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Atlantic bluefin tuna (Thunnus thynnus) off the coast of Spain. © Brian J. Skerry / National Geographic Stock / WWF

On the Med tuna trail: linking science with conservation

Why WWF is tagging Atlantic bluefin tuna in the Mediterranean Sea and how this project is helping save an iconic marine species from extinction



WWF is deeply indebted to the following fishermen's organisations and vessels whose participation in the tagging events of *On the Med tuna trail* have largely made this project possible: Organización de Productores Pesqueros OPP51, Circolo Nautico Sambenedettese and Pesca Recreativa Responsable.

The following Spanish recreational fishing boats have helped WWF catch and tag bluefin tuna:

Albamar I Balearic Tuna Calabuig Darfo 2 Deep Sea Enzo Nou Erpapa Le Kouilou Leocadia Maria Cristina II Mariona Rifo II Sardineta Storm Ang Style Farari Fingueu Funa (Above) Jacques Toujan, Skipper of the WWF Columbus. Tagged juvenile bluefin tuna (*Thunnus thynnus*) being released back into the sea. © Edward Parker / WWF-Canon

(Below) Spanish recreational fishermen catch bluefin tuna for WWF to tag. © Aina Gost / WWF

WWF is grateful for the support of Spain's Pesca Recreativa Responsable.



WWF's *On the Med tuna trail* project benefits from the support of the Prince Albert II of Monaco Foundation. www.fpa2.com



RINCE ALBERT II OF MONACC FOUNDATION

10 things we know about tuna

The Atlantic bluefin tuna, also known as *Thunnus thynnus* in the scientific world, is a magnificent predatory fish that inhabits the entire North Atlantic Ocean and its adjacent seas.

The largest individuals can reach up to 4 metres in length and weigh as much as 900 kilograms.¹

When chasing prey, large individuals can reach speeds of more than 80 kilometres per hour.²

Tuna can exploit habitats from the ocean surface down to depths of 1,000 metres.

Atlantic bluefin tuna can travel thousands of kilometres within a few months, foraging opportunistically within their distributional range for fish, squid, octopus and crabs.¹

Because prey are generally more abundant in areas where water masses meet, bluefin tuna are often associated with ocean fronts or upwelling areas.^{1,3}

Adult bluefin tuna also migrate long distances back to their natal grounds to spawn, and some documentation of these migration patterns exists from previous tagging studies.³ There are two known spawning grounds for the species: the Gulf of Mexico in the western Atlantic, and the Mediterranean Sea to the East.

Because of this natal homing behaviour, there is a distinct genetic subdivision between western- and eastern-born Atlantic bluefin tuna^{4,5} and traditionally the population has been managed as two stocks, separated by the 45°W meridian.⁶

Studies have also shown, however, that there is a greater degree of physical mixing between the two stocks, and that migration patterns are more elaborate and complex than originally thought.

Some bluefin tuna born in the Mediterranean Sea, for example, can spend years in the western Atlantic before returning to their natal grounds.⁷

¹ See references on last page.

Atlantic bluefin tuna feeding in the Mediterranean Sea. © Frédéric Bassemayousse / WWF Mediterranean

The secrets of tuna migration

Surprisingly, the migration patterns of bluefin tuna within and outside the Mediterranean Sea have not been well studied. We have only hypotheses and estimations.

Catches by traditional tuna traps in the Strait of Gibraltar have indicated that some adult migration occurs from the Atlantic Ocean to the Mediterranean basin between April and May, and back out again to the Atlantic from July to August^{8,9}. Meanwhile, scientific studies of Atlantic bluefin tuna in the Mediterranean Sea have indicated that key spawning grounds of the species are located around the Balearic Islands, Sicily, Malta, Cyprus¹⁰ and Libya¹¹; that spawning occurs during May-June in the east and June-July in the central and western Mediterranean³; and that there is genetic subdivision between the west and east Mediterranean populations⁴. However, exact patterns of migration from the Atlantic Ocean to the spawning grounds, duration of stay within the Mediterranean, and differences in migration patterns between juvenile and adult tuna, between tuna inhabiting the western and eastern Mediterranean, and even between tuna within a single area of the sea, remain unknown.



Do you know where your sushi comes from?

The Mediterranean is the most important bluefin tuna fishery in the world.

Most catches of the Atlantic bluefin tuna are taken from the Mediterranean Sea, which is the most important bluefin tuna fishery in the world. Largely due to the booming global market for sushi and sashimi and the high prices fetched for the high quality meat, Atlantic bluefin tuna is severely overexploited by massive hi-tech fleets¹². Illegal fishing is rife, and the fishery has been plagued by lack of enforcement and control. Fishing mortality in 2007 in the Mediterranean, for example, was more than four times the level scientists say would have enabled the recovery of the stock – leading to a high risk of stock collapse. The population of reproductive adults of the eastern Atlantic bluefin tuna is currently estimated to be less than 15 per cent of the historical maximum level⁶. Despite these alarming facts and practices, however, there are serious gaps in knowledge about the biology of the species. Fisheries managers require as many solid tools as possible – such as accurate and up-to-date information on the biology and ecology of the species – in order to develop a successful and effective recovery and long-term fisheries management plan.

Bluefin Tuna sushi. © Bruno Arnold / WWF-Canon

On the Med tuna trail: a pioneering tagging project

"Even though so little is understood about the migratory behaviour of Atlantic bluefin tuna, and therefore how the fishery can best be managed, the species is being chased to the edge of extinction by a greedy spiral of short-term business interests. Through the project *On the Med* tuna trail, WWF and its partners are gathering essential new insights and knowledge about bluefin tuna biology - which, if used well by international fisheries managers, can help keep this magnificent species thriving in our oceans for generations to come." Dr Sergi Tudela, Head of WWF Mediterranean Fisheries Programme

WWF is working in partnership with the Prince Albert II of Monaco Foundation and fishermen to deliver vital information on bluefin tuna.

Motivated by these concerns, then, WWF, supported by the Prince Albert II of Monaco Foundation and in association with the Spanish recreational fishermen's association Pesca Recreativa Responsable, launched a pioneering Atlantic bluefin tuna tagging project in 2008. *On the Med tuna trail* gathers empirical information on the ecology of juvenile and adult Atlantic bluefin tuna in the Mediterranean Sea. First results of this project are already providing valuable scientific information on the migratory routes as well as feeding and diving behaviour of bluefin tuna individuals.

WWF tagging expeditions in the Mediterranean

The programme kicked off in January 2008, with major tagging expeditions taking place in August and September 2008, and from May to September 2009. There are more expeditions in the pipeline for 2010 and beyond.

2008

During the first year of the *On the Med tuna trail* project, two expeditions were carried out: in August and September 2008. In August, four adult Atlantic bluefin tunas (ranging from 50-200kg) were tagged with pop-up tags off the northern coast of Mallorca, in the Balearic Sea. In September, 21 juvenile tunas (ranging from 12-24kg) were tagged with archival tags off the coast of Roses, in the Gulf of Lions.

2009

The promising results obtained from the first year of tagging activities allowed the design of an ambitious plan for 2009. A total of nine expeditions were carried out from May to September, resulting in the tagging of 11 adult Atlantic bluefin tuna (ranging from 50-130kg) with high technology pop-up tags, one juvenile tuna (9kg) with an archival tag, and one young adult tuna (31kg) with both an archival and a miniature pop-up tag (a tag with the same functions, but smaller size than a pop-up tag). The 11 tagged adult tuna consisted of two tagged off the north coast of Mallorca, five off the coast of Roses, and four off the coast of San Benedetto del Tronto, in the central Adriatic Sea. The two juvenile tuna were tagged off the coast of Roses.

The WWF Colombus under full sail carrying out bluefin tuna tagging. Mediterranean Sea, off the coast of Roses, Spain. © Edward Parker / WWF-Canon

Tuna tagging explained

Electronic tags are the black boxes of tuna.

Electronic tagging studies are an effective way of studying the movements of highly mobile species like Atlantic bluefin tuna. Two main types of tag exist: pop-up and archival. Both types of tag are attached to the fish at capture, and both record essential information once the fish is released back into the wild – depth,

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temperature and lightlevel data (which can later be related to the geographical position of the tagged fish). The tags can be compared to a type of black box – they record the large-scale movements and behaviour of fish at a rate of one record per minute, and this valuable and detailed information is all stored within the tag.





 (Above) Archival tags need to be physically retrieved to access the recorded information.
Frédéric Bassemayousse / WWF Mediterranean

(Left) Pop-up tags are designed to release from the fish at a specified time and float to the ocean's surface to transmit summarized information via satellite.

© Edward Parker / WWF-Canon

METHOD 1 POP-UP

If a captured fish is more than 40kg it is tagged with a pop-up tag.

If a captured fish weighs more than 40kg, it is generally tagged with a pop-up tag. The procedure for this is more straightforward than archival tagging. While the fish is kept near the surface of the water, the pop-up tag is attached to the base of its dorsal fin using a long pole with a dart on the end of it.

METHOD 2 ARCHIVAL

The entire procedure, from hauling the fish on board to its release back into the ocean. takes barely 3 minutes.

The procedure for tagging fish with both archival and pop-up tags begins by capturing fish with rod and reel. The captured fish is then reeled in to the vicinity of the boat.

© Edward Parker / WWF-Canon

In general, if the fish weighs less than 40 kg, it is tagged with an archival tag. For this purpose, the fish is hauled on board the fishing vessel with the use of a net and placed upside down on a smooth, cushioned mat.

© Frédéric Bassemayousse / WWF Mediterranean

Its eyes are covered with a wet cloth to minimise stress, and flowing seawater is kept running over its gills to allow it to respire.

© Edward Parker / WWF-Canon

A small (3-4cm) incision is then made on the belly of the tuna with a scalpel, antiseptic is injected into the incision to prevent infection, and the archival tag is inserted into the incision with the stalk left protruding.

© Edward Parker / WWF-Canon

The incision is then sewn up using a surgical needle and suture. Finally, before the fish is put back into the sea, a thin spaghetti tag, offering a €300 reward, is attached to its side. This signals to the fishermen who may eventually re-capture the fish that a tag is retrievable from the fish.

© Edward Parker / WWF-Canon

(Left) Dr Pablo Cermeño, Tuna Tagging Coordinator, on Pesca Recreativa Responsable angling vessel Calabuig, ready with pop-up tagging harpoon to tag a tuna. © Edward Parker / WWF-Canon













First results

"The migration patterns of Atlantic bluefin tuna in the Mediterranean have never looked so interesting..."

Dr Pablo Cermeño, Tuna Tagging Coordinator, WWF Mediterranean Fisheries Programme By the end of the second year of the project, some interesting results began to be seen. From the tags deployed in 2008, all four popups detached from the fish and transmitted data via satellite after 60-125 days. One of the 21 archival tags was retrieved from a juvenile tuna after 391 days – allowing the assessment of the movements of a wild tuna for an entire 12-month period, for the first time ever in the Mediterranean. From the tags deployed in 2009, five pop-ups (three from the coast of Roses and two from the Adriatic Sea) detached from the fish within 20 days, which regrettably provided little information about the

The four adult Atlantic bluefin tunas tagged in mid-August 2008 off the coast of Mallorca stayed within a region north of that island for a period of at least 30 days. Three of them then migrated south-westwards from this region, with their tags detaching off the south-eastern coast of Spain and north coast of Algeria between mid-October and mid-December 2008. The fourth tuna remained north of Mallorca for the entire 70 days before its tag detached at the end of October 2008.



Figure 1 The four adult Atlantic bluefin tunas tagged in mid-August 2008 off the coast of Mallorca.

A school of Atlantic bluefin tuna (*Thunnus thynnus*) during their migration in the Mediterranean Sea. © Brian J. Skerry / National Geographic Stock / WWF

movements of the fish. Six other pop-ups, however, detached from the fish after 30 and up to 172 days. Neither of the two archival tags deployed in 2009 have yet been retrieved, and the mini pop-up tag detached after just 5 days. One of the most remarkable findings from the information retrieved so far from the 11 tags (four pop-ups and one archival from 2008, and six pop-ups from 2009) is that none of the 11 fish left the Mediterranean Sea for between 30 and 391 days after being tagged. Although it is too early to draw sweeping conclusions, these first results do not support the generally perceived understanding of the migration patterns of adult bluefin tuna in the Mediterranean – that of an inward migration of tuna into the Mediterranean Sea from April-May, and an outward migration to the Atlantic Ocean in July-August after spawning. Part of the adult population in the western Mediterranean might either leave the basin later in the year, or stay all year round.

The two adult Atlantic bluefin tunas tagged in mid-August 2009 off the coast of Mallorca showed similar patterns to those tagged in 2008, staying in the waters north of Mallorca for 30 and 68 days before their tags detached in mid-September and mid-October 2009 respectively. The two adult Atlantic bluefin tunas tagged off the coast of Roses in the Gulf of Lions in late August and early September 2009, for which the tags remained attached for 102-104 days, both travelled southeastwards, spending a significant period of time in the waters between the Balearic Islands, and Sardinia and Corsica. One was still within these waters, while the other



Figure 2 The two adult Atlantic bluefin tunas tagged in mid-August 2009 off the coast of Mallorca (blue and yellow) and the two adult Atlantic bluefin tunas tagged off the coast of Roses in the Gulf of Lions in late August and early September 2009 (red and black).

had continued to travel eastwards passing south of Sardinia and to

the north of Sicily, when their tags detached in mid-December 2009.



Figure 3 The two adult tunas tagged off the coast of San Benedetto del Tronto, central-eastern Italy.

Of the two adult tunas tagged off the coast of San Benedetto del Tronto, central-eastern Italy, one stayed in the Adriatic Sea for the entire 103-day period that its tag was attached, seeming to spend more time in deeper areas. It was heading towards the northern Adriatic Sea when its tag detached in late December 2009. The other tuna traveled steadily southwards for the entire 172 days while its tag remained attached, crossing the Ionian Sea and reaching the waters north of Libya when its tag detached in early March 2010.





Figure 4 The juvenile Atlantic bluefin tuna tagged with an archival tag on August 31 2008 off the coast of Roses, Spain.

Finally, the juvenile Atlantic bluefin tuna tagged with an archival tag on August 31 2008 off the coast of Roses, which was recaptured by fishermen 13 months later at the end of September 2009 in the same region, sheds light on the movements of juvenile tuna in the Mediterranean Sea. This fish spent two months rounding the Balearic Islands before travelling speedily eastwards to the south

Tyrrhenian Sea in early November, and spending the following four months migrating slowly southwards between Sardinia and Sicily. In early April 2009, when it was close to the eastern coast of Tunisia, it once again speedily migrated, this time westwards, back to the Balearic Sea - and stayed there, circling the islands until its capture in late September 2009.

> A school of Atlantic bluefin tuna (*Thunnus thynnus*) during their migration in the Mediterranean Sea. © Brian J. Skerry / National Geographic Stock / WWF



Tuna and the seasons

The 11 tags from which information has been received so far have also provided extensive information on the vertical movements of the fish within the water column – their depth and temperature preferences, and their movements during day and night and in relation to the seasons and the phases of the moon.

As an example, Figure 5a demonstrates the vertical profile of the juvenile Atlantic bluefin tuna during a two-day interval in summer 2009, while it was south of Mallorca in the Balearic Sea. Keeping in mind that the blue line shows the depth at which the fish is swimming and the red line shows the light level indicating day or night - it is clear that during the night the fish spends almost all the time close to the sea surface, while during the day it makes frequent, short dives down to 300 metres or deeper. It can also be seen - keeping in mind that the green line shows sea temperature and the purple line shows the internal temperature of the fish – that when the fish dives deeper, it crosses a steep temperature gradient from more than 29°C at the surface down to 16°C at the deepest depths. This change in sea surface temperature affects the internal body temperature of the fish, which fluctuates from a maximum of 31°C to a minimum of 18°C. The large gradient in temperature from the surface to deeper depths is called a thermocline, and is typically present in summer months in the Mediterranean. If we look at the vertical profile of the same fish during a two-day interval in winter 2009 (Figure 5b) while the fish was in the waters between Sicily and the eastern coast of Tunisia, it is evident that the environmental conditions and the behaviour of the fish are different. The fish stays in deeper waters - between 150-300 metres throughout most of the day, rarely going up to the surface. Overnight, meanwhile, it spends most of the time on the surface, while still making some deep dives. The sea temperature is an almost constant 16°C at all depths - and as a consequence, the internal body temperature of the fish only fluctuates between 16°C and 18°C.



Figure 5a The vertical profile of the juvenile Atlantic bluefin tuna during a two-day interval in summer 2009, while it was south of Mallorca in the Balearic Sea.

Figure 5b The vertical profile of the same fish during a twoday interval in winter 2009, in the waters between Sicily and the eastern coast of Tunisia.

Why are these results significant?

On the Med tuna trail is the first ever study that has succeeded in collating extensive information on the possible migration paths of Atlantic bluefin tuna in the Mediterranean Sea, using electronic tags. **Results obtained** from the 2008 and 2009 expeditions so far suggest that both adults and juveniles of the species in the western and central Mediterranean spend more time exploiting the habitats of the Mediterranean basin than originally thought. Results suggest that tuna use the waters around the Balearic Sea not only as a spawning ground, as has been believed to date, but also as a suitable foraging ground. Furthermore, it appears that tuna rely strongly on the topographical features of the sea bed in the Adriatic Sea. There is probably a link between the feeding area in the Adriatic Sea and the Libyan spawning grounds. Last, none of the tagged individuals to date ventured into waters of the eastern

Mediterranean, giving more weight to the possibility that - again, contrary to popular belief - populations of the western and eastern Mediterranean may not frequently interact. In view of these preliminary findings, and being aware that further research is needed in order to obtain definite conclusions, WWF remains convinced that the novel results of On the Med tuna trail project so far should be seen as a first step towards a better understanding

of the ecology and demography of bluefin tuna in the Mediterranean Sea. With greater knowledge of this unique species, scientists will increase their understanding of the population structure and dynamics of bluefin tuna - and will thus be able to give sound advice to fisheries managers (such as ICCAT, the International Commission for the **Conservation of Atlantic** Tunas) and legislators of the Atlantic bluefin tuna population in the Mediterranean Sea.

Tuna tagging hits the headlines

Spreading the word about On the Med tuna trail

From the outset, global media interest in WWF's tagging project On the Med tuna trail has been high. The pioneering nature of the project, great images and colourful stories from the field have kept audiences hooked on news and developments. Press releases and media material have been regularly drafted, translated and shared with top journalists covering environmental issues around the world. Press conferences and trips coinciding with launches and highlights have also helped attract media attention, while a specially designed interactive WWF website has provided an attractive information hub for a range of stakeholders. Raising visibility among key audiences is essential for the dissemination of project results, and to ensure that ultimately the findings help make Atlantic bluefin tuna fisheries management more sustainable. On the Med tuna trail is in the global spotlight!

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WWF has launched a special web section for On the Med tuna trail. Follow project developments online at www.panda.org/ tuna/tagging



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August 2000, The most ambituous Maditerranean funs tagging articles and the second se The scandalous that we know a fittie about a species we are putting under such huge pression for the scandalous that we have a fittie about a species we are putting under such huge pression for the scandalous that a set of the scandalous that a set

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The World Wildlife Fund has resumed its bluefin tuns t fish migration in the Mediterranean off northern Spain. WWF scientists hope to work with traditional Spanish fisher seen catches fall by more than 80 per cent in the past 20 yes

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interiew to Channel Four, the UK news network, on

board the WWF Columbus, which was broadcast in prime time evening news programmes and online.



Continuing on the Mediterranean tuna trail



Dr Sergi Tudela, Head of WWF Mediterranean Fisheries Programme, and Dr Pablo Cermeño, Tuna Tagging Coordinator, discuss next steps. © Frédéric Bassemayousse / WWF Mediterranean

Dr Pablo Cermeño, coordinator of WWF's Mediterranean bluefin tuna tagging activities, was honoured in 2009 by a Young Researcher Award from the Prince Albert II of Monaco Foundation. These annual Awards were initiated by His Serene Highness the Sovereign Prince to acknowledge exemplary action in support of the environment and sustainable development. Thanks to the Award, Pablo is able to continue post-doctoral studies regarding the influence of oceanographic conditions on the spawning, feeding and migratory behaviour of Atlantic bluefin tuna. In-depth analysis of satellite data revealed by the electronic tags of WWF's *On the Med tuna trail* project will help further improve knowledge and understanding of tuna biology and behaviour.

WWF plans to continue its Mediterranean bluefin tuna tagging activities, with further research and expeditions under a new phase of *On the Med tuna trail*. The project has already provided valuable new understanding of an enigmatic migratory species, which is woefully overexploited due in part to lack of knowledge about its biology and behaviour. With more field tagging work, WWF and its partners can help give this emblematic fish a chance at survival in the long run.

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Why we are here. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.



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