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SETTING BYCATCH LIMITS FOR SEA TURTLE IN THE WESTERN AND CENTRAL PACIFIC OCEANS SHALLOW-SET LONGLINE FISHERIES

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Abstract

The Western and Central Pacific Fisheries Commission is tasked with managing the largest industrial tuna fishery in the world. This includes a multi-national fleet of 4-5,000 longline vessels fishing throughout (but not evenly distributed in) the Western and Central Pacific Ocean. Interactions with sea turtles include incidental capture during longline operations, particularly when they actively take bait, or become entangled in the fishing gear.

In the context of the concerns surrounding sea turtle conservation, and the extent of the Western and Central Pacific Fisheries Commission's longline fleets, the Commission has recognised that mitigation measures may reduce sea turtle captures. The Commission has attempted to reduce sea turtle capture in the fisheries managed under its jurisdiction, through resolution RES2005-04 and conservation and management measure CMM2008-03.

Conservation and Management Measure CMM2008-03, agreed to in December 2008, tasks the Scientific Committee to assess and make recommendations on an acceptable "minimal" sea turtle interaction rate for shallow-set longline fisheries. This paper outlines some of the issues that need to be considered when developing this standard and proposes a "minimal sea turtle interaction rate" for the Scientific Committees consideration.

Introduction

Sea turtles are highly migratory species covering large distances in the world's oceans throughout their life. These species are predominantly tropical in their distribution during the breeding season, and rely on sandy beaches in all tropical oceans to come to shore and lay their eggs. While they are largely confined to tropical and subtropical oceans, adults particularly of the larger species are known to pass occasionally through cool temperate waters.

In the Western and Central Pacific Ocean (WCPO) five species are generally encountered in longline fisheries, namely: green (*Chelonia mydas*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*) turtles. These species are generally long lived and reach sexual maturity at between 6-30 years old (SPC 2001). Large turtles have few natural predators and longline bycatch can result in high levels of fishing mortality on the large sub-adults and adults (Lewison and Crowder 2007). All of the species listed above are threatened with extinction and the IUCN (2008) lists olive ridley turtles as vulnerable; loggerhead and green turtles as endangered; and hawksbill and leatherback turtles as critically endangered.

The FAO (Anon 2004) lists the following as important contributors to anthropomorphic sea turtle mortality: inappropriate manipulation of turtle populations; habitat degradation (from tourism and development); collisions with boats; construction and blasting; pollution (debris, oil and gas extraction); direct harvesting of turtles, including exploitation of eggs; and fisheries bycatch from shrimp trawlers, longline fisheries, gillnets and fish trawlers and to a lesser extent other gears such as beach seine fisheries (Table 1). While shrimp trawlers are thought

to be the fishing gear that poses the main threat to many sea turtle populations, other trawling and longlining account for significant mortalities. Quantifying the most serious sources of anthropomorphic sea turtle mortality is difficult. It is most likely that the total effect of all these factors is resulting in declining populations. As these species are threatened with extinction, mitigating the effects fisheries have on sea turtle mortality is an important contribution to overall sea turtle conservation efforts.

Kaplan (2005) estimated that there is likely to be a combination of impacts that are causing declines in leatherback turtle populations. In particular, Kaplan identified the following two that need to be addressed: (*i*) bycatch by longline fishing vessels and (*ii*) coastal sources of mortality. He calculated point estimates of longline bycatch based on turtle catch rates from the US Hawaii-based fleet and used effort data for the international Pacific longline fleet. His estimates suggest that in the Western and Central Pacific Ocean, coastal sources lead to a 13% annual mortality rate, compared with a point estimate of 12% from longlining. In the eastern Pacific Ocean, coastal sources account for a 28% annual mortality rate, compared with a point estimate of only 5% from longlining. Others have estimated longline associated mortality to be between 17 and 27% (Aguilar et al. 1995; McCracker 2000).

A Bayesian risk assessment undertaken as part of Kaplan's (2005) analysis showed that reducing coastal sources of mortality, as well as longline bycatch, was necessary if the populations are to avoid extinction. But he also stated that international efforts to protect leatherback turtles should expand beyond focusing solely on reducing longline bycatch and should attempt to reduce coastal harvest of adult females and eggs, as well as reduce bycatch by inshore gears such as gillnets. Mitigation of sea turtle catch from gillnets is seen to be an important addition to the overall conservation efforts as it is estimated that 50% of sea turtles that get caught by gillnets die (Lewison and Crowder 2007).

Table 1: Types of gear related to incidental captures of female and juvenile sea turtles – the possibilities of being captured, according to their behaviour. L - low, M - medium, H - high, U - unknown, N – none (Anon 2004).

Method	Chelonia	Caretta	Lepidochelys	Eretmochelys	Dermochelys
Gillnet	M	M	M	M	L
Shrimp trawl	M	H	H	L	L
Fish trawl	L	M	M	L	L
Longline	L	L	L	N	M
Purse seine	L	L	L	N	M
Beach seine	L	L	L	L	N
Crab trap	L	L	L	L	N
Cast net	L	L	L	L	N
Butterfly net	L	L	L	L	N
Hook line	L	L	L	L	L
Sport fishing	L	L	L	L	L

Longline sea turtle mitigation methods have not been rigorously tested in a broad range of experimental trials covering large geographic areas. However, the work of Watson et al. (2005) and Gilman et al. (2006), shows promise, and suggests that good results can be achieved with gear modifications for sea turtle species that ingest bait (see also Reid 2007 and Epperly and Boggs 2004). These sentiments have been echoed by the FAO and formalised into a set of *Guidelines for Reducing Sea Turtle*

Mortality in Fishing Operations. But that document did not recommend maximum allowed catches or catch rates.

The Western and Central Pacific Fisheries Commission (WCPFC) has recently (December 2008) agreed to a Conservation and Management Measure (CMM2008-03) that focuses on mitigating captures of sea turtles in longline and purse seine fisheries in the Western and Central Pacific Ocean. Under measure CMM2008-03, the Scientific Committee has been tasked with making recommendations on a "minimal[1]" sea turtle interaction rate for shallow-set swordfish longline fisheries. Fisheries with higher than the minimal catch rates will be required to implement a specific range of measures aimed at reducing sea turtle bycatch. Such measures would be in addition to other WCPFC requirements including for longline vessels to carry and use mitigation equipment including de-hookers, line cutters and, where appropriate, scoop nets. This paper outlines some of the issues that need to be considered when developing this standard and proposes a "minimal sea turtle interaction rate" definition for the Scientific Committee to consider.

Identifying a minimum sea turtle interaction rate

Broad guidelines to reduce sea turtle mortality have been developed by the FAO (*Guidelines to Reduce Sea Turtle Mortality in Fishing Operations*) and adopted by Inter-American Tropical Tuna Commission (IATCC Resolution C-07-03) and WCPFC (RES2005-04 and CMM2008-03). However, no Regional Fisheries Management Organisation (RFMO) has yet to quantify minimal catch rates for sea turtles in a longline fishery. There have not been any studies published in peer reviewed literature that attempts to identify what level of catch rate for sea turtles is acceptable.

It is important to recognise, however, that sea turtle capture in longline fisheries does not equate to mortality. FAO guidelines focus on ways to avoid catching sea turtles (this occurs either by entanglement, by ingestion of bait and hook or by hooking followed by entanglement) but equally as importantly guidelines suggest ways to minimise the mortality of sea turtles once captured.

Any standard needs to be achievable, realistic, and appropriate for the goal it is attempting to achieve, in this case reduce the level of sea turtle mortality from the current to some level that will halt population declines within the WCPO. In addition, the standard needs to be one that compares consistent units of catch and effort. Furthermore, a decision needs to be made as to whether the Commission uses a global sea turtle catch rate that covers all species encountered by a fishery or do we require a species specific catch rate that is more restrictive on species that are deemed to be more endangered. For example, given the critically endangered status of hawksbill and leatherback turtles, the rate that is considered 'minimal' may be lower than an equivalent measure for olive ridley turtles, which are vulnerable. As another example, it might be useful over time to consider whether some areas such as turtle hotspots would benefit from more conservative limits so that bycatch rates are reduced further.

[1] For the purposes of this paper, to be consistent with CMM2008-03, the term "minimal" catch rate is used, however, it is defined here as the maximum acceptable rate that a fishery should not exceed.

Summary of reported capture rates

Lewison and Crowder (2007) note that determining precise point estimates for a single region and fleet is unrealistic as different fleets and regions have different fishing methods, and fisheries and sea turtles are not evenly distributed in space and time. This issue is further complicated by variable reporting rates. It is widely acknowledged that the only reliable information on sea turtle captures can be obtained from observers. As a result, only studies that use observer data or observations made by scientific staff are considered here. Sea turtle capture rates are incredibly variable and reported positive capture rates from 0.00067 to 16.88 turtles.1000 hooks^{-1} have been reported (Table 2). The high level of variation is a result of spatially heterogeneous turtle distribution and fishing effort, and differing reporting formats. Some studies present the results for all turtle species pooled, while other studies report species specific catch rates. Most studies that present sea turtle capture rates do not clearly specify the gear used and most capture rates are reported over a large area, where data are pooled for different gear and different target species. Furthermore, most of these studies have been conducted outside of the Pacific.

While a number of studies have been carried out in the Mediterranean Sea and the Atlantic Ocean, published work on sea turtle capture rates in the Pacific is sparse and largely has been focused on Hawaii. Those studies that report different capture rates on specific gears in the Pacific are most useful as a starting point to further this discussion (Gilman et al. 2006 and 2007). The results from Hawaiian studies need to be grouped as pre and post implementation of sea turtle mitigation legislation. Prior to the introduction of sea turtle mitigation legislation the capture rates were in the region of 0.174 turtles.1000 hooks^{-1} (all species combined) and 0.019 post legislation (see Watson et al. 2005; Gillman et al. 2006 and 2007 for details). This demonstrates that capture rates can be reduced and provides a basic estimate of capture rates at which the Commission could aim.

The SPC (2001) assessed a large portion of the WCPO, but excluding Hawaii, showed clear differences across the region with the highest capture rates (0.0389 turtles.1000 hooks^{-1}) in the Tropical WCPO, with capture rates declining (and observer rates increasing) in a southerly direction to 0.00067 turtles.1000 hooks^{-1} south of 35^{o}S.

Reducing mortality

The purpose of CMM2008-03 is to reduce the overall sea turtle mortality that results from purse seine and longline bycatch. As noted, one element of the conservation and management measure is to determine what constitutes a "minimal" sea turtle interaction rate for shallow-set swordfish longline fisheries. Fisheries with higher than minimal catch rates are identified in the measure as requiring more active management, for example through additional controls on gear and/or bait used in the fishery. The difficulty with carrying out this analysis is that few WCPO wide analyses have been undertaken. However, it can be concluded that the level of sea turtle catch seen in the Hawaii swordfish longline fishery, prior to regulation of that fishery, was unacceptably high and these rates should be avoided. Rates reported in other fisheries are shown in Table 2, however, most of these are from areas with no mitigation or experimental manipulation of gear in Hawaii.

In determining what can be considered as a "minimal" sea turtle catch rate, the Commission needs to consider the following factors:

- Units of catch and effort,
- The use of a catch rate vs. the use of a maximum allowable number,
- Global rate for all species or species specific catch rates, and
- WCPO wide vs. area specific catch rates.

Units of catch and effort

Within the WCPO the number of hooks can vary from 500 to 3000 per set (SPC 2001). As a result, using set as a measure of effort is probably less meaningful than number of hooks observed. The units for CPUE should be standardised to turtles.1000 hooks^{-1} to be consistent with key publications and avoid issues with differing numbers of hooks per set in different regions and for different target species.

Catch rate vs. number of sea turtles per area

The level of mortality associated with sea turtle bycatch in longline fisheries is an important question that needs to be addressed to put the catch rates and associated mortality in context. The question then becomes what is the acceptable/sustainable level of sea turtle mortality. In other words what is the number of mortalities that these populations can sustain? Estimating actual sea turtle captures has been attempted by a number of studies (SPC 2001; Evans et al. 2001). However, these estimates have extremely high error associated with them due to the complex nature of making reliable estimates based on low number of observations compounded by issues with the spatial heterogeneity of the sea turtle distribution and longline effort data. If we are not sure then using a precautionary approach what level of catch should we find acceptable?

Until such time as a full stock assessment is undertaken for each species and an acceptable level of mortality can be reliably calculated, a catch rate that is lower than current is probably appropriate. But this rate should be practical and achievable and should not be lower than levels that have been achieved using all known mitigation techniques.

Table 2: Published sea turtle catch rates for a number of studies. SWO = swordfish; GRE= green turtle; LBT = leatherback turtle; LHT = loggerhead turtle; ORT = olive ridley turtle. Hook type J = J-hook C = circle hook.

Paper	Hook type	Bait	Area	Target	Species	Catch rate turtles /1000 hooks
Deflorio et al. 2005	J	?	N Ionian sea	SWO	GRE/LBT	0.08
		?	N Ionian sea	SWO	GRE/LBT	0.22
		?	S Ionian Sea	SWO	GRE/LBT	0.29
		?	S Ionian Sea	SWO	GRE/LBT	0.71
		?	Overall			0.13
		?	N Ionian sea	ALB	GRE/LBT	0.29
		?	N Ionian sea	ALB	GRE/LBT	0.71
		?	S Ionian Sea	ALB	GRE/LBT	0.2
		?	Overall			0.13
Deflorio et al. 2005 (Other studies cited)	?	?	N Ionian sea	SWO	?	0.06
	?	?	W Mediterranean	SWO	?	1.44
	?	?	W Mediterranean	SWO	?	4.47
	?	?	SE Pacific	SWO	?	16.88
	?	?	NW Atlantic	SWO/Tuna	?	0.15
	?	?	NW Atlantic	SWO/Tuna	?	0.32
	?	?	N Ionian sea	ALB	?	0.14
Watson et al. 2005	J	Squid	NW Atlantic	SWO	LHT	0.50
	C	Squid	NW Atlantic	SWO	LHT	0.056
	J	Mackerel	NW Atlantic	SWO	LHT	0.13
	C	Mackerel	NW Atlantic	SWO	LHT	0.042
	J	Squid	NW Atlantic	SWO	LBT	0.49
	C	Squid	NW Atlantic	SWO	LBT	0.21
	J	Mackerel	NW Atlantic	SWO	LBT	0.15
	C	Mackerel	NW Atlantic	SWO	LBT	0.15
Gilman et al. 2007 (Numbers estimated from figure)	J	Squid	Hawaii	SWO	LHT	0.13
	C	Fish	Hawaii	SWO	LHT	0.025
	J	Squid	Hawaii	SWO	LBT	0.04
	C	Fish	Hawaii	SWO	LBT	0.010
Jribi et al. 2008	J	Fish	Mediterranean (Tunisia)	SWO/Tuna	LHT	0.823
	J	Fish	Mediterranean (Tunisia)	Grouper	LHT	0.278
Monteriro et al. 2008	?	?	EPO	SWO/Tuna	LHT	1.340
	?	?	EPO	SWO/Tuna	LBT	0.030
Nannarelli 2008	?	?	Mediterranean	SWO/Tuna	LHT	0.880
Sales et al .2008	?	?	W Atlantic	SWO/Tuna	LHT	0.263
	?	?	W Atlantic	SWO/Tuna	LBT	0.064
	?	?	W Atlantic	SWO/Tuna	GRE	0.004
	?	?	W Atlantic	SWO/Tuna	ORT	0.004
Gilman et al. 2006	J	Squid	Hawaii	SWO	All	0.174
	C	Mackerel	Hawaii	SWO	All	0.019
	J	Squid	Hawaii	SWO	LBT	0.070
	C	Mackerel	Hawaii	SWO	LBT	0.005
	J	Squid	Hawaii	SWO	LHT	0.148
	C	Mackerel	Hawaii	SWO	LHT	0.013
SPC 2001	?	?	Tropical WCPO	SWO/Tuna	All	0.0386

	?	?	Sub-tropical WCPO	SWO/Tuna	All	0.00312
	?	?	Temperate WCPO	SWO/Tuna	All	0.00067

Global sea turtle catch rate vs. species specific catch rate

If a Pacific wide stock assessment for sea turtle populations is undertaken, in future, that suggests substantially different catch rates (or total catch) for different species are required, then species specific catch rates may be appropriate. However, due to issues of incorrect identification of hard shelled turtles and the threatened status of all species in the WCPO it is probably appropriate to have a single overall catch rate at this time.

Area-based or WCPO catch rate

Areas with higher catch rates, i.e. those in sea turtle hotspots, may be required to do more to reduce their sea turtle bycatch. This is probably appropriate as these are the areas that are most likely having the biggest impact on these stocks. However, assessing what the catch rates in each area should be is complex and modelling this using depurate data will result in high levels of uncertainty. Therefore having a single WCPO wide minimum catch rate will have the greatest impact in areas with the highest interaction rates while still maintaining a level of equity.

Proposed WCPFC catch rate

The minimum catch rates should be achievable. An example of a concerted effort to reduce sea turtle bycatch in longline fisheries in the Pacific Ocean is provided by the US in Hawaii. The Hawaiian swordfish longline fishers are required to use size 18 circle hooks and fish bait, and have a code of practice that uses timed area closures based on ocean temperatures and the associated risk of catching a sea turtle. These efforts have managed to lower their catch rates to 0.019 turtles.1000 hooks^{-1}. However, while assessing the efficacy of those practices Gilman et al. (2007) note that this estimate is probably an underestimate due to regulated requirements for night fishing [as a seabird mitigation tool], fishers actively hiding turtles from observers and lower turtle population numbers since the time of the initial estimates, all of which may have lowered estimated capture rates.

It is also important to note that catch rate does not equate directly to mortality rate particularly for those species that do not ingest bait. As release practises improve across the fishery, with the implementation of the FAO guidelines, it can be expected that survival of turtles caught and released from longlines will improve. Improved information over time will allow conservation and management measures to be refined so that they act to minimise mortality on turtles with minimum disruption to commercial fisheries.

In conclusion, considering the points above, it is proposed that catch rates of 0.019 (all species combined) turtles.1000 hooks^{-1} or less be considered for sea turtles in shallow-set longline fisheries targeting swordfish in the WCPO (based on the results of Gilman et al. 2006). This rate will result in a reduction of sea turtle catch rates in the tropical areas of the WCPO, and, as demonstrated by the Hawaiian example, it is achievable. The unit of effort can be standardised across longlines of differing length and is easily understood by fishers and managers in all areas. This rate should apply to

the total sea turtle catch rate and should not be species specific. This rate should be periodically reviewed by the Scientific Committee as new information comes to light.

Finally, we recommend that capture rates do not exceed an upper bound and should be the minimum standard applied.

The Scientific Committee should recommend to the Commission that in order to fulfil the requirements of paragraph 7(a) of CMM 2008-03, observed sea turtle interaction rates must be lower than 0.019 turtles.1000 hooks^{-1} over the last three consecutive years.

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