Southwest Fisheries Science Center
Administrative Report H-96-02

Recommendations for Scoping the Sea Turtle Observer Program for the Hawaii-Based Longline Fishery

Robert A. Skillman, Jerry A. Wetherall, and Gerard T. DiNardo

Honolulu Laboratory, Southwest Fisheries Science Center
National Marine Fisheries Service, NOAA
2570 Dole Street, Honolulu, Hawaii 96822-2396

August 1996

NOT FOR PUBLICATION

INTRODUCTION

A scientific observer program is conducted by the Southwest Region (SWR) to monitor sea turtle interactions in the Hawaii-based pelagic longline fishery. The SWR requested that the Honolulu Laboratory develop alternative survey designs for the observer program and recommend a preferred alternative. Factors requested to be included in the reevaluation were coverage rates of the survey strata, precision of the take estimates, and costs.

This report a) recommends a specific stratified survey design and an observer effort allocation plan (fielding strategy), b) describes the procedures followed in selecting the preferred design, c) discusses the advantages and disadvantages of alternative fielding strategies, and d) provides information on coverage, costs, and precision in tabular and graphic format.

RECOMMENDATION

A random stratified survey design consisting of two strata based on boat size is recommended to replace the current pilot design based on historical species targeting. These two strata are:

1. vessel length equal to or less than 70.0 ft, and

2. vessel length greater than 70.0 ft (U.S. Coast Guard-registered length).

From the inception of the mandatory observer program in late February 1994 through December 1995, the large boat stratum has had an average take rate of 0.0875 turtles/1,000 hooks and has accounted for 87% of the estimated takes, 40% of the trips, and 36% of the hooks fished. The small boat stratum has had an average take rate of 0.0073 turtles/1,000 hooks, less than one-tenth the rate for the large boat stratum.

The survey should be fielded using a proportional distribution of observer sampling effort among the two strata based on the estimated mean turtle take rate within the strata.

The number of trips to be observed should be increased considerably from the current 4% coverage rate to at least 20% coverage to estimate turtle take more reliably. The desired precision of the turtle take estimates and the amount of available funds are factors that must be balanced in determining sample size.

Selection of Stratification Design

Seven stratified survey designs were evaluated to determine the most appropriate design for revising the turtle observer program. The specifications of the seven designs are given in Table 1.

The coefficient of variation (CV) of the mean take rate estimate was used as a measure of precision to compare the alternative survey designs (Table 2). Since the CVs of the alternative designs differed by no more than 3 percentage points, none of the alternatives provide a clear advantage with respect to estimated precision of the take rate estimate.

Among the alternatives examined, the 2-boat size stratification is recommended. Its advantages include the following:

1. Easy to set up because the U.S. Coast Guard-documented vessel lengths are readily available;

2. Easy to maintain because inclusion of boats in the strata would not have to be reevaluated annually as is the case with the pilot design;

3. Easy to field because it consists of only two classes of boats from which trips must be chosen at random;

4. Easy to field in contrast to all the designs involving latitude, which would require determining the geographical area to be fished and potentially the use of vessel monitoring systems; and

5. Simple and easy to explain because it is generally recognized that large boats tend to target swordfish, fish in more northern latitudes, and are involved in more interactions with turtles.

Selection of the Fielding Strategy

Four fielding strategies were evaluated.

1. Sampling in proportion to fishing effort (status quo).

The first strategy allocates observer sampling as it was done in the pilot survey. That is, it was based on the historical distribution of fishing effort (trips) within four fish targeting strata prior to the start of the pilot survey. This status quo strategy serves as a baseline for comparison.

2. Sampling large boats only.

The second strategy involves sampling only the large boat stratum, which accounts for 87% of the estimated turtles taken. There are two advantages for this strategy. First, under this option, the small boat sector, which accounts for only 13% of the take of turtles, is not burdened with carrying observers (these boats also have less capability of carrying an observer without disrupting fishing operations). Second, all of the observer effort would be allocated to the large boat sector which should result in a take rate estimate with greater reliability. There are also two disadvantages for this strategy. First, an estimate of turtle take by the small boat sector would not be available unless estimated using the take rate computed from the data collected under the pilot program. That is, the take rate would be assumed to be constant. Second, any changes in the take rate of the small boat sector would not be monitored. Data from the mandatory longline logbook could be examined for changes in fishing practices (distribution, targeting, gear configuration), but any changes in take rate caused by changes in availability or catchability of turtles probably would not be detected with these data.

3. Sampling in proportion to the take rate.

In the third strategy, observer sampling is allocated in direct proportion to the estimated mean take rate by strata. There are four advantages for this strategy. First, the take of the small boat sector could be estimated directly from the survey data. Second, at least some monitoring of the small boat sector would occur, thus providing the potential for detecting large changes in turtle take rate. Third, the small boat sector is subject to a minimal amount of observer monitoring. Fourth, most of the observer effort is allocated to the large boat stratum, which accounts for 87% of the turtle take, and this should result in a more precise estimate of that take. It seems desirable to increase the reliability of the estimate for that sector of the fleet that has the highest take rate and accounts for the highest take of turtles. On the other hand, with the small amount of observer effort in the small boat sector, only large changes in take rate, such as might be caused by major changes in fishing practices or turtle vulnerability, would have any chance of being detected. Again, monitoring the mandatory longline logbook data for changes in fishing practices would be wise.

4. A middle ground.

Because the second and third strategies differ drastically from the way the program has been conducted, a fourth strategy may be considered that involves allocation percentages between those in the status quo strategy and the strategy involving directly proportional allocation.

Strategy 3 is recommended.

Coverage and Costs of the Fielding Strategies

For the four fielding strategies described above, the 2-boat size design was computed and evaluated at different fixed coverage levels and budget limits (Table 3). This was done to show not only differences between the fielding strategies but also to provide guidance in setting the total number of trips to be observed. The estimated cost of an observer trip was rounded from $6,890 to $7,000 for these computations. While larger boats tend to take longer trips and thus probably cost more to monitor, no attempt was made to break out costs by boat size-strata.

The trip-wise coverage rate in the observer program has averaged about 4% for both calendar years 1994 and 1995. To facilitate comparisons, strategies were computed with a 5% overall coverage rate as well as 10% and 20% rates. Since the SWR indicated that only $250,000 might be available to conduct the program in fiscal year 1997, fielding strategies were calculated at this cost level as well as with an additional $100,000. For fielding strategy 2 (sampling only the large boat stratum), estimates were computed with the coverage rates for that stratum fixed at 10% and at about 7% (which was the coverage for the large boat stratum under the status quo strategy at 5% overall coverage rate).

In strategy 4, costs of the observer program were evaluated for a particular (arbitrary) combination of coverage rates. Specifically, averages of the annual coverage rates for the large boat stratum under strategies 1 and 3 were computed for the overall coverage rate (5% and 10%) and cost limit ($250,000 and $350,000) scenarios.

Survey Error and Reliability

Using pooled 1994 and 1995 data, the expected performance of the 2-boat size stratified sampling design was evaluated with respect to the relative error of the total take estimate (all species combined) at the 90% confidence level for 18 observer sampling coverage scenarios (Table 4). Relative error was estimated using a nonparametric bootstrap procedure, and can be interpreted using the following example. At a 1% small vessel observer coverage and 10% large vessel observer coverage, there is a 90% chance (confidence level) that the estimate of total turtle take will be within ± 54% (relative error) of the true take value. Expected costs associated with each scenario were also computed assuming an average observer trip cost of $7,000.

The lowest relative error is of course obtained at the highest coverage rates for both small and large boats (Fig. 1). Below a coverage rate of 1% for small boats, the relative error increases dramatically regardless of the large boat coverage rate. The extreme at 0% coverage of small boats (actually 2 trips for computational reasons) results in the highest relative error rate and is equivalent to the second fielding strategy presented earlier. Increasing small boat coverage above 5% results in little improvement in relative error. The lowest levels of relative error are associated with a 20% large vessel coverage rate, regardless of the small boat coverage rate. The largest decrease in relative error occurs between 5 and 10% large boat coverage rate, but the drop between 10 and 20% is still substantial. Expected costs associated with the observer coverage sampling scenarios range from $168,000 to $1,561,000 (Fig. 2).

The performance of possible coverage scenarios was evaluated with respect to the probability of detecting a turtle take in the fishery at the species level, defined as the probability of taking at least one turtle of a given species in the observer program. This was computed as a function of observer effort and the assumed actual total turtle take by the fleet (Fig. 3). This type of information is pivotal, especially for species rarely encountered. Detection probabilities were computed assuming a simple random sampling design and thus are only an approximation with respect to the 2-boat size sampling design. However, they provide general sampling coverage guidance regarding the power to detect a take relative to the rarity of interactions with the species. Computed probabilities of detection can be interpreted using the following example. For 50 observer trips, there is about a 20% chance of detecting a take of a species (recording at least one take in the observer program) when the total annual fleet take of the species is five. For species rarely encountered (low annual fleet take), the probability of detection is low when the number of observed trips is low. In both 1994 and 1995, the number of observed trips was less than 50 and for some species no take was observed (no hawksbill in either year and no green turtle in 1995). Interpreting the absence of observed takes is clearly problematic given the low probability of detecting takes with such low observer coverage.

Table 1.--Stratum characteristics of alternative stratified survey designs.

Design alternative	Strata names		Strata characteristics
Pilot design (status quo)	Mixed		Generalist
	Switcher		Target species changes trip to trip
	Swordfish		Targets swordfish
	Tuna		Targets Tuna
3-Boat size classes	≤ 48.0 ft		Only zero-take trips
	48.1-74.9 ft		Zero- and single-take trips
	> 74.9		Includes higher-take trips
2-Boat size classes	≤ 70.0 ft		Zero-take trips, some single-take trips
	> 70.0 ft		Includes higher-take trips
3-Latitude classes	≤ 17.2° N		Only zero-take trips
	17.3-28.7° N		Zero- and generally single-take trips
	> 28.7° N		Includes higher-take trips
2-Latitude classes	≤ 24.0° N		Zero- and single-take trips
	> 24.0° N		Includes higher-take trips
3-class crosses	≤ 48.0 ft	≤ 17.2° N	No trips monitored yet
	≤ 48.0 ft	17.3-28.7° N	Only zero-take trips
	≤ 48.0 ft	> 28.7° N	No trips monitored yet
	48.1-74.9 ft	≤ 17.2° N	Only zero-take trips
	48.1-74.9 ft	17.3-28.7° N	Zero- and single-take trips
	48.1-74.9 ft	> 28.7° N	Zero- and single-take trips
	> 74.9 ft	≤ 17.2° N	No trips monitored yet
	> 74.9 ft	17.3-28.7° N	Includes higher-take trips
	> 74.9 ft	> 28.7° N	Includes higher-take trips
2-class crosses	≤ 70.0 ft	≤ 24.0° N	Zero- and single-take trips
	≤ 70.0 ft	> 24.0° N	Only zero-take trips
	> 70.0 ft	≤ 24.0° N	Only zero-take trips
	> 70.0 ft	> 24.0° N	Includes higher-take trips

Table 2.--Coefficient of variation (CV), mean take rate per 1,000 hooks, and standard error of the mean take rate by stratification model. Observer data from February 1994 through December 1995 (97 trips).

Stratification model	CV take rate estimate (%)	Mean take rate/1,000 hooks	Standard error of mean take rate
Pilot design (status quo)	21	3.92×10^{-2}	8.21×10^{-3}
3-Boat size classes	19	3.69×10^{-2}	7.11×10^{-3}
2-Boat size classes	21	3.65×10^{-2}	7.50×10^{-3}
3-Latitude classes	19	5.24×10^{-2}	1.01×10^{-2}
2-Latitude classes	20	4.92×10^{-2}	9.98×10^{-3}
3-class crosses	18	4.43×10^{-2}	7.84×10^{-3}
2-class crosses	19	4.71×10^{-2}	7.25×10^{-3}

Table 3.--Average coverage and costs by strata and fielding strategies for the 2-boat size stratification design.

	Coverage			Cost		
Fielding strategy	<= 70 ft	> 70 ft	Total	<= 70 ft	> 70 ft	Total
1. Sampling in proportion to effort in trips (status quo)						
~4%	3.4%	5.9%	4.4%	$157,500	$182,000	$339,500
5%	3.9%	6.7%	5.0%	$180,906	$208,819	$389,725
10%	7.7%	13.5%	10.0%	$361,812	$417,638	$779,450
$250K	2.5%	4.3%	3.2%	$116,018	$133,982	$250,000
$350K	3.5%	6.0%	4.5%	$162,426	$187,574	$350,000
2. Sampling large boats only						
5% overall	0.0%	12.6%	5.0%	$0	$389,725	$389,725
~7% large	0.0%	6.7%	2.7%	$0	$208,819	$208,819
10% large	0.0%	10.0%	4.0%	$0	$310,450	$310,450
$250K large	0.0%	8.1%	3.2%	$0	$250,000	$250,000
$350K large	0.0%	11.3%	4.5%	$0	$350,000	$350,000
3. Sampling in proportion to take rate						
5% overall	0.7%	11.5%	5.0%	$30,755	$357,220	$389,725
10% overall	1.4%	23.0%	10.0%	$64,863	$712,837	$777,700
20% overall	2.8%	46.0%	20.0%	$129,872	$1,427,278	$1,557,150
$250K	0.4%	7.4%	3.2%	$20,851	$229,149	$250,000
$350K	0.6%	10.3%	4.5%	$29,191	$320,809	$350,000
4. Between status quo and sampling proportional to take rate						
5% overall	2.6%	7.2%	5.0%	$95,681	$292,294	$389,725
10% overall	5.2%	14.3%	10.0%	$194,425	$583,275	$777,700
$250K	1.7%	4.6%	3.2%	$62,500	$187,500	$250,000
$350K	2.3%	6.5%	4.5%	$87,500	$262,500	$350,000

Table 4.--Bootstrap estimates of the relative error of the total take estimates (at a 90% confidence level) and estimates of total costs by selected coverage rates for the small and large boat strata. Also shown are the total number of trips used in the computations, a breakdown of these for small and large boats, and the overall coverage rates.

		Small boat coverage					
Large boat coverage		~0% (2 trips)	1%	2%	5%	10%	20%
5%	Relative error	86%	68%	64%	62%	60%	59%
	Total cost	$168,000	$203,000	$245,000	$392,000	$623,000	$1,092,000
	Small trips	2	7	13	34	67	134
	Large trips	22	22	22	22	22	22
	Total trips	24	29	35	56	89	156
	Overall coverage	2%	3%	3%	5%	8%	1
10%	Relative error	77%	54%	50%	45%	44%	43%
	Total cost	$322,000	$357,000	$399,000	$546,000	$777,000	$1,246,000
	Small trips	2	7	13	67	134	178
	Large trips	44	44	44	44	44	440
	Total trips	46	51	57	78	111	178
	Overall coverage	4%	5%	5%	7%	10%	16%
20%	Relative error	76%	46%	39%	33%	32%	30%
	Total cost	$637,000	$672,000	$714,000	$861,000	$1,092,000	$1,561,000
	Small trips	2	7	13	34	67	134
	Large trips	89	89	89	89	89	89
	Total trips	91	96	102	123	156	223
	Overall coverage	8%	9%	9%	11%	14%	20%

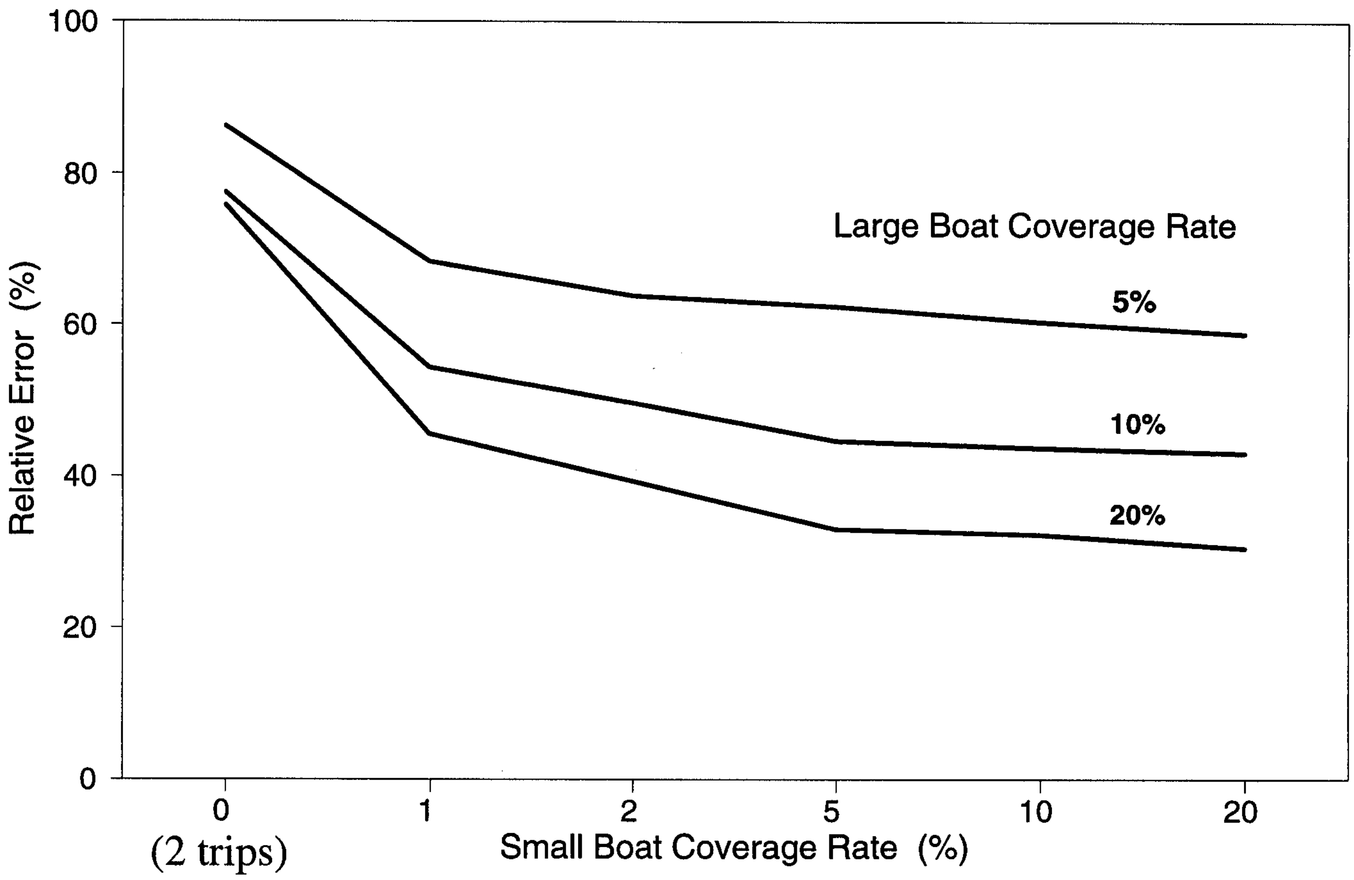

Figure 1.--Relative error of total take estimate at 90% confidence level given alternative coverage rates in the 2-boat size design observer program.

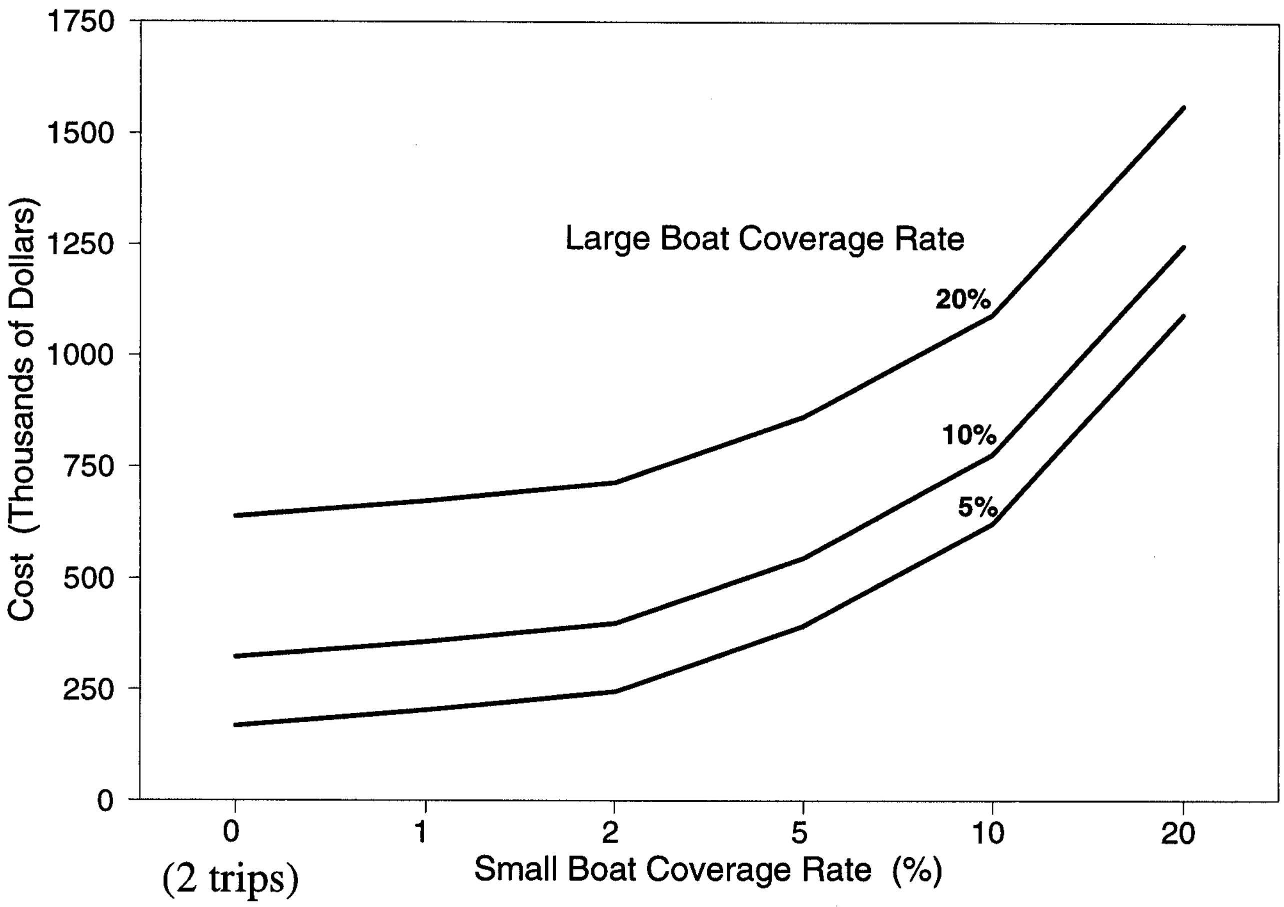

Figure 2.--Expected cost of the 2-boat size design observer program under alternative coverage rates.

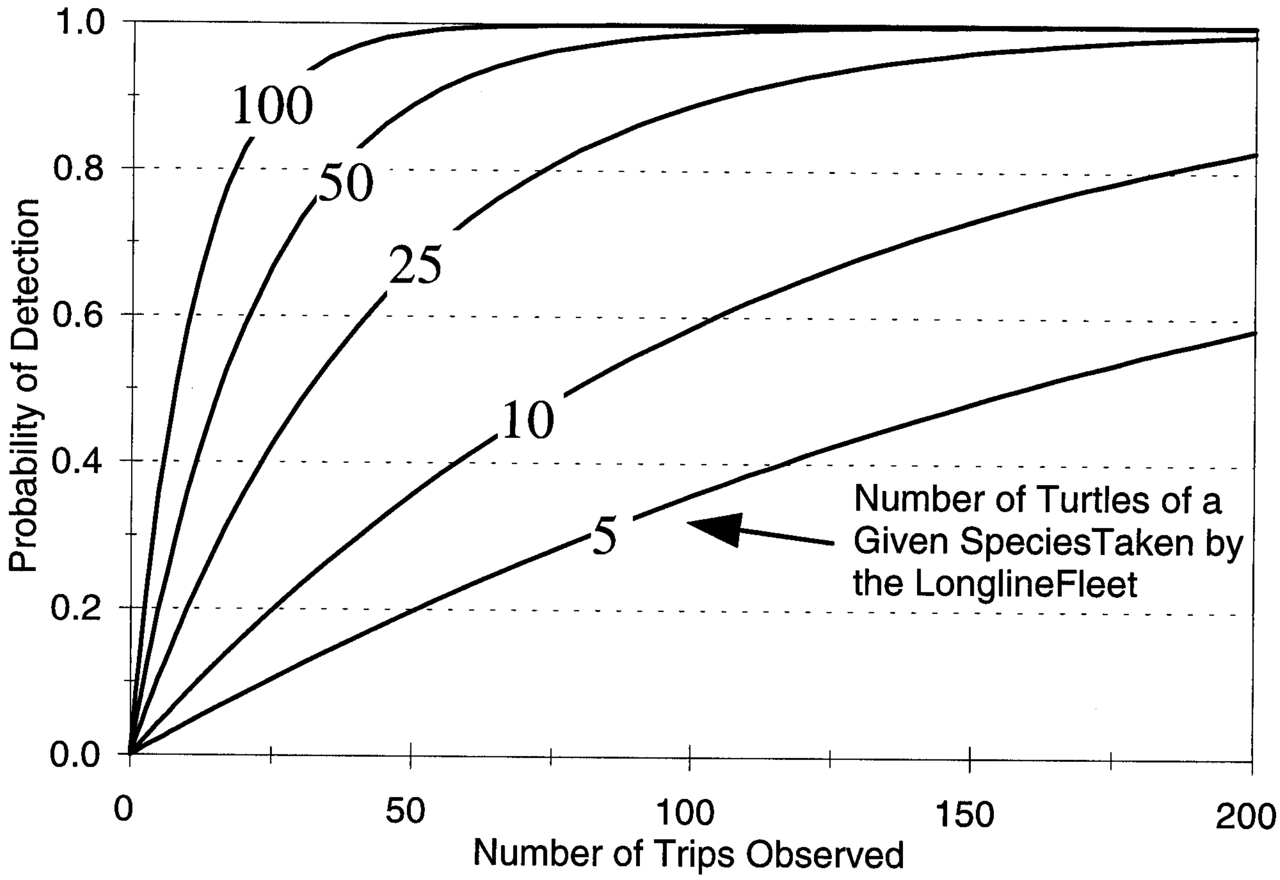

Figure 3.--Probability of detecting turtle interactions in the longline fishery (recording at least 1 turtle take in the observer program) given the observer effort and actual magnitude of take by the fleet. (assumes current level of total fleet effort)