BRIEF SYNOPSIS OF THE BIOLOGY OF THE BLACK MARLIN *(MAKAIRA INDICA),* WITH REFERENCE TO THE INDIAN OCEAN.

Julian C Pepperell

Pepperell Research & Consulting Pty Ltd

Australia

Taxonomy:

The black marlin is a member of the family Istiophoridae, and is one of two members of the genus *Makaira*, the other being the blue marlin. This classification is based on an artificial character, however, viz: the height of the first dorsal fin relative to the depth of the body. However, the early developmental stages of blue and black marlin show some marked differences, which may indicate a more distant relationship. It is accepted that the black marlin is a single species throughout its range. The black marlin is identified by its rigid pectoral fin (above a size of about 10-15 kg), and its relatively low dorsal fin (half or less the maximum body depth). A further diagnostic character is that the second dorsal fin is anterior to the second anal fin at all sizes (in all other Istiophorids, the second dorsal is posterior to the second anal).

Distribution

Although black marlin are distributed throughout the Indo-Pacific oceans between about latitudes 40°N and 40°S, closer examination of historic Japanese longline catch rates clearly shows that the density of the species is very sparse in open ocean areas, but much more clumped near some land masses. In fact the black marlin is the most land-associated of the billfishes, preferring waters on or near continental shelves, at least during some stages of its life cycle. Juvenile black marlin (10-25kg) are seasonally common inside the continental shelf off northeastern Australia, in the East China Sea and the Gulf of Thailand. Adults, on the other hand, are generally found in oceanic waters in close proximity to the continental slope.

Areas where black marlin aggregate include the Great Barrier Reef, the east of Australia, the northwest shelf of Australia, extending to the southern islands of Indonesia, the South China Sea off Vietnam, Malaysia and Thailand (mainly juvenile fish being caught in this area), Kenya and Madagascar, and in the eastern Pacific, off central America (Ecuador) and Peru. Major seasonal concentrations occur in the north-west Coral Sea (September-December), the north-east Indian Ocean (November-March), the eastern Banda Sea west of Irian Jaya (January-April) and the East China Sea, between Taiwan and Japan (June-November). There is also an area of increased catch rates north of Sumatra during the months of May and June. Relatively small fish (20-50kg) dominate the catches in May-September south of the Indonesian Islands, with a wider range of fish (30-140kg) in the catches between October to March

Movements/Stock Structure

Although black marlin are relatively uncommon in most areas, off eastern Australia, it is the dominant species of marlin. Consequently, recreational anglers have tagged and released large numbers of black marlin along the eastern Australian seaboard over the past 25 years or so. Table 1 illustrates this well. Of the 32,000 black marlin tagged, over 330 recaptures have been reported.

Table 1. Numbers of marlin tagged on the Australian Gamefish Tagging Program.

Species	Total tagged	Eastern Aust	% East Aust
Black Marlin	32,719	32,320	98.8
Blue Marlin	2,169	1,643	75.7
Striped Marlin	7,231	6,964	96.3

In the Indian ocean, on the Australian tagging program, less than 100 black marlin have been tagged off Western Australia, and about 50 have been tagged off Kenya. On the South African Oceanographic Research Institute's (ORI) tagging program, 210 black marlin have been tagged and one recapture recorded.

Selected long distance movements of black marlin tagged in the Pacific are shown in Figure 1.

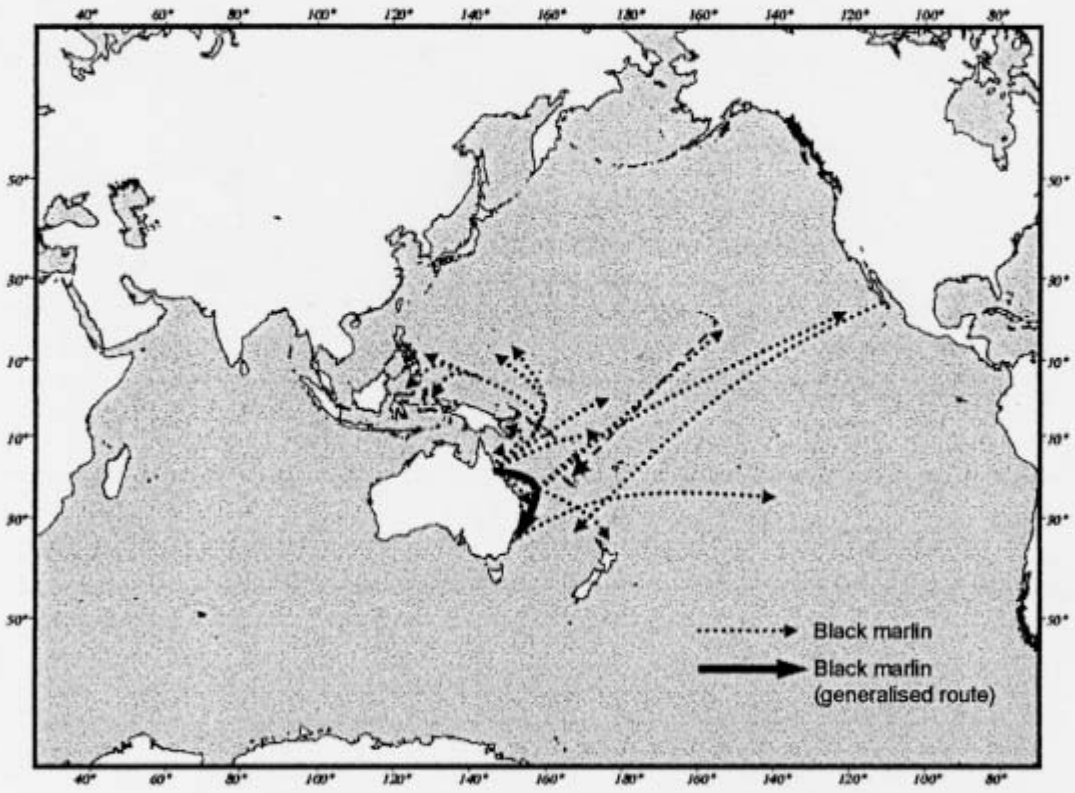

Figure 1. The release and recapture positions of selected black marlin tagged in the Pacific Ocean. The generalised route indicates the well-defined seasonal movement of juvenile black marlin along the eastern coast of Australia

This illustration of long distance dispersal of black marlin is the result of tagging over a span of more than 25 years. This illustration does not necessarily mean that many or most fish take these routes in all or most years, but it does clearly indicate that the species is capable of very extensive movements, and that exchange of individuals throughout the Pacific ocean can and does occur. It also indicates that some black marlin may enter the Indian ocean from the Pacific, via the Indonesian archipelago, but as yet, there is yet to be a reported recapture of a tagged black marlin to prove this. This finding of apparent widespread mixing is very important. It indicates

that there is very likely only one stock of black marlin in the Pacific (quite possibly extending to the Indian ocean as well).

As is normal with any tagging program, there will always be quite a few fish which are recaptured within a short period, not far away from their points of release, simply because there has been insufficient time to disperse before they were recaptured. Figure 2 shows this phenomenon, but also indicates that, after a couple of months, on average, the distance moved by tagged fish increases rapidly with time at liberty, at least for the first nine months or so after release.

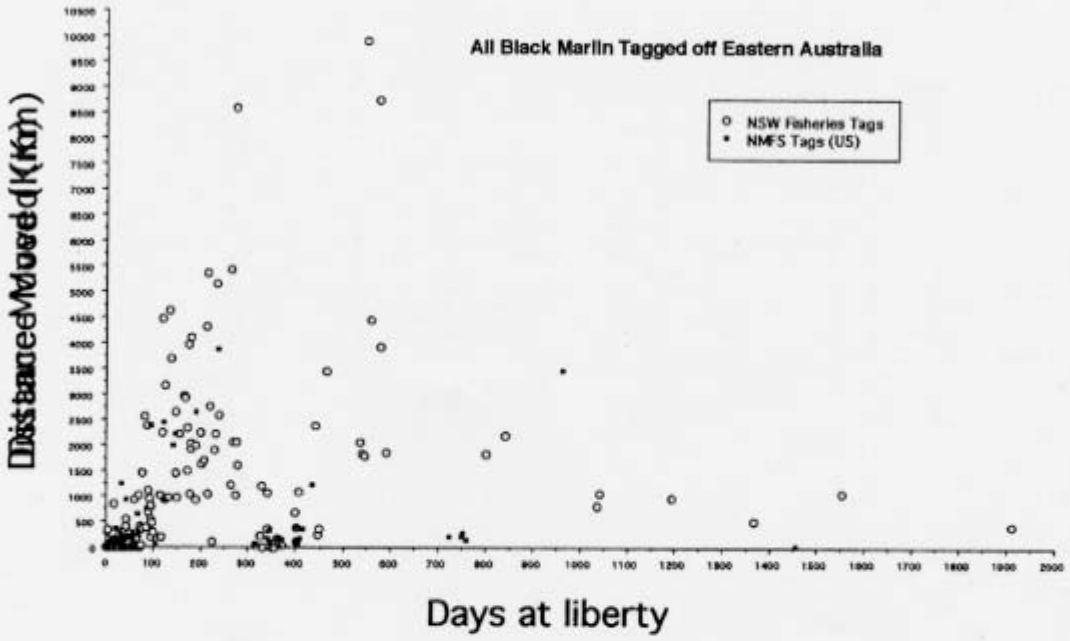

Figure 2. Black marlin tag recaptures over a period of five years. Marlin recaptured at half-yearly intervals indicate movement away from the original tagging location, while recaptures at yearly intervals show a tendency to return to about the same location.

These rapid movements, take fish away from the tagging grounds, throughout the western Pacific, and beyond, at an average rate of approximately 20km per day. (Movement rates of over 60km per day have been recorded for some recaptured fish, but these have been short-term recaptures and are the exception rather than the rule).

Figure 2 also indicates that there is a very marked 'cluster' of recaptures near the point of release after about one year (330 to 400 days. Dispersal occurs again after this time, but after two years, more fish are recaptured at their release area. There is even some indication of this for three, four and five years (naturally with decreasing numbers of recaptures as time increases). This finding suggests either that some fish never leave the areas in which they were tagged, or that annual homing occurs, at least for a proportion of the population. Careful examination of Japanese catch data for the Great Barrier Reef over long periods clearly shows that black marlin appear to depart this area *en masse* by early summer each year. Long term charter skippers in the area also attest to the fact that black marlin virtually disappear completely at this time, leaving the conclusion that at least some fish must be returning to the reef on an annual basis. An important, remaining unknown is the proportion of the population which completes this annual cycle. Hopefully, increasing use of satellite tag technology will help answer this question

Analysis of black marlin samples taken from the same location over many years (Port Stephens, NSW) indicates that genetic profiles are temporally stable, and that collections taken in different years can therefore be pooled to increase the power of geographic analyses. Analysis of reasonable collections from Australia, Vietnam, South Africa, and the eastern Pacific Ocean revealed no major genetic differences. This is consistent with the null hypothesis that there is sufficient gene flow among locations to prevent the accumulation of significant genetic differences, and therefore, separate populations. Having stated these findings, it should be noted that the molecular methods used to study blue marlin and black marlin have revealed considerable genetic variation within their populations. To improve analyses of stock structure what is needed are larger sample sizes and better geographical coverage of samples for each species. This would include samples from within the Pacific, and especially samples from the Indian Ocean, which has been insufficiently sampled to date.

There is the possibility of movement of fish between the Indian Ocean and the south-west Pacific stock, either as a result of larval advection or juveniles moving through Torres Strait or of fish swimming through the Banda Sea and around the northern coastline of Irian Jaya and Papua New Guinea. Potential advection of larvae or movement of juvenile or adult black marlin between the Pacific Ocean and Indian Ocean could be facilitated by ocean currents of the Indonesian Throughflow. However, no significant evidence is available to determine the extent of movements between these presumed stocks, if any.

Size and Growth

It has been reported that the size range of black marlin caught by Indian Ocean Japanese longliners in the 1960s was generally between 121 and 260 cm (body length). The larger fish of the Indian Ocean appear off western Australia (221-230cm modal size), and the smallest in the Arabian Sea and Bay of Bengal (mode at 181-200cm). Northern areas also tend to have larger fish than more southerly latitudes.

As is the case with all of the billfishes, much uncertainty exists regarding the growth rate, age at maturity and longevity of black marlin. Early growth rates of black marlin through the first three or four years are thought to be reasonably understood, in contrast to growth rates in later years. By analysing modal progression of small black marlin which appear along the east coast of Australia, it is estimated that they reach a size of about 25kg at one year of age, and that a 100kg fish would be 3 to 4 years old.

Rapid early growth rate is also indicated by some preliminary counting of presumed daily growth rings on otoliths of very small fish. Ageing of two rare specimens weighing 3.9 kg in this way resulted in an estimated age of 130 days (4 months) old when they were caught. An even smaller specimen of a black marlin, only 45cm in length, was also aged in this way at about 80 days. These ages fit quite well with the estimated growth rates outlined above, adding weight to these estimates. After several years of age, the growth rates of black marlin are difficult to assess, but all evidence so far points to continued rapid growth. It is quite likely that male black marlin grow more slowly than females and die at an early age, explaining why all fish over about 170kg are female. Regarding longevity, current 'guesstimates' place the age of a 454kg female black marlin at 15-20 years, suggesting that the oldest fish in the population may be as much as 30 years old.

The maximum recorded total length for black marlin is 448cm and the maximum recorded weight is 708kg (game fishing record, caught off Peru in 1953). Black marlin show a strong sexual dimorphism with males rarely, if ever, exceeding 180kg

Reproduction

Only limited numbers of larvae of black marlin have been collected. Based on these, as well as the presence of apparent spawing adults, the spawing areas of the species in the Indo pacific are shown in Figure 3.

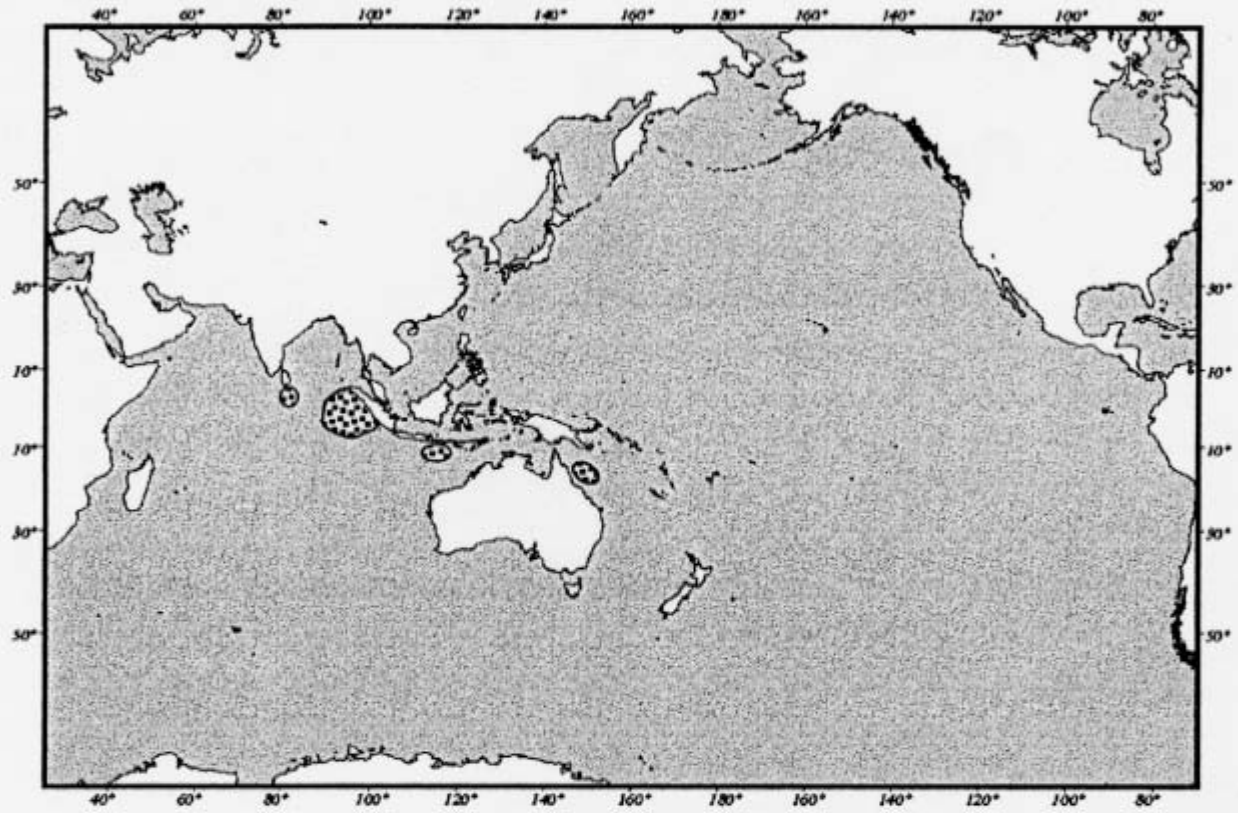

Figure 3. Presumed spawning grounds for black marlin based on collections of larvae and adult fish in spawning condition.

The major Indian Ocean spawning grounds are believed to be south of Java and the Lesser Sunda Islands and northwestern Australia (Howard and Ueyanagi, 1965). East coast studies suggest that black marlin migrate to the spawning area in the Coral Sea from equatorial regions before or during October. Black marlin off northwest Australia also show a southerly migration in October and it is believed that this is also a precursor to spawning in this region. While the age at maturity remains uncertain it appears that males mature around 2-3 years (60kg) while females mature around 3-4 years (70kg). The size at maturity for females is suggested from the size frequency of fish found on the spawning grounds. Egg counts indicate a high fecundity with the number of viable eggs in the range 65-250 million. It is not known whether all eggs are released simultaneously, in batches 2 or 3 times during the spawning season, or like many tuna species, every two days or so.

Given this enormous fecundity, it is perhaps odd that very few black marlin larvae have been recorded. Another enigma regarding the life cycles of black

fork length) in either commercial or recreational catches. One suggested reason is that their growth is so rapid that there is only a short period when they might be caught. It may also be that such sized fish live in habitats where they are not prone to conventional fishing gear.

Behaviour

Five black marlin estimated at between 100 and 420 kg, caught by normal rod and reel methods off the Great Barrier Reef, Australia, were successfully tracked for periods of 8 to 27 hours. Of 3 others tagged, one was killed by a shark and 2 shed their tags, probably as the result of poor attachment. Like blue marlin, the tracked black marlin tended to swim closer to the surface for longer periods during the night compared with the day, and there was also a tendency to dive to deeper depths after dawn, and to make more trips to the surface after about noon. The tracked fish rarely penetrated the thermocline and then only briefly, remaining at temperatures no more than 8°C below that of the surface waters. The two deepest dives were to 178 m. Four of the five marlin tracked initially moved offshore from the edge of the reef before heading parallel to the shore, whereas the other marlin stayed close to the reef edge. The average mean swimming speeds over the ground for entire tracks ranged from about 1.5 to 4 knots. During the tracking, it was not possible to determine if the marlin were feeding or not, but their activity seemed to increase before and after dusk, possibly indicating increased searching activity. This type of behaviour was very similar to that of blue and striped marlin tracked in other parts of the world. Of all billfish so far tracked to date, survival rates after release are between 85% and 90%, with very little evidence of mortality caused by exhaustion.