 2. Figure 6 shows the images recorded using the proposed setup, with one monocamera and two stereocameras (SC1 and SC2).

Transfer ID	T_CRO
Transport cage	EUHRV013 (with other 4 transfers)
Date and time	20240713 08:59-9:30
Farm cage	HRV008004
Video duration (min)	31
Video duration transferring (min)	1
Number of cameras	2 lateral SC and 1 MC
Video link	Link

Table 2. Transfers from purse seiners to transport cages recorded in the Adriatic. SC: stereocamera; MC: monocameras.

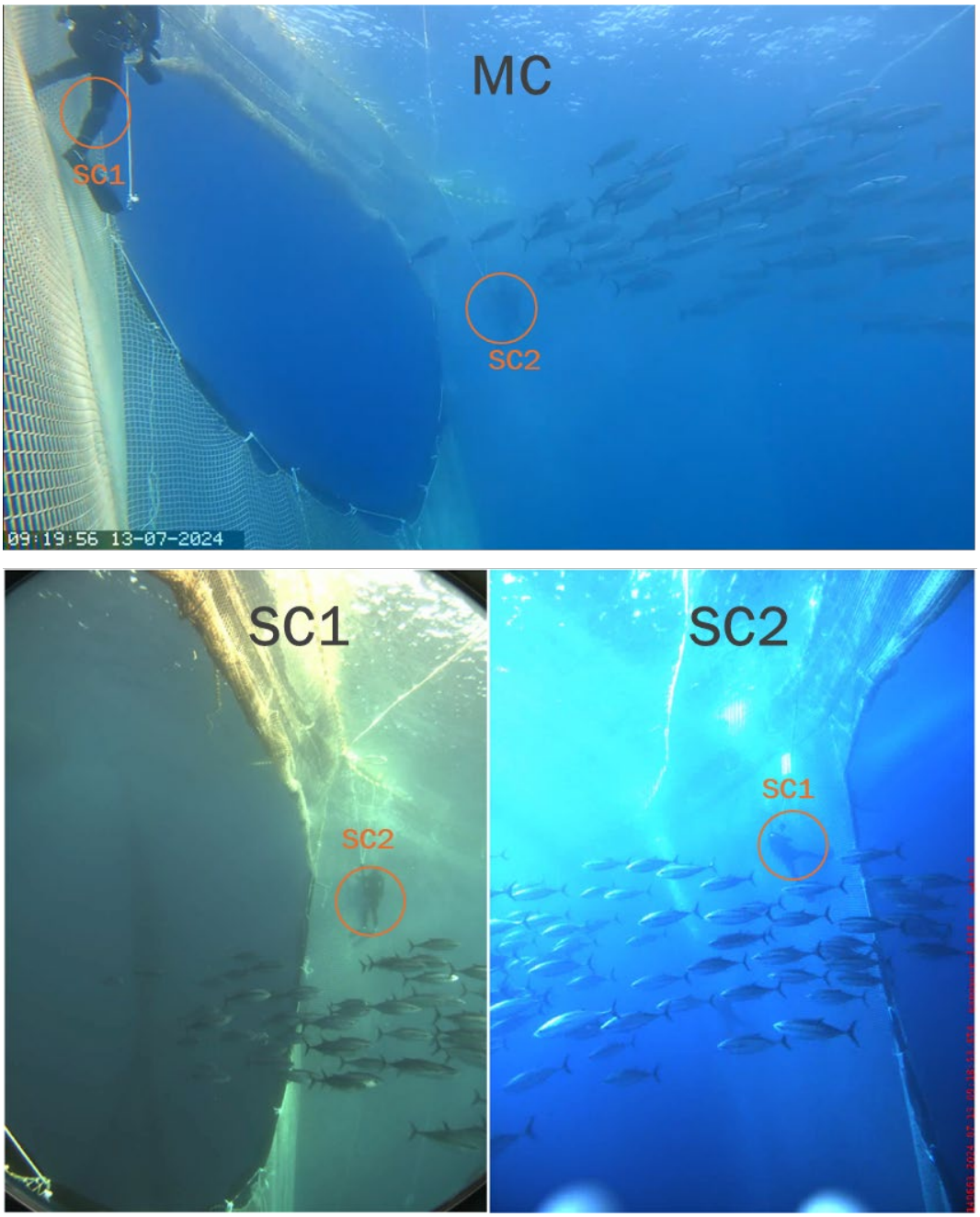

Figure 6. Images of a transfer from a purse seiner to a transport cage recorded in the Adriatic with one monocamera (MC) and two stereocameras (SC1 and SC2). The position in the cage of the two divers holding the stereocameras can be observed in the images of different cameras (highlighted in orange).

1.3. First transfer from a trap to a transport cage

UPV coordinated with ICCAT and Tunipex, the company from Portugal collaborating in the campaign, to organize the recordings. The following agreements were reached:

- Unlike purse seine operations, where fish are transferred first to transport cages and subsequently to fattening cages, trap operations involve a direct first transfer from traps to fattening cages. These transfers are already monitored with stereocameras in accordance with ICCAT Recommendation 22-08 using a 3x3 meters gate frame.

- The initial idea was to use the 3x3 meters frame normally used in transfers from trap to transport cages (Figure 7), adding a second stereocamera opposite to the first stereocamera at the other side of the gate. However, operational restrictions made it impossible, so the use of divers described in the next point was adopted.

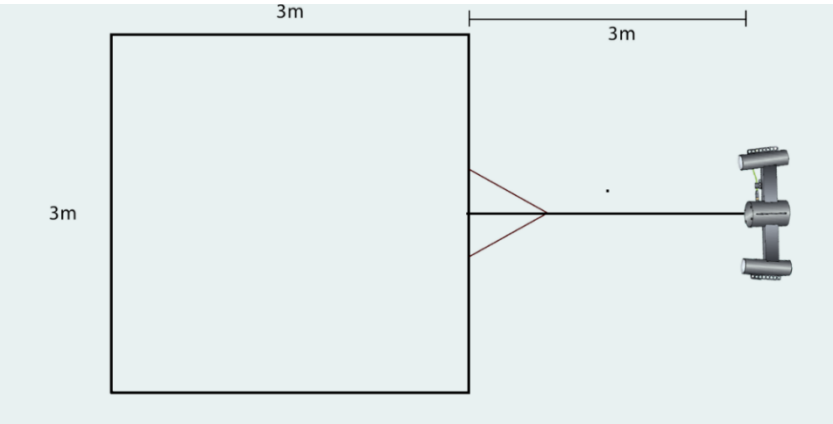

Figure 7. Gate frame and stereocamera normally used in transfers from traps to cages.

- Divers will be in charge of recording the first transfers with two stereocameras and one monocamera. The positioning is depicted in Figure 1. SC1 and SC2: Two stereocameras positioned 2-3 meters away on each side of the gate, capturing the fish from a lateral view at distances ranging from 2 to 5 meters. MC: one monocamera in the same position as SC2.

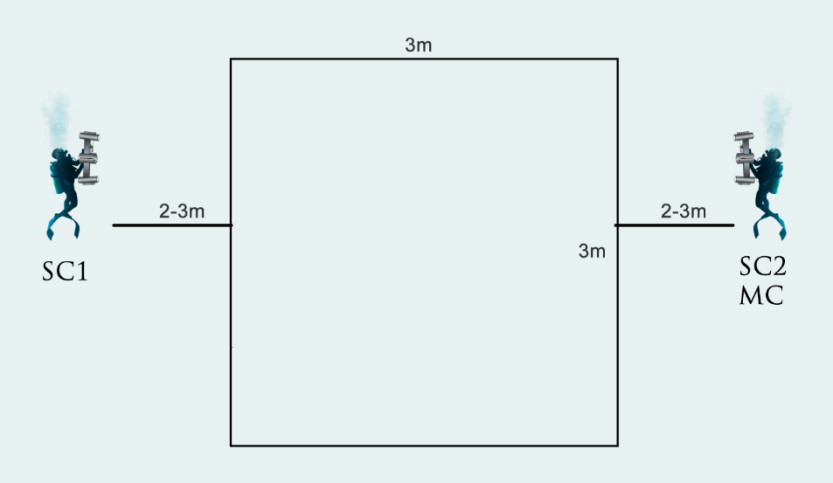

Figure 8. Positioning of monocamera (MC) and stereocameras (SC1 and SC2) during first transfers from trap to transport cages.

Table 3 three transfers recorded with the proposed setup, whereas Figure 9 shows the images recorded with monocamera (MC) and stereocameras (SC1 and SC2) with the proposed setup. Note that the gate does not have a frame, so the shape should be approximately a 3x3 square but is in fact more like an inverted triangle.

Transfer ID	TR1	TR2	TR3
Date and time	20250707 08:55 – 09:12	20250708 09.55 – 10:20	20250710 07:59 – 8:15
Video duration (min)	17	25	16
Number of cameras	2 lateral SC and 1 MC		
Video links	Link		

Table 3. Transfers from trap to transport cages. SC: stereocamera; MC: monocamera.

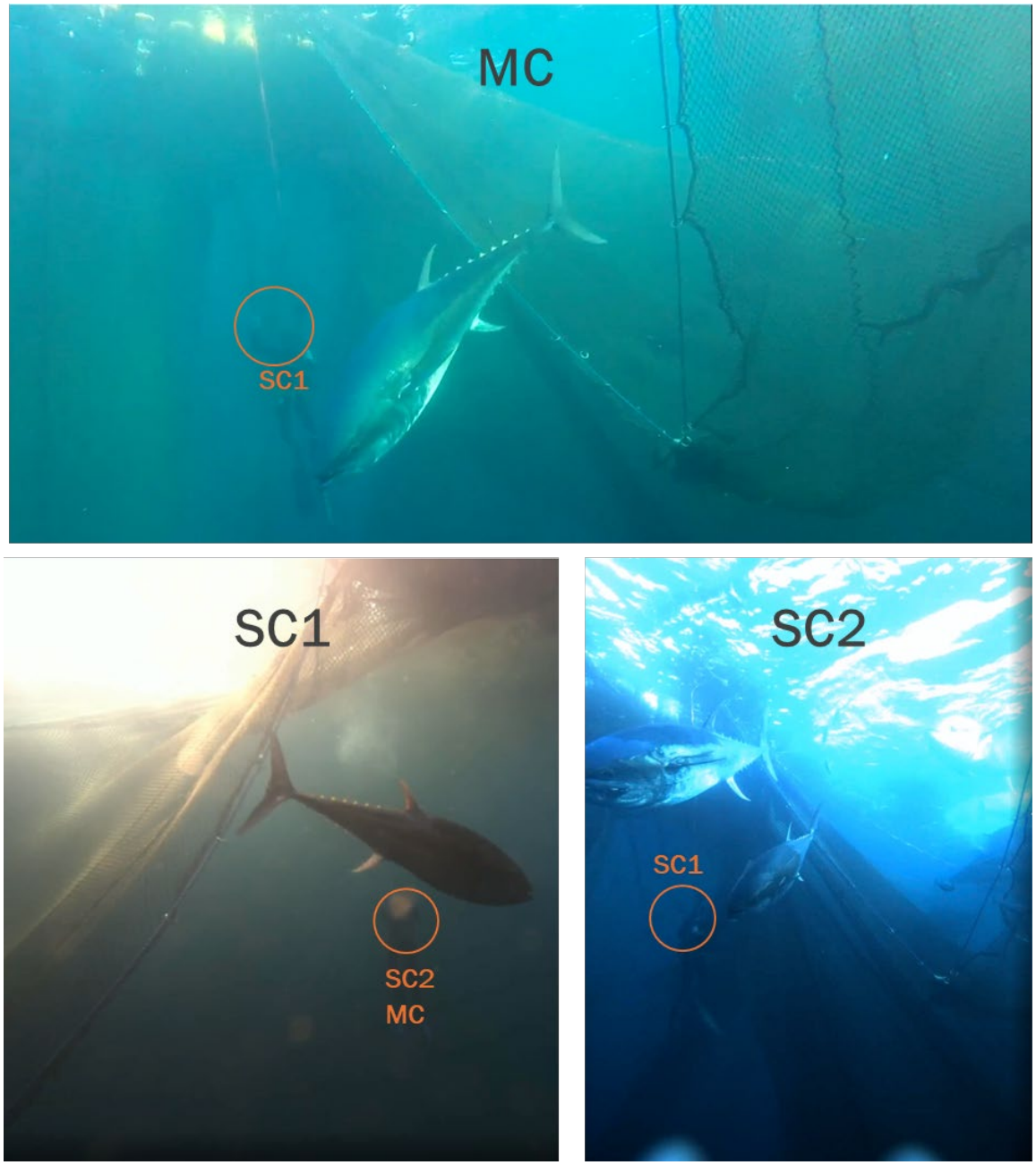

Figure 9. Images of transfers from trap to transport cages recorded in Portugal with one monocamera (MC) and two stereocameras to record the lateral view of the fish (SC1 and SC2). The position in the cage of the two divers holding the SC1 and SC2 stereocameras can be observed in the images of different cameras (highlighted in orange).

2. Materials and methods

2.1. Stereoscopic vision systems

Two types of stereocameras were employed during the recording of the transfers: AM100 stereocameras from AQ1 Systems and customized UPV stereocameras. The AM100 stereocamera, currently used by most operators, capture recordings at a resolution of 1.4 Megapixels (1360 x 1024), with a framerate ranging from 12 to 20 fps. The UPV stereocamera consists of two Gigabit Ethernet cameras, each with a resolution of 3.1 Megapixels (2048 × 1536) and a framerate of 33 fps. These cameras are mounted in an underwater housing with a baseline of 85 cm and 5° inward convergence. The system uses the IEEE 1588 Precision Time Protocol (PTP) synchronization and is rated to function at depths up to 40 meters. The system's power is supplied via ethernet umbilical cables, which also transfer images to a logging computer. The computer encodes the left and right videos using GPU encoding, and the system has been tested with cables extending up to 100 meters.

2.2. Stereocamera calibration

The principles of stereoscopic vision involve projective geometry and matrix algebra. Calibration of stereoscopic cameras requires recovering intrinsic parameters (such as the focal length, principal point, and lens distortion for each camera) and extrinsic parameters (the transformation between the two cameras). This calibration process is essential to correct image distortions and establish a relationship between the 2D image pixels and real-world 3D dimensions. The calibration typically involves capturing images of a checkerboard pattern from various angles, which are then processed to estimate the parameters via mathematical optimization. Accurate 3D measurements depend heavily on precise calibration of the cameras. Figure 10 illustrates a setup using the checkerboard method for calibration, which determines the rotation (R) and translation (T) between the two cameras, crucial for deriving length measurements from the images.

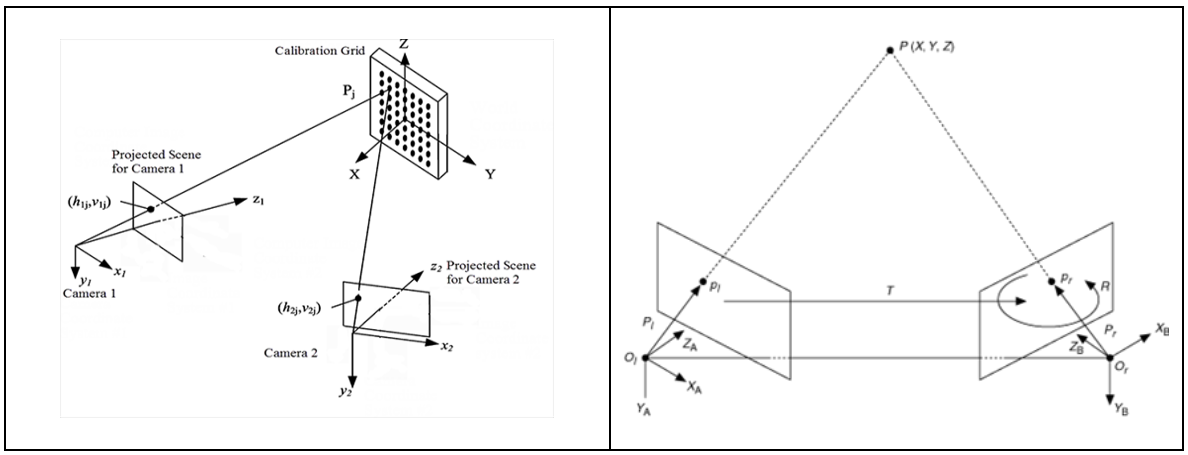

Figure 10. Description of a stereocamera calibration setup to find the rotation R and translation T between the two cameras.

In our projects, we use software such as MATLAB and the OpenCV library to carry out the necessary geometric transformations and matrix calculations. presents a part of the calibration process using MATLAB's Stereo Calibration Tool. This approach ensures compatibility across all stereocamera models and has been successfully demonstrated with the AM100 stereocamera in our research articles and enables us to operate commercial stereocameras in parallel with our custom stereocameras. Calibration parameters and images, necessary for the second objective of the Pilot Project, are provided together with the videos of each transfer.

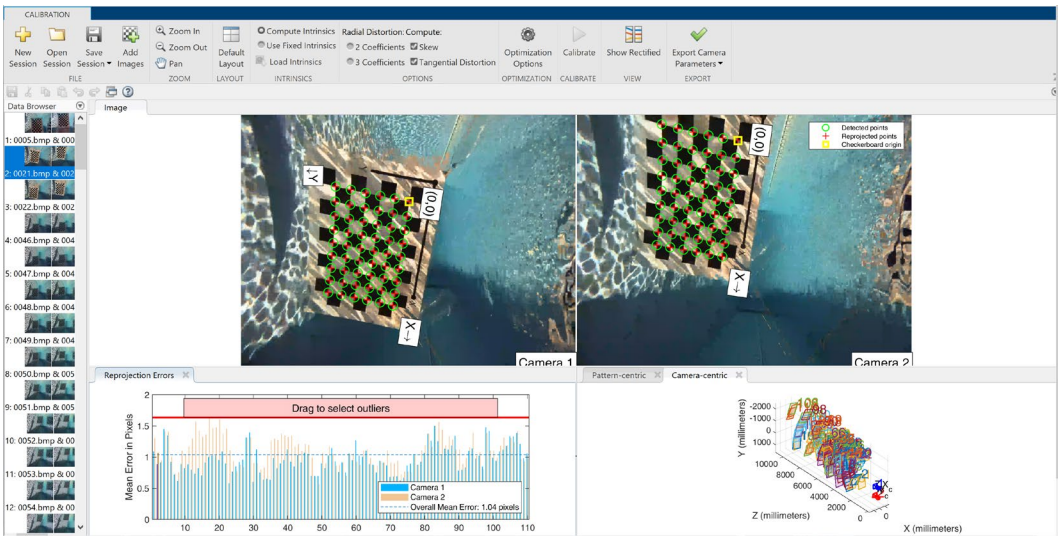

Figure 11. Snapshot of the stereocamera calibration conducted using MATLAB's Stereo Calibration Tool.

2.3. Fish sizing and counting software

A custom software was developed for manual sizing and counting of the fish, featuring a user-friendly interface. Users can navigate through video recordings, zoom in on specific regions, and mark the snout and fork tail points of selected fish in both the left and right video frames. This allows the extraction of Straight Fork Length (SFL), and the software can also infer fish weight based on established length-weight relationships. Figure 12 and Figure 13 showcase the software's interface and a length-frequency histogram from a first transfer in the Mediterranean. In addition to manual processing, the software is equipped for automatic processing of the recordings.

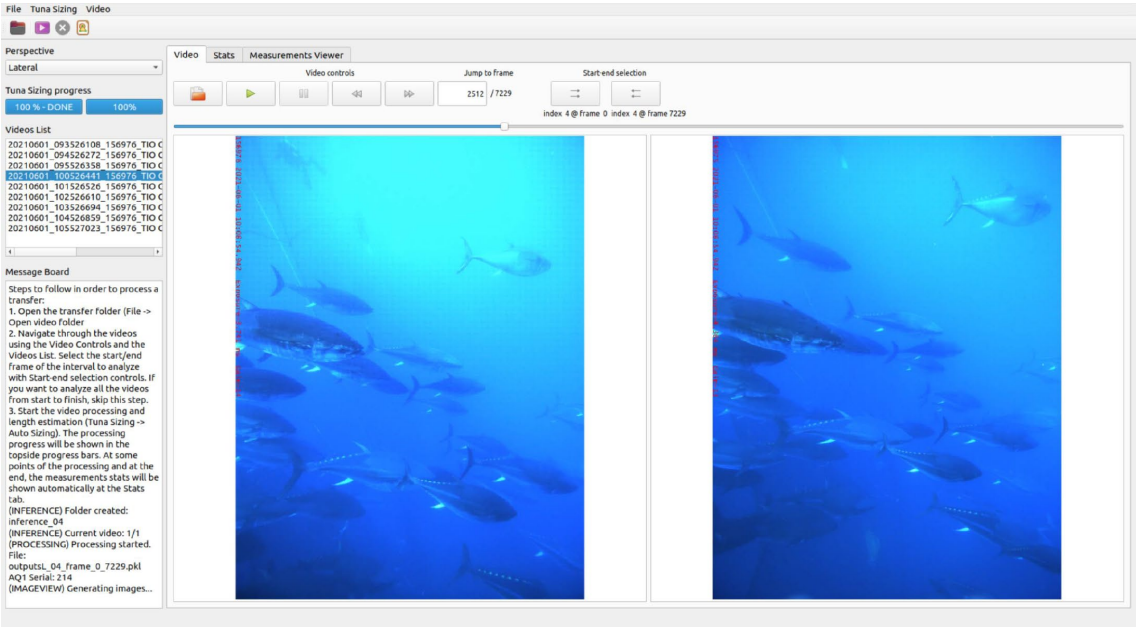

Figure 12. Snapshot of the software's user interface for fish sizing and counting from stereocamera recordings.

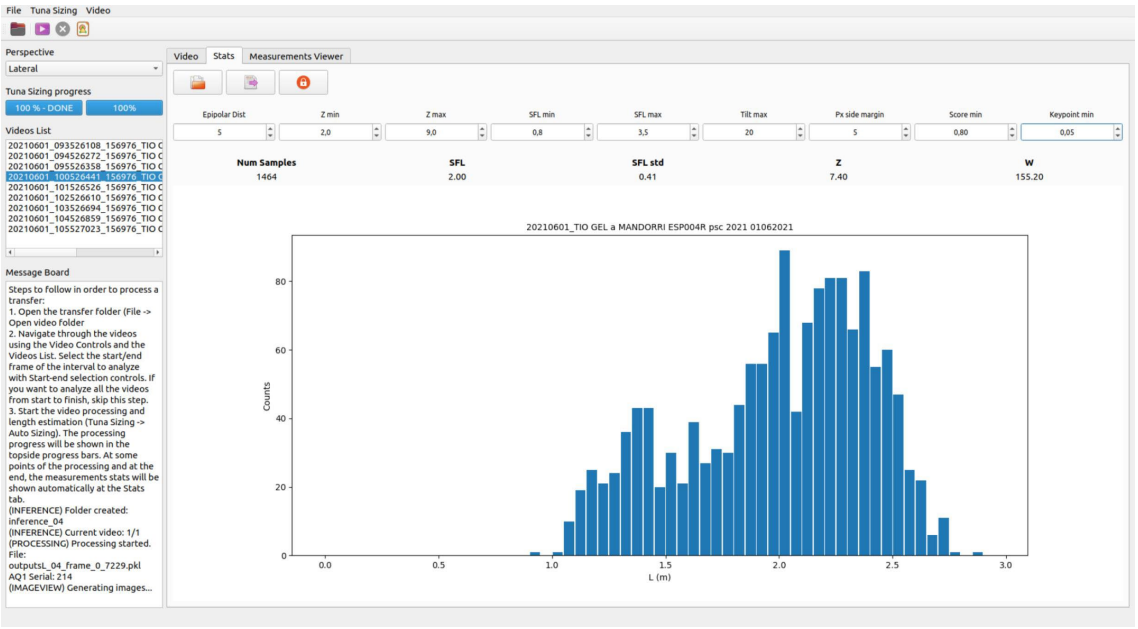

Figure 13. Snapshot of the length-frequency histogram resulting from fish sizing using the UPV software.

3. Results

This section presents an analysis of the procedures for counting and sizing fish during both first and second transfers. Fish counting is conducted manually by visually inspecting recordings from a monocamera and a stereocamera. For fish sizing, stereocamera recordings of first transfers are processed using manual methods to examine the average length, number of samples, and time invested. Where available, comparisons are made with results provided by the authorities in second

transfers. In at least one transfer from each scenario, the manual measurements aim to cover as close to 100% of the transferred individuals as possible.

3.1. First transfers from a purse seiner to a transport cage in the Mediterranean

Table 4 presents the results for manual fish counting with the monocamera during first and second transfers. Our team performed the fish counts twice for each first transfer, while fish counts were performed by fishing inspectors in second transfers. The disparity in transfer M1 is due to the bad visibility in the monocamera recording. In transfers M3-4, where no additional fish were transferred to the transport cage, the counts using the monocamera differed by 5%. Since all fish fit within the camera's field of view, this disparity can be attributed to variations in water turbidity, differences between operators, and the inherent difficulty of counting fish in overlapping schools. Due to the narrower field of view of the stereocamera compared to the monocamera, fewer fish were counted. Studying the feasibility of using acoustic echosounders for counting—capable of detecting occluded fish even in turbid waters and potentially automatable—may be beneficial. The time invested in counting ranged from 1.5 to 4 hours per transfer, with a cumulative total of 10.5 hours for all transfers.

First transfers ID	M1	M2	M3	M4
Number of fish in monocamera recordings	308/430	280/285	1379/1391	687/689
Number of fish in stereocamera recordings	313	272	1138	559
Time (min)	120 (2h)	90 (1.5h)	240 (4h)	180 (3h)
Transport cages	**ESP010R (with another transfer)**		**ESP014R**	**ESP008R**
Number of fish	1129		1315	653

Table 4. Manual fish counting during first transfers (with monocamera and stereocamera) and second transfers (provided by authorities) in the Mediterranean.

Table 5 provides an overview of fish length estimation. Manual measurements were carried out by using custom software and stereocamera recordings, based on marking snout and fork-tail points of at least 20% of the number of fish being caged. In first transfers, 32%, 21%, 45%, and 73% of fish recorded by the stereocamera were manually measured, corresponding to 23%, 20%, 37%, and 59% of the fish recorded by the monocamera. Note that the percentage of samples depends on whether the counting is based on the monocamera or the stereocamera recordings, due to the fish missing due to stereocamera's narrower field of view. The time invested for fish length estimation varied between 1.3 and 9.5 hours per transfer, amounting to a total of 16.3 hours across all first transfers.

In transfers M3-4, there were no additional transfers after the first, so the results could be compared with those obtained by fishing authorities during second transfers. Average lengths were 201.9 and 210.5 cm in the first transfers, compared to 192.6 (-4.6%) and 207.4 (-1.5%) cm in second transfers. This disparity could stem from differences in sampling, operator variability, and software (with second transfer measurements provided by fishing authorities using AM100 software).

First transfers ID		M1	M2	M3	M4
Counting with monocamera		308/430	280/285	1379	687/689
Counting with stereocamera		313	272	1138	559
Number of samples (%SC - %MC)		97 (31% - 23%)	56 (21% - 20%)	507 (45% - 37%)	406 (73% - 59%)
Average length (cm)		207.3	212.7	201.9	210.5
Average distance (m)		5.6	5.6	5.8	5.4
Time (min)		150 (2.5h)	80 (1.3h)	570 (9.5 h)	180 (3h)
Second transfer: transport cage ID		**ESP010R (with another transfer)**		**ESP014R**	**ESP008R**
Counting with monocamera		1207		1315	650
Counting with stereocamera		1140		1119	642
Authorities Manual	Number of samples (%SC - %MC)	242 (21% - 20%)		270 (24% - 21%)	130 (20% - 20%)
	Average length (cm)	212.0		192.6	207.4
	Average distance (m)	6.2		6.1	6.3
Harvests	Number of samples	882 (73%)		892 (68%)	341 (52%)
	Average length (cm)	218.5		210.1	215.2
	Dates	+ 5.5-6 months 2024/12/13 to 2025/01/08		+2-5 months 2024/09/26 to 2024/12/09	+3.5-4 months 2024/10/25 to 2024/11/04

Table 5. Manual fish length estimation with stereocamera during first transfers in the Mediterranean and second transfers (provided by authorities). %SC: Percentage of samples with respect to manual counting with stereocamera; %MC: Percentage of samples with respect to manual counting with monocamera.

3.2. First transfers from a purse seiner to a transport cage in the Adriatic

Table 6 presents the results for manual counting with the monocamera and one stereocamera during the first and second transfer. Our team counted each recording of the first transfer twice and the count with the stereocamera resulted in 16.7% fewer fish than count with the monocamera. However, since all fish fit within the field of view of both the monocamera and the stereocamera, the disparity is attributable to occlusions, the different perspective, and the wider field of view of the monocamera.

Transfer ID	A
Date and time	20240713 08:59-09:30
Transport cage	EUHRV013 (with other 4 transfers)
Farm cage	HRV008004
Video duration (min)	31
Video duration transferring (min)	1
Counting in first transfer	
Manual with monocamera	290/300
Manual with stereocamera	243/250 (-16.7%)
Counting in second transfer	
Manual with stereocamera	2668 (with other 4 transfers)

Table 6. Manual fish counting with monocamera and stereocamera during first and second transfers in the Adriatic.

Table 7 presents the results for fish length estimation during first and second transfers. Manual measurements covered 65% of fish counted with the stereocamera, which corresponds to 54% of fish counted with the monocamera. The rest could not be measured due to occlusion. Fishing inspection counted and sized the fish during second transfer, but no comparison can be made, as fish from four additional transfers were placed in the transport cage. Changes in the recording setup should also be studied, as proposed in Section 1.2, by reducing the transfer gate and making its dimensions as

similar as possible to the setup used in second transfer operations, where gates approximately 4x3.5m in size are used, since it represents the optimal configuration for estimating sizes with stereocameras.

Transfer ID	A
Date and time	20240713 08:59-09:30
Transport cage	EUHRV013 (with other 4 transfers)
Farm cage	HRV008004
Video duration (min)	31
Length estimation for first transfer	
Number of fish with monocamera	290/300
Number of fish with stereocamera	243/250
Number of samples	160 (SC: 65% - MC: 54%)
Average length (cm)	80.6
Time (min)	180 (3h)
Length estimation for second transfer	
Number of fish with stereocamera	2668
Number of samples	917 (34%)
Average length (cm)	79.1

Table 7. Manual fish length estimation during first and second transfers in the Adriatic. %SC: Percentage of samples with respect to manual counting with stereocamera; %MC: Percentage of samples with respect to manual counting with monocamera.

3.3. First transfer from a trap to a transport cage

Table 8 provides an overview of fish length estimation from traps. Manual measurements covered 85%, 35%, and 79% of the fish counted with the monocamera. No harvesting data was available for these transfers. As observed in the Mediterranean, some fish could not be counted due to the narrower field of view of the stereocamera. However, when transfers are conducted through a 3×3 m frame gate, the stereocamera is able to cover the passage and be used for counting.

First transfers ID	TR1	TR2	TR3
Manual counting with monocamera	129	368	91
Number of samples (%MC)	110 (85%)	130 (35%)	72 (79%)
Average length (cm)	202.5	155.5	188.9
Time (min)	90 (1.5h)	120 (2h)	60 (1 h)

Table 8. Fish length estimation with stereocamera during first transfers from trap.

4. Conclusions

The tests proved that estimating the weight of the captured bluefin tuna during first transfers (from purse seiners or traps to transport cages) is technically feasible.

In the Mediterranean, four first transfers were recorded using a setup similar to that employed during second transfers (from transport cages to farm cages): monocameras for counting and stereocameras for sizing, both recording fish laterally. In two transfers where no additional fish were moved into the transport cage, monocamera counts differed by only 5% between first and second transfer. Since all fish passed within the field of view, this difference is attributed to variations in water turbidity, operator performance, and the inherent difficulty of counting overlapping schools. Fewer fish were counted with the stereocamera due to its narrower field of view, not being able to cover the entire gate. Average lengths were 201.9 and 210.5 cm during first transfers, compared to 192.6 (-4.6%) and 207.4 (-1.5%) cm during second transfers. These discrepancies may reflect sampling differences, operator variability, and differences between software versions.

For trap transfers, fish were counted manually from monocamera recordings. As in the Mediterranean, some fish could not be captured by the stereocamera due to its narrower field of view.

However, when a 3 × 3 m frame gate was used, the stereocamera covered the entire passage and was suitable for counting. Manual measurements covered 85%, 35%, and 79% of the fish counted with the monocamera. No supplementary validation data were available from either authorities or harvesting.

Overall, weight estimation at first transfers using stereoscopic and conventional cameras is feasible in the Mediterranean and in trap fisheries, following procedures consistent with ICCAT Recommendation 22-08, as already applied to second transfers. Nevertheless, it should be borne in mind that there are some additional demands on the existing ones for first transfers that must be taken into account, in particular the use of a stereoscopic camera in addition to the conventional one currently in use, the training on stereoscopic camera usage and software of the personnel already used for bluefin tuna management and a longer time to carry out the transfer operation.

In the Adriatic, two recording setups with different gate sizes and stereocamera configurations were planned, but only one transfer could be recorded due to poor weather, limited catches, and the timing of operations late in the season after most of the quota had been landed. In this transfer, comparisons between first and second transfer were not possible, as fish from four other transfers were mixed in the transport cage. Manual counts were successful with the monocamera, and 65% of individuals were sized with the stereocamera. The Adriatic Sea fishery presents particular conditions, as bluefin tuna farming is based on catching small schools of juveniles. The fact that only one test could be carried out and the differences between this fishery and the Mediterranean fishery do not allow a clear conclusion on the suitability of the use of stereoscopic cameras in the Adriatic, and further testing would be desirable.

Spreadsheets containing detailed results for all transfers, including average lengths and number of measured fish, are available for download via the following link[1].

Acknowledgements

This work has been carried out within the scope of the project REM-BFT (project acronym), and co-funded by the European Union through the EU Grant Agreement No. 101103829, and a voluntary contribution by the United States.

The authors acknowledge the collaboration of Balfegó Tuna and the Spanish Navy patrol vessel *Alborán* (P-62) for providing vessels and divers during the transfers conducted in the Mediterranean. Appreciation is also extended to Jadran Tuna and the Croatian Ministry of Agriculture for their support in the Adriatic transfers, and to Tunipex for their assistance with the trap transfers.

[1] https://upvedues-my.sharepoint.com/:f:/g/personal/pamuobe_upv_edu_es/EmBbujDyRMVAumwubK3X7KEB_zxNufx-wtOoqgMIeKA1bg?e=aIDPRG

Annex 1: Diaries of the fishing campaigns.

In the present section the logbooks of the two fishing campaigns are presented. The first one, in the Mediterranean (Balearic Sea, Spain), and the second one in the Adriatic (Croatia). Both transferring from purse seine to transport cages.

Diary in the Mediterranean (Balearic Sea, Spain)

25/05/2024
Two technicians from the Universitat Politècnica de València embarked at the Real Club Náutico de Dénia aboard the Spanish Navy's patrol vessel Patrullero de Altura Alborán P-62. We set course for the Ibiza-Mallorca waterway. Upon boarding, we were informed that there was no satellite internet, so we lost connection as soon as we moved away from the coast.

26/05/2024
We woke up off the northeast coast of Ibiza and met with the fisheries inspectors. It was suggested that the objectives of the inspectors and the UPV might not align, as there are many other vessels from various companies that could be inspected. Around 10:30, we received instructions to proceed to the position of Tio Gel II (a collaborating vessel) to record a possible transfer. However, we were unable to reach the transfer due to a breakdown in the vessel's black water system, which forced us to return to Cartagena. A delay of at least 1 or 2 days is expected.

27/05/2024
We arrived at the port of Cartagena in the morning and waited for further information. Around 17:30, we were informed that the repairs had been completed and that we could be back in the fishing area by 29 May 2024, around 8:00.

28/05/2024
At around 11:30, the Navy and fisheries inspectors conducted simulated exercises to practice the inspection and seizure of a fishing boat. We then set course for the Balearic Islands again.

29/05/2024
We arrived in the area where most of the boats were located. We spent the day near La Frau (a collaborating vessel) and Tio Gel II, but we received no communication throughout the day.

30/05/2024
We remained close to the Balfegó vessels all day but received no further notice. No fishing took place today. Bad weather is expected in the coming hours. We met with the Navy Commander to request divers. They are willing to provide divers, provided it does not interfere with inspection work and meets safety protocols.

31/05/2024
We stayed sheltered from the storm. No fishing activity was reported all day.

01/06/2024
At 12:30, we received notice from Balfegó staff. We successfully completed the first recording, although we have concerns about the quality of the ventral perspective. Later, we were informed that the catch was released due to the presence of too many small fish.

03/06/2024
The Balfegó staff informed us that Cap Horizon (a collaborating vessel) was going to make a transfer. They were located north of Ibiza, but we were 3 hours away and unable to reach them because the inspectors were conducting an inspection between Denia and Ibiza. Tio Gel II was in this area.

04/06/2024
We recorded the second transfer. It was challenging due to rough sea conditions. The Navy divers were occasionally operating outside their safety limits. The ventral perspective was difficult to capture because they could not hold their position, but the other two perspectives were successful.

05/06/2024
We were unable to record today. Tio Gel II deployed a fishing gear around a tuna school, but the fish escaped.

06/06/2024
We were ready to record a transfer from La Frau, but ultimately, the Balfegó staff informed us that recording was not possible because it was a double transfer, and longer cables would be needed.

07/06/2024
At around 17:00, we docked at the port of Maó (Menorca), concluding our stay after 13 days onboard. Due the complexity of managing fish inspection needs and UPV needs in the patrol vessel, and coordinating with Balfegó Tuna's fishing boats, it was agreed between Balfegó Tuna and UPV that, in case some more transfers could be done during the following days, at least one more first transfer will be recorded with two lateral stereocameras. Thanks to this symbiosis, two more first transfers were finally recorded and apported to the project.

Diary in the Adriatic (Croatia)

30/06/2024
Two technicians from the Universitat Politècnica de València traveled to Sibenik (Croatia). We arrived at Sibenik - Amadria Park at approximately 22:00.

01/07/2024
We met with the fishing inspectors, divers, and collaborating fishermen. The details for making the recordings were finalized. The remaining quota percentage was small (about 5%). The weather forecast for the next two or three days is unfavorable, with bad seas expected.

02/07/2024 and 03/07/2024

The boats remained in port due to bad weather. We stayed at the hotel in Amadria Park, which is 10 minutes from the pier, ready for the inspectors' call.

04/07/2024
The inspectors advised us that the fishing boats went out to sea early in the morning. However, they returned to port in the afternoon with no catch due to bad weather.

05/07/2024
The fishing boats left the port in the morning, and the inspectors informed us that we would depart with the patrol boat tomorrow. A transfer was made, but the inspectors reported that we did not meet the recording requirements. The exact reason is unknown. We extended our stay in Croatia.

06/07/2024
We went out to sea and waited all day. Bad weather in the afternoon forced us to return to port. Upon arrival, the inspectors informed us that a catch had been made, but no communication was sent until after we had left.

07/07/2024
No news all day. In the evening, we contacted the inspectors, who told us they would provide a forecast the following morning.

08/07/2024
We went out to sea but made no recordings, and there was no catch. Bad weather in the afternoon forced us to return.

09/07/2024
In the afternoon, the inspectors informed us that they could only provide divers for two more days; beyond that, they could not guarantee anything.

10/07/2024
We went out to sea without recording. In the afternoon, we were informed that the surveyors had other obligations the next day and could not take us out to sea. We picked up a third team member from the airport to take over.

11/07/2024
A team member left Sibenik. We did not go out to sea all day and remained at Amadria Park, awaiting news from the inspectors. Late in the evening, we were informed that we would go to sea the following morning at 6:00 a.m.

12/07/2024
We went out to sea, but there was no notification of a catch. In the afternoon, we were informed that, due to health reasons, the divers they were providing would not be available until Sunday or Monday. We made arrangements to contract two new local divers for the next day.

13/07/2024
We set sail early and successfully recorded the first transfer.

14/07/2024
We went out to sea but did not receive any notice of a catch. Divers were provided again by Croatian authorities.

15/07/2024
We went out to sea but did not receive any notice of a catch.

16/07/2024
Return trip to Spain after a 17-day extended stay, up until the final day of the campaign.

Diary in transfers from traps (Portugal)

Two technicians from the Universitat Politècnica de València traveled to Olhão (Portugal). They stayed from 06/07/2025 to 11/07/2025 without any unpredictable or remarkable event, so we successfully recorded three first transfers from a trap to fattening cages.