The scientific role of Malcolm Clarke in the Azores

Abstract

Malcolm R. Clarke (1930 – 2013) was a British teuthologist who made an important contribution to marine science in the Azores archipelago (Portugal). An authority in the study of oceanic cephalopods during the second half of the XXth century - particularly in the use of stomach contents to understand both prey and predators - he started doing research in the Azores from 1980's onward, settling for residency after his retirement in 2000. He is the lead or contributing author of ca. 30% high scientific impact publications resulting from a search for "Azores" and "cephalopod" (source Science Direct, June-2013), spanning from 1981 to 2012.

Malcolm believed the way to understand the marine ecosystem was through sampling commercially exploited and top predator species, thus allowing to i) identify how species interrelate, ii) understand which species/organisms are critical to sustain the present balance and iii) determine how the island and the oceanic ecosystem interact. His research in the Azores focused on two main of areas: dietary studies from cephalopod predators and the ecology of cephalopods on seamounts. Since his first visit in 1981, he was involved in the description of the dietary ecology of several cetaceans, large pelagic fishes, deep-water fishes and seabirds. Regarding seamount ecology, Malcolm revised the association of cephalopods with seamounts, by using his own data, updating and enlarging the different cephalopod groups according to species behavior and ecology.

Malcolm taught several students working in the Azores on cephalopods and beak identification, lecturing the Third International Workshop in Faial (2007).

Other contributions benefited the recently established research community, such as establishing important contacts with foreign institutes. He belonged to the advisory board of the local journal "Arquipelago - Life and Marine Sciences" 1990-2013 and collaborated in the cetacean stranding network RACA. But the scientific role of Malcolm Clarke in the Azores goes beyond the academic activities, outreaching science to a wider audience or being a regular speaker in local conferences.
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In the last 10 years Malcolm and Dot Clarke dedicated themselves to building and running of a museum on Pico Island, showing the biology of the sperm whale and its interaction with squid. A cultural and touristic legacy, for future generations to yield.

I. The life and work of Malcolm Clarke

One of the leading cephalopod experts in the world, Malcolm Roy Clarke (1930-2013) chose Pico Island (Azores, Portugal) to live and work during the last phase of his career.

His professional career started in 1950 as teacher at the Secondary Modern School in Scunthore (UK), after serving from 1948 to 1950 in the National Service in the Royal Army Medical Corps. In 1954 he made a sharp turn in his career and went to the Antarctic for eight months serving as an official whaling inspector aboard the *Southern Harvester.*

He obtained his PhD on marine mammals' parasites in 1959 (Hull University, UK), after which he focused his attention on cephalopods and their predators in the deep waters of the Northeast Atlantic as Scientific Officer (and later Principal Scientific Officer) at the National Institute of Oceanography (Surrey, UK). This switch in interest arouse when realizing the amount of information whale stomachs could provide on cephalopod diversity and biomass (17).

In 1972 Malcolm started working for the Marine Biological Association of the UK (MBA), initially as Principal Scientific Officer and later as Senior Principal Scientific Officer.

In 1981 his outstanding contributions to science were recognized by being elected Research Fellow of the Royal Society [1]. In this year, he also organized a workshop that 5 years later lead to the most important beak guide in the World.

While working at the MBA, Malcolm made his first visit to the Azores and started studying the diet of sperm whales (*Physeter macrocephalus*) using individuals landed at the São Roque whaling station on the island of Pico. The work was undertaken from 1981 to 1984 in close collaboration and with the support of researchers and technicians of the recently created Department of Oceanography and Fisheries, from the University of the Azores (DOP-UAç, established in 1975).

During the last period of his career he became Visiting Professor of Liverpool University (1989-2005), of the National Institute of Atmospheric and Water Research, New Zealand (2001-2003), Kaichung University, Taiwan (2003) and visiting scholar of University of the Azores, Portugal (1990-2011). He collaborated regularly with the British Antarctic Survey, particularly in the late 1970´s and early 1980´s.

He retired from MBA in 1987 with a respectable body of work. After retiring he went on with his research, which became essentially self-funded.

His academic *curriculum* is vast. He has undertaken research on all continents during 58 years working in biological oceanography, physiology and ecology of marine animals. The scientific contribution of Malcolm adds up to more than 150 articles and scientific books (Annex).

In teuthology his research was catholic, including fields as diverse as taxonomy, ecology, physiology, evolution and paleontology. He even applied his knowledge on cephalopod ecology to improve mid-water trawls for sampling deep sea squid?. He also has a vast body of work in cetology, including studies on parasitology, physiology, anatomy and diet. In fact, the study of the diet of several taxa, including fish, birds, seals and cetaceans, was an important part of his research.

In parallel to his research activity, Malcolm was founder (and president during three years) of the Cephalopod International Advisory Council (CIAC). He supervised PhD and Post-Doctoral students in eight countries. In the scope of international courses he trained many researchers in several aspects of teuthology and on the use of cephalopod beaks for dietary studies.

Malcolm was also involved in television documentaries with the major American and British television producers (e.g. National Geographic, BBC, Discovery Channel, Pitcairn Productions).

II. Contribution of Malcolm Clarke to science in the Azores.

After his first visits to the Azores between 1981 and 1984, in the early 1990's Malcolm and his wife Dorothy (Dot) Clarke bought a house in Pico Island, moving permanently in 2000 (Dot Clarke, Pers. Comm.).

During his "Azorean period" Malcolm continued doing research and had a key role in the research conducted by numerous colleagues in the Region, either by formal or informal advisory, directly participating in their work or by training and/or supervising them. These aspects are discussed in detail below.

II.i. Malcolm's research in the Azores

II. i. a) Bibliometry

It would be expectable that the presence of a prolific researcher such as Malcolm Clarke would have a positive impact on the scientific output of an ultra-peripheral region such as the Azores. To test that premise we set to gauge Malcolm's contribution to the Region in the field of teuthology, his chief line of research.

In order to quantify the publications on cephalopods relevant to the study of those animals in the Region, a search was carried out in the Science Direct search engine using the terms "Azores" and "cephalopod". The search was restricted to peer-reviewed, indexed journal articles. The Abstract or full text (when available) of the resulting references were analyzed and only those that included relevant research on cephalopods from the Azores were retained. This method can obviously miss relevant publications, but there is no reason to believe that it favours the presence of any author over others. Thus it was considered that it would give a fair sample of an individual's contribution to a research field for any given geographical area.

That search yielded 21 results directly related to the Azores, spanning from 1966 to 2012. Malcolm Clarke appears either as lead or contributing author in almost one third (28.57 %) of the resulting publications, an indication of how influential his work was for the development of teuthology in the Azores. Incidentally, the only resulting publication published prior to 1981, when Malcolm started his work in the Azores, was his review of the systematics and ecology of oceanic squids from 1966 [2].

This rather simplistic bibliometric analysis attempts to quantify Malcolm's contribution to the study of cephalopods in the Azores, even though it fails to show his contribution to other fields and his role in providing the tools for other researchers to carry on their work.

II.i.b) Research

Malcolm's research and contribution to the knowledge of the Azorean marine ecosystem focused on two main areas, dietary studies of selected predators and the ecology of cephalopods on seamounts.

Dietary studies

Malcolm was one of the first persons to recognize the potential of beak identification not only to the study of cephalopods but also of their predators and of the functioning of entire ecosystems [17,18].

In a talk given in Semana das Pescas in 1994 entitled “Marine Azorean Foodwebs - The known, the unknown and the unlikely” (Week of Fisheries, Clarke & Martins 1994), Malcolm explained his approach on how to better understand the Azorean marine ecosystem and predict shifts in the community upon environmental or anthropogenic changes. This included identifying I) how species interrelate, II) which are critical to sustain the present balance and iii) how the island depends on the oceanic ecosystem. In his words, it would “take us a long way towards understanding the ecosystem, (…) providing data to the models”, a picture only given by "research nets after much more of the inter-relationships between species are known”.

In the 1980’s, Malcolm initiated a series of dietary studies collaborating with several colleagues from the Azores. In the following years he further collaborated with some of his students on other dietary works. It included sorting and identifying thousands of squid beaks and fish otoliths from the stomachs of sperm whales (*Physeter macrocephalus*), pigmy sperm whales (*Kogia breviceps*), Sowerby beaked whales (*Mesoplodon bidens*), blue sharks (*Prionace glauca*), swordfish (*Xiphias gladius*), orange roughy (*Hoplostethus atlanticus*), Cory’s shearwaters (*Calonectris diomedea*) and Barolo shearwaters (*Puffinus baroly*) [3-11, + Hartog &Clarke 1996; Pereira et al. 2011]. Some other studies in that line of work are still underway, including studies on the diet of other cetaceans and benthopelagic fishes (JGP, RP).

Dietary studies in the Azores continue to occur but only sporadically, at a much lower number as anticipated? by Malcolm, mainly caused by the lack of funds for such type of research. Besides the work of T. Morato on several demersal fishes (e.g. Morato et al. 2000, 2003), the diet of many of the most important commercial species in the Azores remains unknown (e.g. Wreck fish *Polyprion americanus*, *Thunnus albacares*, etc). Such lack of data remains a concern today (Guénnete and Morato 2001; Morato et al. in prep), limiting computational assessments in support of an ecosystem-based approach to ocean management.

Seamount cephalopod ecology

Interest in seamount research has greatly increased in the last two decades, after they were recognized as a major habitat in the high seas [15]. Within an international effort to improve our understanding of seamount habitats, where the Azorean scientific community provided a crucial input (e.g. Pitcher et al. 2007), Malcolm revised the association of cephalopods with seamounts, by compiling his previous works on the vertical distribution of oceanic cephalopod in the eastern North Atlantic [14]. He provided an updated and enlarged version of the groups of oceanic cephalopods occurring near seamounts early proposed by K. Nesis [12], according to species behavior and ecology [13]. These works are of relevance not only for the regional marine research but also for the regional strategies related to marine governance and economy. With oceanic cephalopods being a key zoological group in seamount food webs, acting both as predators and prey, understanding their ecology in these

ecosystems is of paramount importance to understand and manage seamounts. Obviously, that becomes even more relevant in seamount dominated ecosystems such as the Azorean plateau. As an example, such groups have been used to investigate if the cephalopod food source of deep-water schooling fishes were autochthonous or allochthonous to seamounts they inhabited [16].

Other works

Driven by his natural fascination about marine life, combined with an endless energy, Malcolm continued doing research until his last days. Other works include identification keys for the Azores cephalopods and the description of new species based on fossil cephalopod statoliths.

With a long career in teuthology, having published several systematic keys, procedure manuals and guides for the use of cephalopod beaks (e. g. [2,19-21]), he compiled a poly-copied systematic key on cephalopods of the Azores, entitled "Identification of cephalopods and their lower beaks. Azores Region". It includes a checklist with indication of depths of occurrence and habitat, and identification keys for the Cranchiidae of the NW Atlantic as well as the Histioteuthidae and the Octopoda of the Azores. Although this key remains unpublished, it has been an essential reference for many of his students and colleagues working with specimens collected in the Azores.

II.ii Teaching

Malcolm further passed his legacy by lecturing several individual graduate and post-graduate students working in the Azores on cephalopods and beak identification. Between 1997 and 2000, Malcolm was funded by the project AMIR on Azorean seabird food webs, based at the University of the Azores. Working as a guest scientist, he gave personal training to V. Neves at his home in Ancarva, United Kingdom.

Malcolm lectured the third international course on cephalopod beak identification in Faial, Azores, in 2007 ([22]), after Plymouth 1981 and Aberdeen 2000 (Hockberg and Hatfield 2002). Organized by José Xavier (Institute of Marine Research of the University of Coimbra and British Antarctic Survey) and Maria Carvalho (Centre of IMAR at the University of the Azores), it aimed "to increase knowledge about this technique and stimulate a new generation of beak experts" [22]. Through this workshop Malcolm managed to pass on some of his knowhow in cephalopod beak identification and biomass estimation to several young researchers working in the Azores, Spain, France, Greece, United States and the UK (for a complete list of the participants refer to Xavier et al. [22]).

II.iii Other contributions

Malcolm's collaboration with the Azorean marine researchers, particularly from the Department of Oceanography and Fisheries/UAz in Faial Island, was beneficial beyond his professional production and academic teaching. Arriving to the Azores in the early years of the DOP/UAç (or Z) local research department, Malcolm contributed by introducing the local scientists to several foreign researchers and institutes, from which profitable collaborations emerged (e.g. Pat Hargreaves, IOS; Steve Hawkins, Isle

of Man, Liverpool University; etc). He also contributed by facilitating copies of bibliographical material and offered field experience to local scientists by inviting them onboard HRM Challenger in 1983-1984. He integrated the advisory board of DOP/UAz(or ç) Journal "Arquipelago - Life and Marine Sciences" 1990-2013, collaborated in the cetacean stranding network RACA, as well as in the identification of the occasional encounter of unusual oceanic cephalopods.

Other contributions include the provision of scientific advise to local researchers and ongoing research (such as on pelagic sampling). He was also invited onboard IFAW Song of the Whale research ship to do what?

III. Malcolm Clarke, the communicator.

Communicating science is as important as producing it, and Malcolm was an excellent communicator. Either during an informal conversation, in the course of scientific talks, or as a lecturer or in wildlife documentaries. He was often theatrical, and would grab the attention of his audience not only by using an accurate but accessible discourse even for the lay person, but also by resourcing to props from actual specimens to back his statements.

He helped projecting the name of the Azores abroad not only through the publication of his scientific work and by presenting it at international *fora*, but also through his participation on high profile wildlife documentaries.

III.i Wildlife Documentaries

He participated in two National Geographic documentaries filmed in the Azores, associated with the search of a giant squid. In 1997, alongside Clyde F.E. Roper (Smithsonian's National Museum of Natural History), they sailed to the Azores onboard ship XXX, and later in New Zealand. In 2012 another team attempted to find clues on *Architeuthis dux* in the Azores, consulting Malcolm for advisory. Such documentaries have worldwide broadcast, revealing the Azores marine life, in particular the deep-diving whales and mysterious squid.

III.ii Talks

At a regional level, he was also very active. Malcolm was a regular presence in *Semana das Pescas* ("Fisheries Week", an international meeting with fisherman, scientists and politicians focused on all aspects of fisheries that was held yearly in Faial Island from 1981 to 2004; [23]). He was also deeply involved in Bienal das Baleias (Biannual Conference on Cetaceans) in Pico Island 1999-2004.

III.iii Museum "dos Cachalotes e Lulas" (Sperm whales and Squid)

But perhaps his most important contribution to scientific dissemination in the Region, is the *Museum of the Sperm Whales and Squids* that he created with his wife Dot.

Malcolm cooperated with several museums during his life: the Natural History Museum of London (UK), the Smithsonian National Museum of Natural History, Washington D.C. and Los Angeles Natural History Museum (USA), Melbourne Museum (Australia), Museum of New Zealand Te Papa Tongarewa (N.Z.), National Museum of Natural Science (Taiwan), National Museum of Nature and Science (Japan), South African Museum, Cape Town, and Port Elizabeth Museum (South Africa). In his own words, Malcolm "examined the methods of exhibition in those as well as in Berlin, Paris and Santa Barbara (USA) Museums", which served as the basis to create the concept of a totally new exhibit about the biology of spermaceti whales (*Physeter macrocephalus*, *Kogia simus* and *K. breviceps*) and their cephalopod prey.

The museum was entirely self-funded and was built by Malcolm and Dot in their home estate, opening to the public in 2004. It comprises 24 sections:

1. Vertical section of the largest female sperm whale ever measured in the Azores.
2. Bones and a model skeleton.
3. History of sperm whale from its external marks.
4. Swimming.
5. Breath holding.
6. Diving.
7. Problems with diving.
8. Buoyancy control.
9. Ambergris.
10. Light and eyes.
11. Sound, sonar and hearing.
12. Other senses.
13. Brain and intelligence.
14. A little on behavior.
15. Comparative sizes.
16. Growth.
17. Populations.
18. Distribution and migration.
19. Ancestors.
20. Parasites and enemies.
21. Food and squids.
22. Little known squids.
23. Squid biology and how they cope in the deep sea.
24. A ghost whale.

The exhibit concept created by Malcolm for the *Museum of the Sperm Whales and Squids* is completely innovative, in great part due to the careful planning but also due to creative solutions to cope with the budgetary constraints. The exhibit used low tech, everyday use objects to convey the information on the subject in a simple, accessible but accurate manner, in the same style of Malcolm's presentations.

In 2012 the exhibit was acquired by the Municipality of Vila da Madalena, in Pico Island, and is expected to move soon to a new facility. It is a unique asset for the Region, being the only museum of its kind in the world and carrying the name of one of the lead scientists in his field.

IV. Final remarks.

This work is meant to serve as a tribute to the work and life of Malcolm Clarke and is biased to an unrecoverable degree since the authors were all influenced by him both professionally and personally. Nevertheless, this note shows that his presence in the

Azores had a positive and, at least partially, measurable influence in the regional marine science.

Science and technical expertise are important factors for economic growth, making the scientific output an important measure of the nations' economic condition and social development [24,25]. Through his constant cooperation with regional researchers, Malcolm contributed directly to improve the scientific output of the Region. Since he had ongoing work with several researchers in the Region, it is expected that new publications with his participation will soon see the light. But his contribution to the scientific productivity of the region is bound to go beyond the publication of pending work. By training young scientists in the Azores in specialized research techniques, Malcolm has given his disciples the power to build their own work and create new original research. This transmission of scientific capacity, tied to national and local needs and backed by increased financial investment, is one of the pillars for strengthening the research base of nations [26].

The scientific role of Malcolm Clarke in the Azores goes much beyond the published papers, including promoting the growth of a newly created research center, teaching generations of researchers, and outreaching science to a wider audience – culminating in the creation of a museum - perpetuating his life occupation of revealing the mysteries of giant whales and squids.

Through the creation of such unique museum, Malcolm and Dot contributed both to the tourism industry and to the cultural mystic around whales and their prey, forever associated with the Azorean people from their recent whaling history. By passing it to the hands of the local population, he created an opportunity for future generations to benefit both culturally and economically from his presence in the Azores. It is in our hands to guarantee that this opportunity is seized and his memory is kept alive.

V. Acknowledgements

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