

IN MEMORIAM OF A TUNA SCIENTIST, PROF. PASQUALE ARENA

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SUMMARY

Professor Pasquale Arena, a Sicilian marine scientist, dedicated his entire career to the study of bluefin tuna. He was the first to adopt advanced techniques for studying the species' behaviour in the wild, particularly during the spawning period. He also studied bluefin tuna fisheries and the fisheries of other species, including related fisheries. This short paper would like to recall the many scientific contributions of Professor Arena, who was also part of the SCRS BFT Species Group in the past. His equations, maturity data, and growth curves, based on a large amount of reliable data, are still used by several Species Groups at ICCAT.

RÉSUMÉ

Le professeur Pasquale Arena, scientifique marin sicilien, a consacré toute sa carrière à l'étude du thon rouge. Il a été le premier à adopter des techniques avancées pour étudier le comportement du thon rouge à l'état sauvage, en particulier pendant la période de la reproduction. Il a également étudié les pêcheries de thon rouge et d'autres espèces, y compris les pêcheries connexes. Ce bref article souhaite rappeler les nombreuses contributions scientifiques du Prof. Arena, qui a également fait partie du Groupe d'espèces BFT du SCRS dans le passé. Ses équations, ses données de maturité et ses courbes de croissance, basées sur de nombreuses données fiables, sont toujours utilisées par plusieurs Groupes d'espèces du SCRS de l'ICCAT.

RESUMEN

El profesor Pasquale Arena, científico marino siciliano, dedicó toda su carrera al estudio del atún rojo. Fue el primero en adoptar técnicas avanzadas para estudiar su comportamiento en la naturaleza, sobre todo durante el periodo de reproducción. También estudió la pesca del atún rojo y de otras especies, incluidas las pesquerías afines. Este breve documento quisiera recordar las numerosas contribuciones científicas del Prof. Arena, que también formó parte del Grupo de especies de BFT del SCRS en el pasado. Sus ecuaciones, datos de madurez y curvas de crecimiento, basados en muchos datos fiables, siguen siendo utilizados por varios Grupos de especies del SCRS de ICCAT.

KEYWORDS

Bluefin tuna; reproductive behaviour; ex-situ reproduction; fisheries; large pelagic species; biological parameters; field observations; Mediterranean Sea

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1. Foreword

Some scientists, in their life, were able to improve in a considerable manner the knowledge in some fields and, at the same time, spreading this knowledge to the scientific community and young scientists. Prof. Pasquale Arena (**Figure 1**) was one of them, always in a kind and gentle manner, basing all his studies on reliable data, directly collected at sea or in the field, with a considerable effort. This short paper would like to shortly recall his work and memory.

I had the chance to work with Prof. Pasquale Arena for several years, learning from him and sharing the many difficulties of the fieldwork, but also the solutions for facing them.

2. The life

Prof. Pasquale Arena was born in Messina (Sicily, Italy) in 1928. He had always a passion for the marine life and he got his degree in 1956 in Natural Sciences at the University of Messina, with the maximum vote *magna cum laude*.

In the same year, the Experimental Centre for Fisheries and Seafood² of the Sicilian Regional Government hired him as Assistant. In April 1959, he became Scientific Assistant and, finally, in 1965 he became the Director. In 1960, Prof. Arena married Ada Gallo and they had two sons, Giuseppe and Paola.

Prof. Arena was a specialist in taxonomy and systematics of marine species, both vegetables and animals, and his practical capacity of identifying the many species was very impressive. Furthermore, he was able to remind the most important characteristics and details for being sure of their identification. Having this capacity, in 1966 he became also Professor of Systematic Zoology at the Faculty of Biological, Natural and Mathematical Sciences at the University of Messina, becoming an associated member of the Institute of Zoology and Comparative Anatomy.

In March 1971, the Centre became part of the Sicilian Industrial Development Agency³ (ESPI), establishing two units, one in Messina (directed by Prof. Arena) (**Figure 2**) and the other in Palermo (directed by Prof. Raimondo Sarà). In his role, Prof. Arena decided to design and build a wooden research vessel, named “Centro Pesca Primo” (**Figure 3**), especially suitable for fishery research.

Prof. Arena retired in 1990, but he continued to follow the research and scientific activities on bluefin tuna for many years. He died on November 2023.

During his lifetime, Prof. Arena was always a master for young scientists and for several of his colleagues. However, he was also an epicurean, he liked good food and, usually, the galley lists for every research missions at sea, which he personally looked after, always started with a coffee liqueur.

2. The scientific activities

During his scientific career, Prof. Arena had the opportunity to work together with many scientists. Of course, the nearest ones were the Italians, at first his assistant Dr. Francesco Li Greci and his colleagues based in Palermo, Prof. Raimondo Sarà and Dr. Giovanni Bombace. His team, over the years, included many young marine biologists at the beginning of their career, Dr. Antonio Cefali, Dr. Antonio Potoschi, Dr. Franco Andaloro and myself. Over these years, the researches were many, mostly on the bluefin tuna fishery (particularly the purse-seine one), but also long and difficult campaigns on the trawl fisheries in the Strait of Sicily. He also cooperated with Prof. Corrado Piccinetti for many researches on bluefin tuna, including an experimental longline fishery in the Strait of Sicily and in western Sardinia in 1994-1995.

At the beginning of his career, while beginning several researches on bluefin tuna, he carried out various campaigns of the bottom trawl fishery in the Strait of Sicily and in the central Mediterranean Sea (**Figure 4, left**), investigating the functionalities of the fishing gears, the yields and the benthic communities impacted by the fishing activities, particularly the deepest ones. He also carried out experimental campaigns for the red coral. He had the opportunity to work on tropical fisheries in western Africa.

² Centro Sperimentale della Pesca e dei Prodotti del Mare.

³ Ente Siciliano per lo Sviluppo Industriale (ESPI).

As concerns the bluefin tuna, *Thunnus thynnus*, his life's passion, Prof. Arena, being always an innovator, started with an experimental fishery campaign in the southern Tyrrhenian Sea and in the Strait of Messina, two areas used by the bluefin tuna for spawning and migrate. While Heldt and Sella were successfully using the hooks for better understanding some tuna migrations, he considered the harpoons used in the Strait of Messina, that provided the evidence of tuna migrations from the Tyrrhenian Sea to Tunisia.

Of course, the trap fishery interested him and he carried out many studies for better understanding how the new and huge industrial chemical plants in the eastern Sicily were impacting the marine environment and the trap fishery in the southern tip of Sicily (Porto Palo). He wrote several reports on these studies in the late '50s, in the '60's and the beginning of the '70s. In the following years, he worked also on other Sicilian traps. In the '60s, he was in touch with a Spanish colleague, Dr. Julio Rodriguez-Roda, and they often exchanged their views on the tuna biology.

Since 1965, he initiated the bluefin tuna tagging in the waters around Sicily. Several juveniles of bluefin tunas were tagged in the Strait of Messina in the late '70s and in the '80s.

At the beginning of the '60s he was attracted by the behaviour of bluefin tuna coming into the southern Tyrrhenian Sea for spawning. The first published study was in 1964 and, since then, he continued these studies for decades. Initially, he studied the tuna behaviour from the fishing vessels but, after meeting several times his French colleague and friend, Dr. Henri Farrugio, who was using the aircraft of the French purse-seine fleet for studying the distribution of bluefin tuna in the NW Mediterranean Sea since 1974, he decided to do the same in the southern Tyrrhenian Sea. Since 1978 and for many years, Prof. Arena studied the spawning and schooling behaviour of bluefin tuna using the spotting aircraft of the Italian purse-seine fleet. At the beginning, he was alone, but later I supported him also in these studies. Then, taking advantage of the opportunities provided by both the PS fishers and the canning industry, Prof. Arena set-up a strategy for monitoring the fleet (**Figure 4, right**), the fishing strategy, the tuna biology and the tuna behaviour. Every year, there were three different teams of researchers, one on the aircraft, one on board of PS vessels and the third one in a canning industry in Palermo, rotating about every month, having the duty of following the many aspects. The team at the factory had the duty to collect the size frequencies, measuring all fish, taking note of the stomach contents, the maturity of the gonads and any other interesting information. In this way, for the very first time in the Mediterranean Sea, it was possible detecting the bites of *Isistius brasiliensis* in bluefin tunas, a natural mark indicating large movements in the Atlantic. On board, it was possible strictly monitoring the fishing operations and collecting *in situ* measures for detecting the thermocline and then correlate these measures with the aerial observations on fish behaviour. The amounts of data collected over these years are a patrimony for the scientific community.

Between 1976 and 1977, Prof. Arena, together with Prof. Guglielmo Cavallaro of the Institute of Zoology and Comparative Anatomy of the University of Messina, was in charge of studying the full ecosystem of a large lagoon close to Marsala (Sicily). The study, carried out over one full year with a numerous team of marine biologists and divers, was very complex for the diversity of communities and species, concerning both the benthic and the nektonic domains.

In 1978 he was the first coordinator for the large pelagic studies in the "finalised research programme" decided by the Italian National Council of Research. In 1980, he became the first national coordinator for the triennial research programme for large pelagic species established by the Direction general for Fishery and Aquaculture of the Italian Ministry of Merchant Marine and he organised a national network of Operational Units made by Universities and other research Institutes, which remained active and in place for about 20 years. He continued as national coordinator until 1989. Prof. Arena traced the course for all future Italian national research coordinators for large pelagics (Prof. Corrado Piccinetti, Prof. Gregorio De Metrio, Prof. Giovanni Marano, Prof. Lidia Orsi Relini and myself), with whom he always willingly collaborated, providing and sharing his indispensable contribution of knowledge and experience.

In 1980 he, together with his colleague Raimondo Sarà, organised the first meeting of the ICCAT SCRS BFT SG in Palermo (Sicily). Dr. Peter Miyake (ICCAT), Dr. Michael Parrak (USA), Dr. Henri Farrugio (France) and Prof. Corrado Piccinetti (Italy) attended the meeting also. Then, they moved to Trapani and Favignana, for looking at the tuna harvesting in a trap, where I finally joined them. This was the first of few SCRS meetings organised in Sicily over the years. Dr. Peter Miyake and Dr. Papa Kebe were very grateful to Prof. Arena for the important amount of reliable data he provided to ICCAT, while Dr. Alain Fontaneau was always kin working on Prof. Arena's documents, because they were supported by detailed and helpful data (size frequencies, fishery data, growth curves, and biological data).

In 1978, Prof. Arena, in cooperation with Prof. A. Yasuda, Dr. H. Khono, Dr. A. Yatsu, Dr. H. Ida and Dr. Y. Taki of the Tokyo University of Fisheries, organised a campaign for trying the very first experiment of artificial reproduction of bluefin tuna (*Thunnus thynnus*). The research campaign was carried out in the southern Tyrrhenian Sea on board of purse-seine vessels, and the full Arena's team (Dr. Cefali, Dr. Potoschi and myself) joined the Japanese team in this challenge. The experiment was partly successful, the eggs were fertilised but the larvae died after five days for a feeding problem. The results of this experiment were never published for unknown reasons, but Prof. Arena officially reported them to ESPI in 1981.

In the same year, in cooperation with the same team of the Tokyo University of Fisheries, plus and a second team with Prof. Teruo Harada, Prof. Osamu Murata and other young scientists of the Fisheries Laboratories of the Kinki University (Japan), Dr. Antonio Cavaleri of the Thalassografic Institute in Messina and Dr. Francesco Li Greci, they carried out the very first experiment of artificial reproduction of swordfish (*Xiphias gladius*). The results of this experiment were published in 1978 and 1981.

After these experiments, the deep scientific knowledge of Prof. Arena about the biology and fishery of large pelagic species was very clear to the Japanese scientists and he was officially invited to Japan in 1982 (**Figure 5**) for a series of lectures and conferences.

After decades of field studies on the purse seine fishery carried out in cooperation with the Italian fleet, both on spawners and small adults, he finally concluded that the trials for using the CPUE from this fishery were useless for determine the abundance of the stock. The motivation was because the CPUE index was fully driven by many external factors, and mostly by the fishing strategy and the marked needs. On the opposite, the same CPUE series, having the complete data sets, were useful for economic analyses of this fishery.

He was able to describe in detail the variable schooling behaviour of bluefin tuna during the spawning season and how larger tunas were driving and apparently protecting the sides of the schools, never studied before, as well as how the spawners use the thermocline for activating the emission of gametes when they are mature and not stressed by external factors. Only after thousand hours of aerial observations, it was possible to describe these behaviours in the wild, confirming the biological data taken on bluefin tunas after checking them at the tuna factory. During these studies, he was one of the few at that time to correlate satellite images of the ocean⁴ to bluefin tuna concentrations and migrations, looking particularly at the seafronts.

Prof. Arena's methodologies for studying the bluefin tuna were among the basis for planning the very first ICCAT GBYP aerial survey for spawning aggregations in the Mediterranean Sea.

Prof. Arena carried out also important studies on albacore (*Thunnus alalunga*) and particularly on the growth and the sexual maturity, sampling in various Mediterranean areas. The data on Mediterranean albacore collected over more than 20 years of research have been used in recent ICCAT SCRS ALB SG meetings and they are considered an essential reference.

The latest paper by Prof. Arena was written together with Prof. Piccinetti and myself, and then published in ICCAT Collected Volumes of Scientific Papers in 2013. It is a compendium of about five decades of field observations on the reproductive biology and behaviour of bluefin tuna in the Mediterranean Sea and the possible correlations with some environmental and oceanographic components.

In the final part of this paper, there is the complete bibliography of the works written by Prof. Pasquale Arena, in chronological order. Many of them are in Italian, because they were domestic technical reports, and this language issue, along with the difficulty to access some of these documents, may have caused a reduced use of the often very important scientific contents.

⁴ In those years, the satellite images were provided to Prof. Arena by NASA. They were black and white printed photos, and they were difficult to couple with observation maps. It was necessary using drawings on transparent supports for analysing the field data.

3. A legacy

Prof. Arena (**Figure 5**), mostly during the long campaigns at sea, was always very focused on the proper training of young researchers. Apart from the constant practical lessons on the identification of the many species, benthic or pelagic, which were the fruits of his encyclopaedic knowledge and his extraordinary visual and scientific memory, there was a sort of decalogue that he always quoted and of which I found traces in several old note-books.

- a) Always read past research, to benefit from observations made by others in times long gone by and sometimes with a different view.
- b) Study critically, delving deeply into the topics that interest us most, never neglecting an overall view.
- c) Never limit your readings to peer-reviewed works: there are often academic or economic power systems behind them. Always have the scientific and knowledge tools to judge for yourself the seriousness and reliability of a work, beyond the form or journal.
- d) Nature is an open book, with infinite pages; it is up to us to read them.
- e) In nature, equilibria are never stable, but dynamic and responsive; a stable equilibrium would have to be isolated from the environment around, which would make it extremely fragile.
- f) Knowing the species is essential to understanding their role in ecosystems; being able to identify them means better understanding the entire environment where they live.
- g) Always observe the sea and the behaviour of species in the wild very carefully: they are a constant source of research and insights.
- h) Mathematical models are useful descriptors that can simplify complexity. Never believe them uncritically, always check that their results do not deviate from acquired scientific knowledge. Prediction models are like crystal balls: to work well they should contain all the main components of the ecosystem in which each individual species lives. Since this is practically difficult to obtain, the error increases for each missing component, but we never know how many are missing!
- i) The biology of each individual species is complex and its relationships with environmental factors are often difficult to identify. The keys to understanding them are often outside the visual field of the microscope.
- j) Stomach contents are a constant source of discoveries and serve as a basis for understanding marine trophic chains, which we often talk about without knowing them.
- k) Always talk to the fishermen, without presumption. They are at sea every day, we only sometimes. They have the opportunity to observe rare events or behaviors that can be valuable to our understanding and knowledge.
- l) Every fishing gear is often the result of technologies developed over the centuries, sometimes in a different way by each fisherman. Understanding how it works requires careful and critical observation skills and long discussions with those who use it on a daily basis.
- m) The work of a marine and fisheries biologist is made up of constant challenges, seemingly endless hours, rough seas, humidity, often smelly and dirty environments, uncomfortable bunks in constantly moving environments, long hours behind a microscope, endless time in libraries and efforts to write what we have observed in a way that we suppose will be clear to the reader.
- n) Always look for a moment of relaxation after work. A good meal can certainly help, but so can looking at the infinity of the sky and the sea.

Prof. Arena was himself putting them into practice, but they are useful tips for all researchers.

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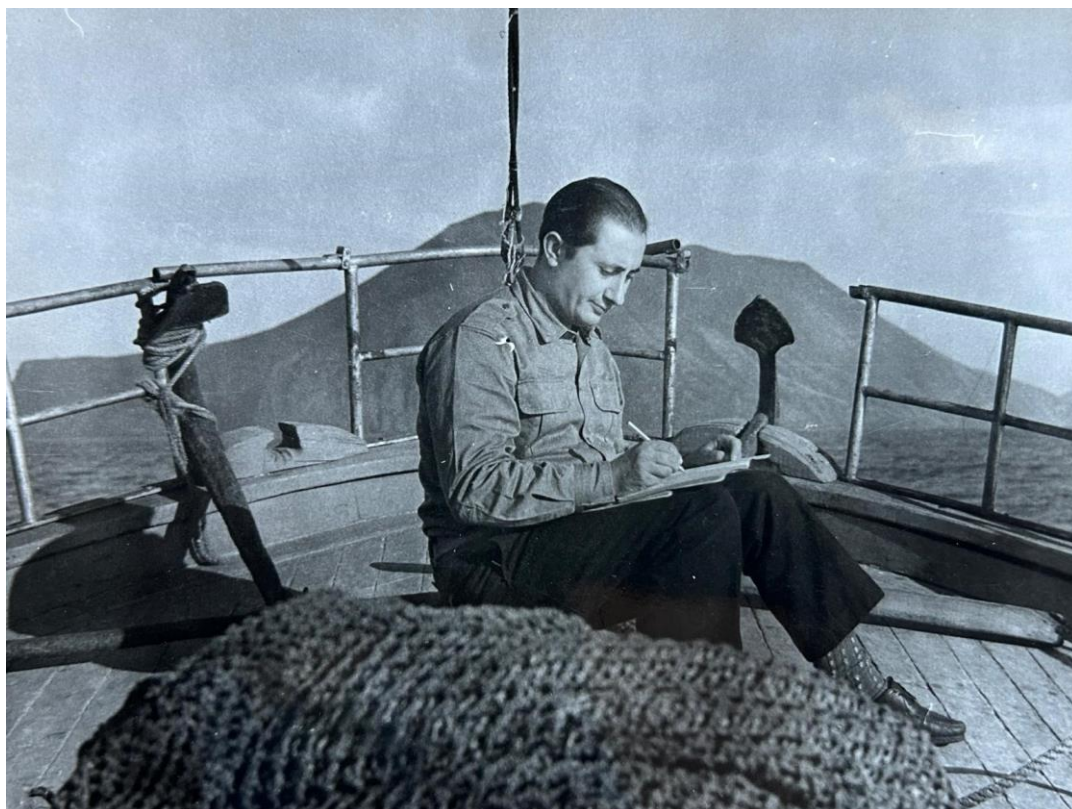


Figure 1. Prof. Pasquale Arena on board of a fishing vessel in the Aeolian Islands in the late '60s.



Figure 2. Prof. Pasquale Arena in his office at the Centro Sperimentale per la Pesca e i Prodotti del Mare (ESPI) in Messina in 1978.



Figure 3. The research vessel “Centro Pesca Primo” in 1971.



Figure 4. Prof. Pasquale Arena on board of a bottom trawler vessel in the Strait of Sicily (left) and on a tuna purse seine vessel in the southern Tyrrhenian Sea (right).



Figure 4. Prof. Pasquale Arena visiting the Tokyo Fish Market (Tsukiji) in 1982.



Figure 5. Prof. Pasquale Arena during the latest period in his lab (ESPI) in Messina (Sicily, Italy).