Evaluation of U.S. Turtle Protective Measures Under Existing TED Regulations, Including Estimates of Shrimp Trawl Related Turtle Mortality in the Greater Caribbean

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Executive Summary

In response to recent shrimp embargo legislation (Section 609, Public Law 101-162), the National Marine Fisheries Service was tasked with providing estimates of sea turtle take and mortality by U.S. shrimp trawlers under current sea turtle conservation regulations. This required a rather complex analysis of shrimping effort, turtle catch rates, turtle mortality rates, effectiveness of TEDs and tow time restrictions, and compliance with existing regulations. Results of these analyses will be used as a "standard" by the State Department in evaluating the relative effectiveness of foreign sea turtle conservation programs.

Current TED regulations, assuming 100% compliance, have resulted in a 67% reduction in sea turtle mortalities by shrimp trawlers in U.S. waters. However under current regulations, an estimated 23,376 turtles are captured annually by shrimp trawlers and 4,360 of these turtles drown. Based upon a recent analysis by the National Academy of Sciences, these estimates may underestimate true mortality by a factor of four.

INTRODUCTION

Section 609, Public Law 101-162, imposes an embargo on shrimp imports into the United States by nations not meeting or exceeding U.S. standards of sea turtle protection. In response to this legislation, the National Marine Fisheries Service (NMFS) undertook an extended reanalysis of sea turtle mortalities in U.S. waters (see Henwood and Stuntz, 1987 for the earlier analysis). Our principal objective was to provide current estimates of turtle catch and mortality rates in U.S. waters under existing TED regulations (**Federal Register**, Vol. 52, No. 124, June 29, 1987) for use as a standard of comparison with turtle take in foreign commercial shrimp trawling operations. We also provided gross estimates of turtle catch and mortality by foreign nations based on metric tons of shrimp exported, assuming turtles catch rates comparable to those in U.S. waters.

Providing these estimates in support of the embargo legislation, facilitated a more complete evaluation of the recommendations of the National Academy of Sciences regarding the need to expand current TED regulations. The results of our analyses clearly support expansion of existing TED regulations, and a proposed rule that will significantly improve U.S. sea turtle protection has been drafted. If U.S. regulations are expanded, more extensive use of TEDs by foreign nations and resultant increased protection to sea turtles will be a likely consequence.

PURPOSE OF LEGISLATION

Section 609, Public Law (P.L.) 101-162, addresses foreign commercial shrimp fishing operations that may adversely affect sea turtles covered by Department of Commerce shrimp trawling/turtle regulations of June 29, 1987. The law (1) calls for international agreements to conserve such species of sea turtles, and (2) bans importation of shrimp or shrimp products by foreign nations unless harvesting nations implement regulatory programs governing the incidental take of sea turtles that are comparable to U.S. regulations, and the average incidental take rates are comparable to U.S. rates.

While the State Department has primary responsibilities for international agreements, including those for sea turtle conservation, NMFS has been tasked to develop technical and certification procedures that will allow foreign nations to meet U.S. legislative requirements. The legislation specifically requires that foreign nations provide information that will allow the President to "determine and certify to the Congress not later than May 1, 1991, and annually thereafter that --

(A) the government of the harvesting nation has provided documentary evidence of the adoption of a regulatory program governing the incidental taking of such sea turtles in the course of such harvesting that is comparable to that of the United States; and

(B) the average rate of that incidental taking by the vessels of the harvesting nation is comparable to the average rate of incidental taking of sea turtles by United States vessels in the course of such harvesting; or

(C) the particular fishing environment of the harvesting nation does not pose a threat of the incidental taking of such sea turtles in the course of such harvesting."

The U.S State Department has interpreted this legislation to apply only to countries in the wider Caribbean, and consequently, we have limited our analysis of turtle take by foreign fisheries to this area. Further, since the legislation requires that U.S. actions be based on comparisons with all U.S. shrimp fisheries, we have included a description of fisheries outside of the Gulf of Mexico and southern North Atlantic.

DESCRIPTION OF U.S. SHRIMP FISHERIES

Gulf of Mexico and southern North Atlantic fisheries:

Federal TED regulations were directed at protecting sea turtles from incidental capture and mortality by shrimp trawlers in the Gulf of Mexico and the southern North Atlantic. The southeast shrimp fishery targets shrimp in the family Penaeidae which inhabit the warm, temperate and tropical waters of the world, and are abundant in waters of the U.S. continental shelf, including estuaries, sounds and bays. Catches are dominated by three species; the white shrimp, Penaeus setiferus, the pink shrimp, Penaeus duorarum, and the brown shrimp, Penaeus aztecus. The most commonly employed gear is the otter trawl, but a variety of fishing gears and techniques are used in localized areas.

In providing a general overview of the southeast U.S. shrimp fishery, the offshore commercial fleet was separated from the inshore fleet. Offshore is defined as those waters seaward of the 72 COLREGS demarcation line (International Regulations for Preventing Collisions at Sea, 1972), as depicted or noted on nautical charts published by the National Oceanic and Atmospheric Administration. The offshore fleet consists of larger vessels with larger nets, that operate over wide geographical areas. Offshore vessels may target all three species of penaeid shrimp at different times of the year. Shifts in target species result in varying levels of effort over depths, seasons and areas.

The Gulf of Mexico offshore fleet consists of approximately 5400 vessels, and the offshore southern North Atlantic fleet is composed of about 1500 vessels (NMFS 1987). The majority of the southeast U.S. commercial shrimping effort occurs in the central and western Gulf of Mexico (approximately 4,000,000 trawling hours). The annual southern North Atlantic effort is roughly 550,000 hours. Actual fishing strategies and preferred equipment of the offshore fleet (vessel size, vessel type, number of nets, types of nets, duration of tows, etc.) vary with geographical location, bottom topography, target species, time of the year, and other factors. The level of fishing effort expended in any given area is controlled by seasonal abundance of target species, i.e., the Key West fishery is primarily a winter fishery; the northern Gulf fishery and the Atlantic fishery are primarily summer/fall fisheries.

The inshore commercial shrimping fleet consists of approximately 11,000 boats (less than 25 feet in length). While the otter trawl is the most commonly employed gear, in certain locations butterfly nets, beam trawls, traps, etc. may be used to capture shrimp. In addition to the commercial fleet, approximately 40-50 thousand recreational shrimpers harvest shrimp in inshore waters. Under the existing TED regulations, boats under 25 feet in length are not required to use TEDs but must restrict their tow times to 90 minutes or less duration in specified areas and during specific seasons.

Gulf of Maine fishery:

The target species in the Gulf of Maine shrimp fishery is the northern shrimp (Pandalus borealis). This species is circumpolar in distribution, and supports several regional fisheries including the Alaskan and Gulf of Maine fisheries. The depth range of the northern shrimp is 20 to 1,450 m, but most commercial fishing occurs in waters less than 300 m. During the 1988 season in the Gulf of Maine nearly 400 U.S. vessels participated in the fishery. These vessels accounted for 8,900 trips, and approximately 3,000 metric tons of shrimp were landed.

This fishery is managed under the auspices of the Atlantic States Marine Fisheries Commission and state agencies, and management of the fishery has been based primarily on seasonal closures and mesh size regulations. The fishery is restricted to winter/spring months, but the actual length of the season varies according to strength of year classes and status of the shrimp stocks. No turtle/fishery interactions have been reported in this fishery, nor are such interactions considered likely because of the cold water temperatures and seasonality of effort.

Alaskan shrimp fisheries:

The target species in the Alaskan shrimp fishery is also Pandalus borealis, although several other Pandalid species comprise a minor portion of the landings. The Alaskan fishery is predominantly an otter trawl fishery, but a small pot fishery for larger pandalids also exists. Management of this fishery is based upon maintaining stock size for harvesting. No turtle/fishery interactions are likely because of the geographic location and absence of turtles.

Washington-California shrimp fisheries:

The target species of this fishery is Pandalus jordani which occurs from Alaska to southern California in depths from 37 to 450 m. The greatest abundance is from northern California to the Strait of Juan de Fuca, with highest concentrations off the coast of Oregon at depths greater than 100 m. The predominant gear used in this fishery is the otter trawl.

This fishery was historically managed by state regulatory agencies. In California and Oregon, the fishery was generally restricted to the non-ovigerous periods from April through October. The State of Washington, however, permitted shrimp fishing without a closed season. The fishery is presently managed under the auspices of the Pacific Fishery Management Council and state agencies. No turtle/fishery interactions have been reported, nor are any turtle protective measures thought to be necessary in this fishery. Cold water temperatures likely prevent turtles from moving into this area.

EFFECTIVENESS OF U.S. TURTLE CONSERVATION MEASURES IN SOUTHEASTERN SHRIMP FISHERIES

Background

Henwood and Stuntz (1987) provided preliminary estimates of incidental turtle catch and mortality rates by shrimp trawlers in offshore U.S. waters. These estimates were based on observer data collected aboard commercial trawlers. They indicated that approximately 47,973 turtles were captured annually, and 11,179 of these turtles were drowned in the trawls.

In promulgating the Federal TED regulations, all available information on turtle/trawler interactions, turtle strandings, basic sea turtle biology, etc. was assembled and presented to a mediation team of shrimp industry and the environmental community representatives. The team negotiated and agreed to many of the seasonal and areal restrictions included in the final TED

regulations. Therefore, the existing TED regulations were based partially upon what was known about sea turtle biology and turtle interactions with shrimp trawlers, and partially upon compromises that did not always consider the biology of the species. In assessing the effectiveness of existing regulations, it is clear that more sea turtles could be saved by expanding the TED requirements to year-round in both inshore and offshore waters.

No data on catch or mortality rates of sea turtles by inshore shrimp trawlers were available when the regulations were drafted. Because of this information gap, and as a result of negotiations and compromises, TEDs were not required in inshore waters. A

mandatory 90-minute tow time restriction was substituted for the TED requirement, but the effectiveness of this measure is difficult to evaluate without historic inshore catch and mortality data.

Assumptions

Estimating the average catch rates and mortality of sea turtles in U.S. shrimp fisheries under existing TED regulations is a complex procedure requiring a number of assumptions. In computing estimates of the effectiveness of existing TED regulations, the following was assumed:

(1) Turtle catch per unit of effort (CPUE) is a direct function of net size and length of tow, e.g., a 100 ft net will catch twice as many turtles as a 50 ft net over tows of equal length. (NOTE: All trawl measurements are reported in terms of headrope length, a measure of the distance across the top line of the net. For normalization purposes, a 100 ft. (30.5m) headrope length was used as a standard.)

The effect of this assumption is that quad rigs, twin trawls and single trawls are assumed to catch turtles with equal regularity, and that the size of the net influences catch rates. Additionally, all net types are assumed to be equally effective in turtle capture. These assumptions may result in a bias, but it is not clear whether this bias would be positive or negative.

(2) CPUE does not vary seasonally; i.e. it remains constant throughout the year.

This assumption probably results in an overestimate of turtle captures during months of the year when temperatures are lowest. In the southern North Atlantic, for example, most scientists believe that turtles move up and down the coast as temperatures warm in the spring and cool in the fall. Therefore, turtles would not be subject to capture during some months of the year because they have moved out of the area. Conversely, CPUE rates could be higher than mean CPUE

estimates provided in Henwood and Stuntz (1987) during summer months in certain areas.

(3) CPUE in inshore waters is the same as in offshore waters.

The effect of this assumption could be an overestimation or underestimation of CPUE in inshore waters. Inshore habitat probably supports different age/size/sex classes and different species composition of turtles than offshore waters. Thus, CPUE by species could differ greatly from that observed in offshore waters.

(4) Mortality rates are a direct function of tow time, and remain constant throughout the year.

This assumption is probably violated. Data suggest that turtles are more likely to survive forced submergence at cold water temperatures than in warm waters because of differences in metabolic rates. Therefore, turtles are probably at higher risk of drowning during summer months. Use of mean mortality rates may result in overestimation of deaths at some times of the year and underestimation at other times of the year.

(5) Compliance with the TED regulations and 90-minute tow time restrictions are 100%.

Given the NMFS enforcement capabilities, it is likely that total compliance with TED regulations will not be immediately achieved. The effect of this assumption will be an underestimate of total captures and mortalities.

(6) In areas and seasons when regulations are not in effect, no TEDs or tow time restrictions are used.

The effect of this assumption could be an overestimate of turtle catch and mortalities. As fishermen become accustomed to use of TEDs, they may choose to leave them in nets year-round. Additionally, TEDs may be used at times and in areas where jellyfish are abundant, regardless of whether they are required by law.

(7) All TEDs are at least 97% effective in excluding sea turtles.

This assumption is supported by the TED certification process. However, if TEDs are improperly installed or the design is modified, effectiveness could be less than 97%. This assumption could result in an underestimate of turtle catch and mortality rates if fishermen alter certified TEDs in any manner.

(8) All comatose turtles are resuscitated; all will survive and be released alive.

The effect of this assumption is probably an underestimate of turtle mortalities. Existing data suggest that resuscitated turtles may suffer long-term damage from ingestion of water into the lungs. Thus, a certain proportion of turtles that have been revived and released alive will probably die.

Computations

In deriving estimates of turtle catch and mortalities for offshore waters of the Gulf of Mexico under the existing TED regulations, an average effort/year for the period 1984-1988 of 5,117,021 hours was used (Galveston Laboratory, pers. comm.). Assuming that vessel rigging has not changed substantially since 1984 when the average vessel used 35.47 m of headrope, average effort/year was multiplied by 35.47/30.5 which resulted in an average normalized offshore effort of 5,935,744 (100 ft net hrs)/year. During seasons and in areas where TEDs are not required, mortality estimates were computed on the basis of effort, estimated turtle catch rates, and mortality rates reported in Henwood and Stuntz (1987). For areas and seasons with TED requirements, the same computations were used except that estimated turtle catch was assumed to be 3% of the estimated catch without TEDs (97% reduction in captures).

Based on data supplied by the NMFS Economics and Statistics Office in Miami, offshore effort in the southern North Atlantic was estimated to be 19,748 days/year (average for years 1984-1987). Assuming that vessels in the Atlantic offshore fleet are rigged similarly to the Gulf fleet, this value was normalized to 549,790 (100 ft net hrs)/year. In computing turtle catch and mortality estimates, it was assumed that 100% of the vessels used TEDs from May through August (except in Florida where TEDs are required year-round), and that no vessels used TEDs during the remaining months of the year.

Average inshore effort in the Gulf of Mexico over the years 1984-1988 was estimated to be 2,190,822 hours. The mean footrope length of trawls was 11.81 m (Galveston Laboratory, pers. comm.). To convert this value to headrope, 2 m was added to this length resulting in a mean estimate of 13.81 m headrope length. To normalize effort, 13.81/30.5 was multiplied by 2,190,822 to estimate an average inshore effort of 991,973 (100 ft net hrs)/year. Mortality rates were computed on the basis of offshore CPUE values and estimated mortality for 90-minute tows. The inshore Atlantic effort was computed based upon an estimate of 14,534 days/year (equivalent to 348,805 hours) which was normalized as above, to 157,934 (100 ft net hrs)/year. In areas and seasons where 90-minute tow times were not required, it was assumed that trawlers operate as they did prior to the regulations.

Table 1. Normalized shrimp fishing effort, mortality rates and catch per unit of effort (CPUE) used in calculating sea turtle mortalities for the Gulf of Mexico and the southern North Atlantic.

AREA	NORMALIZED EFFORT (100 FT NET HRS)	PERCENT MORTALITY	CPUE (TURTLES/ 100 FT NET HR)
offshore			
Gulf of Mexico			
zones 1-7	656,734	34	0.0046
zones 8-17	3,419,827	22	0.0030
zones 18-21	1,859,183	38	0.0026
Atlantic	549,790	21	0.0456[1]
	6,485,534		
inshore			
Gulf of Mexico			
zones 1-7	14,053	12	0.0046
zones 8-17	732,244	12	0.0030
zones 18-21	245,676	12	0.0026
Atlantic	157,934	12	0.0456
	1,149,910		

[1] In statistical zone 28, an estimated CPUE of 0.12745 was used. This value was computed by assuming that a CPUE of 0.0487 (Atlantic mean) could be applied to 75% of the effort in this zone and a CPUE of 0.3643 (Canaveral mean) could be applied to the remaining 25% of the effort. Mortality estimates were taken from Henwood and Stuntz (1987). Figure 1 provides a description of the statistical zones.

Table 2. Estimated sea turtle capture with and without TED regulations for the offshore and inshore shrimp trawl fisheries in the Gulf of Mexico and southern North Atlantic. Current regulations in inshore waters include a 90 minute tow time restriction or TED option.

	Offshore		Inshore	
Month	No Regs.- Estimated Number of turtles captured	Current TED Regs.- Estimated Number of turtles killed	No Regs.- Estimated Number of turtles captured	90-minute tow times Estimated Number of turtles killed
Gulf of Mexico				
JAN	927.20	173.74	34.11	5.17
FEB	944.13	165.18	9.55	0.52
MAR	873.73	7.79	21.65	1.54
APR	997.97	9.06	48.40	4.24
MAY	1786.69	14.77	368.98	42.65
JUN	1755.15	13.65	673.71	79.20
JUL	1732.64	15.25	284.61	33.27
AUG	1928.80	16.53	321.87	37.86
SEP	1769.80	14.67	380.12	44.91
OCT	2079.38	16.99	412.53	48.42
NOV	1748.40	14.57	255.88	29.64
DEC	1570.43	357.21	88.74	13.43
	18114.33	819.41	2900.14	340.85
Atlantic				
JAN	1635.44	136.80	13.76	1.20
FEB	654.40	10.90	2.45	0.02
MAR	353.07	6.61	19.91	2.60
APR	301.66	30.50	137.01	21.92
MAY	1227.57	7.73	415.25	49.21
JUN	3020.18	19.03	854.91	100.63
JUL	4010.91	25.27	2153.28	253.39
AUG	4072.53	25.65	1780.28	208.85
SEP	3661.34	590.46	1086.08	170.61
OCT	4075.94	616.22	787.17	122.99
NOV	3688.49	460.53	322.84	48.96
DEC	2651.93	274.69	118.57	15.19
	29353.47	2204.39	7691.51	995.57

TEDs are required year-round in Florida state waters, southwest Florida (zones 1-4), and Canaveral (zone 28). For the remainder of the Gulf of Mexico, TEDs are required during all months except

December, January, and February. In the Atlantic TEDs are required only for the months of May through August, except in Florida inshore waters and Canaveral where they are required year-round. Estimates of turtle mortality assume Florida and South Carolina TED regulations are in effect. For the inshore, it is assumed that all vessels are using 90-minute tow times when required, and are not restricting tows to 90-minutes during the remainder of the time. Estimated turtle mortalities when TEDs are required under current regulations are calculated by multiplying the number of captures with no regulations by 0.03 (assuming 97% exclusion) and multiplying this value by the applicable mortality rate taken from Henwood and Stuntz (1987). In inshore areas during periods when 90 minute tow times are not required, percent mortality was estimated to be 16%.

Table 3. Summary of statistics of U.S. turtle catch and mortality rates with and without TED regulations.

	Offshore		Inshore		
	Atlantic	Gulf of Mexico	Atlantic	Gulf of Mexico	Total
Effort (hours/ 100 ft net)	549,790	5,935,744	157,934	991,973	7,635,441
CPUE (turtles/ 100 ft net hour)	0.0534[1]	0.0031	0.0487	0.0029	0.0076[2]
Turtle captures (No TED regulations)	29,353	18,114	7,692	2,900	58,059
Estimated mortality rate (% dead - No regs)	21	29	16	16	26.6[3]
Turtles killed (No TED regulations)	6,164	5,253	1,231	464	13,112
Turtle captures (current TED regulations)	10,495	2,925	7,114	2,842	23,376
Estimated mortality rate (% dead - current TED regs)	21	28	14	12	17.1
Turtles killed (current TED regulations)	2,204	819	996	341	4,360
Kill per unit of effort (No TED regulations)	0.01121	0.00088	0.00779	0.00047	0.00172
Kill per unit of effort (current TED regulations)	0.00401	0.00014	0.00631	0.00034	0.00057
Turtle captures with 100% TED coverage *	881	543	231	87	1742
Turtle mortality with 100% TED coverage **	185	152	32	10	379

[1]This estimate is based upon a weighted average computed as described in Table 1.

[2]Average CPUE calculated by dividing turtle captures by effort.

[3]Average mortality rate weighted by effort.

Percent reduction in turtle mortalities under current TED regs	64	84	19	27	67
Percent reduction in turtle mortalities under proposed TED regs	97	97	97	97	99

* This entry assumes that TEDs are used at all times and in all areas (both inshore and offshore).
**Estimated mortality rate X turtle captures with 100% TED coverage.

STANDARDS AND EVALUATION CRITERIA

To satisfy the requirements of the shrimp embargo legislation, foreign nations must meet both the "comparability of regulations," and the "comparability of average rate of incidental taking" standards. The incidental taking requirement (turtle CPUE) is assumed to be part of an overall formula for determining "comparability of regulations." Thus, if a nation's CPUE rates are higher or lower than U.S. rates, the nation may meet U.S. standards by implementing more or less stringent protective regulations.

To facilitate implementation of this legislation, NMFS has estimated levels of take under existing U.S. TED regulations, i.e., how many turtles are captured and killed annually in U.S. waters as a result of shrimp harvesting by trawlers (Table 3). The rates of U.S. turtle capture and mortality can be directly compared to similar estimates by foreign nations to determine whether the comparability standards are met.

Average turtle CPUE for U.S. waters was estimated by dividing estimated turtle captures for the Atlantic and the Gulf of Mexico by effort. The offshore average CPUE was 0.00732, while the inshore average CPUE was 0.00921. The average turtle CPUE for all U.S. waters was calculated to be 0.00760 turtles/100 ft net hour.

The percent reduction in mortality rates under existing TED regulations was calculated by summing the estimated mortalities (Table 2) under full implementation of the regulations (4,360 turtles), dividing that number by estimated turtle mortalities with no regulations (13,112) and subtracting the quotient from one. A 23% average mortality rate was derived by dividing estimated turtles killed by captures. Thus, the U.S. has achieved a 67% reduction in turtle mortalities under current regulations.

Other useful statistics in evaluating comparability of regulations are the percent of effort during which TEDs or tow-time restrictions are required under existing U.S. regulations. TEDs are required in offshore waters during 83% of the shrimping effort. In inshore waters, tow-time restrictions or TEDs are required during 92% of the effort. The percent of the total shrimping effort during which either TEDs or tow-time restrictions are required is 85%. Of the total effort (inshore and offshore), TEDs are required during 71% of the effort.

In cases where nations adopt TED regulations everywhere at all times, precision of CPUE estimates is not of major importance because TEDs are known to be 97% effective at releasing turtles; i.e., at least a 97% reduction in turtle mortalities. However, in cases of partial implementation of TED regulations, tow-time restrictions, or different protective regulations, the precision of

estimates required to adequately assess levels of take and mortality are greatly increased. The burden of proof lies with foreign nations to demonstrate that CPUE values are less than or equal to U.S. rates, or that their regulations compensate for CPUE rates higher than U.S. standards by achieving comparable levels of reduction in mortality.

FOREIGN SHRIMP FISHERY/MARINE TURTLE INTERACTIONS

A review of available information on the worldwide distributions of turtles and potential interaction between shrimp fisheries and turtles was completed in an earlier report (Nancy Thompson, draft report). A description of fisheries with potential turtle interactions also was presented for selected countries. While our estimates of turtle take in foreign shrimp fisheries only concerns those species considered in the U.S. TED regulations, we were unable to determine species composition of take by foreign nations. Therefore, the estimates of take by selected nations may include olive ridleys, which are not considered in U.S. regulations. Selection of countries was based on the known occurrence of nesting or in-water aggregations of marine turtles, and the known or potential incidental turtle take based on the relative fishing effort of a given country.

Mexico

Of the foreign nations importing shrimp and shrimp products to the U.S., the Mexican shrimp fishery and turtle occurrence in their waters is probably best known. In the past, the U.S. has cooperated with Mexico in several fisheries ventures in the Gulf of Mexico, and has worked closely with the Mexican government on fisheries related problems. However, despite our past interactions, we have no reliable data on turtle CPUE in Mexican shrimp fisheries, mortality rates associated with these fisheries, species composition of turtles incidentally taken in these fisheries, or other pertinent information needed evaluate impacts on sea turtle populations.

According to the WATS I National Report for Mexico (Bacon et al. 1984), marine turtles are incidentally taken in the shrimp trawling fishery as follows:

Turtle Species	No. of Turtles
loggerhead	50
green	50
leatherback	10
hawksbill	50
Kemp's ridley	100
TOTAL	260

Unfortunately, these estimates may be of little use in efforts to certify that Mexico meets the standards required by U.S. legislation, mainly because they appear to be low. Applying what we know about U.S. shrimp fisheries in the Gulf of Mexico to what might be expected in Mexican waters, we performed a cursory analysis. We assumed the following:

(1) Turtle distributions in Mexico and the U.S. Gulf of Mexico are the same.

(2) The shrimp trawl fishery operates in the same way, and is composed of similarly rigged vessels fishing in the same manner as U.S. trawlers.

(3) Turtles in Mexican waters behave the same once captured in a trawl as turtles in U.S. waters and trawls.

(4) The value of the shrimp imports to the U.S. are representative of the major ex-vessel value to each country.

The numbers of turtles captured and killed by the U.S. fleet in the Gulf of Mexico per metric ton of shrimp landed was estimated for the period 1980 to 1985. Approximately 113,379 metric tons of shrimp were landed annually over this time period. Based on estimates of Henwood and Stuntz (1987), the average number of turtles captured per year per 113,400 metric tons is over 13,000 with approximately 3,800 killed. Thus, the U.S. catch and mortality rates of sea turtles per metric ton of live shrimp landed are 0.12 and 0.03, respectively. As previously stated, this assumes that the Mexican fleet is similar to the U.S. fleet in headrope length of nets per vessel, that CPUE rates are the same, and that live turtles will be released when incidentally captured.

In 1987, approximately 87,000 metric tons of live weight shrimp were landed in Mexico, primarily from double rigged trawlers. This means that Mexican shrimpers probably captured 10,404 turtles (0.12 X 87,000), of which 2,610 turtles (0.03 X 87,000) may have been killed.

Applying the U.S. standards to the Mexican fishery (assuming that the above assumptions and calculations are reasonable), the total mortality of turtles by the Mexican shrimp fleet (2,610) is substantially less than that of the U.S. fleet (4,788 turtles). CPUE in Mexican waters is 0.0031 (assuming that it is comparable to that observed in U.S. Gulf of Mexico waters), which is also less that the U.S. standard of 0.00685. However, in applying the standard of 62% reduction in mortalities, Mexico would have to reduce their mortalities to 992 turtles to meet the "comparability of regulations" criteria.

The above analysis, of course, is questionable because we know certain things about the Mexican shrimp fishery that violate at least two of our assumptions. First, most captured turtles probably do not survive. Mexican fishermen reportedly do not release turtles; they either eat or sell them. Second, Mexican turtle CPUE rates may be much higher than U.S. rates because of turtle distribution patterns, proximity of nesting beaches, and possible directed fisheries. Thus, a more accurate estimate of turtle mortalities in Mexican shrimp fisheries may be closer to 10,404 turtles.

Central America

No information on the shrimp fisheries of Central American countries was available, but all export shrimp to the U.S. For this reason, we used a description of the Ecuadoran offshore shrimp trawling industry to represent that of Central American countries (This assumes that fisheries are similar - Ed Klima, pers. comm.). The commercial shrimp trawl fishery of Ecuador in 1987 accounted for about 7% of country's total shrimp production or about 5,800 mt of shrimp. Approximately 250 vessels between 50 -70 feet in length are involved in this fishery. All are double rigged with otter trawls, most are refrigerated, and the average trip is 15-22 days. About 90% of the shrimp caught are white shrimp found in waters less than 15 fathoms depth. Thus, if 5,800 mt of shrimp are produced from 250 Ecuadoran vessels, the Panamanian fishery which produced about 5,000 mt of shrimp is about the same size as the Ecuadoran fishery.

The same figures for turtle captures and mortalities (0.12 and 0.03) in the U.S. fishery per 113,400 metric tons of shrimp landed were used for estimation purposes. By Central American country the estimated catch and mortality of turtles is:

	Metric Tons (shrimp)	Turtles Caught	Turtles Killed
Panama	4,970	596	149
Honduras	4,211	505	126
El Salvador	2,787	334	84
Costa Rica	8,502	1020	255
Guatemala	604	72	18

Here again, the number of turtles caught may be a better indicator of mortality, because captured turtles probably are not released.

The above breakdown of Central American countries poses another problem in applying U.S. standards to foreign nations. On a country-by-country basis, the total turtle mortality level may be much less than the U.S. levels. However, the cumulative impact to

sea turtles of fishing activities by groups of countries may result in total mortalities that exceed those from U.S. fishing activities.

Columbia, The Guyanas, Surinam, Venezuela, Brazil and Ecuador

All of these countries probably operate fisheries in the same manner as Ecuador since each are important shrimp producers from an offshore shrimp trawling industry (Ed Klima, pers. comm.). Thus, based upon the previously described computations and assumptions, the estimated catch and mortality of turtles by country using the ex-vessel cost method are:

	Metric tons (shrimp)	Turtles Caught	Turtles Killed
Brazil	78,410	9,409	2,352
Venezuela	6,073	729	182
Ecuador	5,770	692	173
Columbia	4,486	538	135
French Guiana	2,795	335	84
Guyana	1,607	193	48
Surinam	1,107	133	33

Four of the five species impacted by the U.S. TED regulations are found in waters of South America where shrimp trawling occurs. In fact, significant nesting and foraging of hawksbill, green and leatherback turtles occurs along these coasts. In addition to these four species, the olive ridley is also found. However, the proportional representation of the total turtle catch and kill for each species is unknown. Because of the importance of these waters to the hawksbill, green and leatherback turtles, it is likely that the representation of these species is high.

RECOMMENDATIONS

The examples provided in the previous section illustrate the difficulties in implementing this legislation because so little is known about the fisheries of nations importing shrimp to the U.S. Assumptions about catch rates in foreign waters are difficult to verify, and it is questionable whether mortality rates in U.S. waters can be applied to foreign nations. In areas where captured turtles are eaten or sold, regulations must be designed to eliminate captures. The assumption that live turtles will be returned to the sea when incidentally captured is probably invalid <u>everywhere</u> except in U.S. waters.

If the President must certify that foreign nations are in compliance with this law, verifiable estimates of present CPUE and mortality rates, and proof that TED regulations have been implemented and are being enforced must be provided. To the best of our knowledge, the only way to get this information is through an observer program. Once an accurate estimate of a foreign nation's turtle CPUE has been developed, it will be possible to ascertain the level of protection provided by regulations implemented by these countries.

On a country-by-country basis, the most meaningful standard might be a direct comparison of "kill per unit of effort (KPUE)." For example, U.S. TED regulations have resulted in a KPUE rate of 0.00065 turtles per 100 ft net hour of trawling. If a foreign nation can demonstrate that their regulations have resulted in a similar or lower rate of mortalities, they will have met the comparability standard of the law.

This is a relatively easy standard for many foreign nations to meet. By requiring and enforcing TED regulations, for example, foreign nations can expect to reduce turtle catch and mortalities by 97%, regardless of whether the remaining 3% of the turtles are eaten or sold. Thus, the KPUE rate would be reduced significantly, and it may not be necessary to have an accurate estimate of CPUE. We know that TEDs are at least 97% effective in eliminating turtle captures, if properly installed and used. Thus, if CPUE in foreign waters were a magnitude greater than the U.S. standard, year-round implementation of TEDs would still reduce mortalities <u>more</u> than the existing U.S. regulations.

The current U.S. turtle regulations are <u>not</u> particularly difficult to meet or surpass. While a 67% reduction in turtle mortalities by U.S. shrimp fishermen is a major improvement, the U.S. has a long way to go in affording adequate protection to endangered and threatened sea turtles. This point is clearly illustrated by comparing our estimated mortality rates under current regulations with mortality rates under the assumption that TEDs are used

everywhere at all times (Table 3). Thus under current U.S. regulations, foreign nations seeking to avoid this embargo can easily adopt TED regulations that meet or exceed the U.S. level of protection. However, if proposed TED requirements are implemented by the U.S., foreign nations may have to implement TEDs in all places at all times to meet comparability standards.

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