



**SECTION 3**

***U.S. National  
Bycatch Report  
Methods***

Photo on previous page: An inside view of a fishing net's bycatch reduction device. Photo credit: NOAA.

## SECTION 3 U.S. National Bycatch Report Methods

### 3.1 Overview

This section describes the various processes developed during the preparation of the U.S. National Bycatch Report, including a system for evaluating data collection programs and estimation methods (the *tier classification system*); the identification of subsets of stocks (*key stocks*) and fisheries (*fisheries of focus*) based on levels of bycatch in relation to overall catch; and the development of fisheries bycatch estimation improvement plans. Two performance measures were derived from this process that will assist in monitoring improvements to bycatch estimates over time. First, the fisheries tier classification system will be used to monitor progress in bycatch data collection and estimation in fisheries recommended for improvements (i.e., advancing individual fisheries from lower to higher tiers over time). Second, the subset of key stocks will be used to monitor stock, population, and regional bycatch trends over time.

The tier classification system was used to evaluate the data collection programs and estimation methods for all fisheries included in this report. The classification system applied standardized criteria to evaluate bycatch data collection programs and analytical approaches used to estimate bycatch for each individual fishery. Fisheries were classified in one of five tiers (Tiers 0–4). Fisheries classified in lower tiers (Tiers 0–2) will require improvements in bycatch data collection and/or estimation methods, while fisheries classified in higher tiers (Tiers 3–4) are characterized by high-quality bycatch estimates. This process assumes that improvements in bycatch data collection programs and analytical approaches will translate into improvements in the reliability of bycatch estimates used in fisheries management. Section 3.2 provides further details on the tier classification system.

Bycatch estimates were provided for all fisheries in this report for which data and analytical methods supported estimation. Bycatch estimates were also provided for individual fish and marine mammal stocks, and sea turtle and seabird populations, where data were available. The bycatch estimates provided in this report are the best available information for federally managed commercial fisheries. However, in some cases they may be incomplete because bycatch data were not available for all fisheries where a given species is bycaught (e.g., state, international, tribal, or recreational fisheries). Fishery bycatch estimates were calculated as the sum of all bycatch within a particular fishery. Stock bycatch estimates were calculated as the sum of all bycatch of that stock across all fisheries where bycatch estimates were calculated (Figure 3.1). For simplicity, the term *stock* is used throughout this report in discussing estimates made at the population, species, or species group level.

Bycatch ratios were developed for both individual fish stocks (*stock bycatch ratio*) and individual fisheries (*fishery bycatch ratio*) to aid in the evaluation of bycatch levels (further described in sections 3.3.1.1 and 3.4, respectively). The ratio utilizes the basic calculation of bycatch divided by total catch (where total catch is calculated as bycatch plus landings). While other methods are available to calculate a bycatch ratio (e.g., bycatch/landings or a weighted average), utilizing total catch in the calculation is considered the standard approach (and is utilized in both comparative reports, Kelleher 2004 and Harrington et al. 2005). Bycatch ratios were not calculated for protected species since landings of protected species do not occur. The bycatch ratio is not a perfect measure of the contribution of bycatch to total mortality, because not all sources of mortality are accounted for and because not all discarded fish die. Often, the information necessary to correct for these two deficiencies was not available. For instance, a bycatch ratio was not calculated if either the bycatch or landings data were unavailable. Also, since this report did not include state, recreational, or international fisheries, both the bycatch and landings data for some fisheries may be incomplete.

*Key stocks* were identified based on the level of bycatch in relation to overall catch, the management importance of the stock/population, and overall stock status (see Section

	Fishery A	Fishery B	Fishery C	Total stock bycatch
Stock 1	1	0	0	1
Stock 2	1	2	0	3
Stock 3	2	5	3	10
Total fishery bycatch	4	7	3	

**Figure 3.1**

Bycatch estimates were calculated at both fishery and stock levels (sample values are included for illustration). The downward arrow illustrates how bycatch estimates were calculated by fishery (e.g., the total of all stocks caught within fishery A); the arrow pointing right illustrates how bycatch estimates were calculated by stock (e.g., the total amount of stocks 1–3 caught by all fisheries).

3.3 for further details). *Fisheries of focus* were identified as those having bycatch of key stocks or overall bycatch levels above a specified cutoff. All stocks and fisheries were further reviewed based on standardized qualitative criteria (described in Section 3.3.4 and Section 3.4.1, respectively) to address issues that were not explicitly included in the development of the bycatch estimates, such as public perception of a bycatch problem or lack of bycatch data.

*Fisheries bycatch estimation improvement plans* were developed for all fisheries of focus. All improvement plans were developed using a standard format, and address issues such as fishery tier, observer days at sea, feasibility, and management issues. Improvement plans may provide recommendations for implementing new or enhanced data collection programs and/or estimation methods, or may focus on the maintenance of current programs (see Section 3.4.2 for more information).

## 3.2 Tier Classification System

The tier classification system was developed to evaluate the quality of bycatch data and the reliability of estimation methods used to develop bycatch estimates for selected commercial fisheries. Appendix E lists the fisheries included in this report and identifies those evaluated through the tier process. Results of the tier classification process are presented by region and fishery in Section 4.

Some fisheries were grouped to reflect protected species bycatch estimation procedures (e.g., several types of gillnet might be grouped as “New England Gillnet Fisheries”). Grouped fisheries were evaluated as a whole for their data quality and methods for estimating protected species bycatch. So that those scores could be compared with tier scores for individual fisheries, the protected species tier score for each group was also assigned (“cascaded down”) to the individual fisheries in the group. It is important to stress, however, that in these cases (indicated in tables in this report by \*) the fisheries were evaluated and assigned tier scores as part of a group.

### 3.2.1 Criteria and Scores for Tier Classification System

The tier classification system assigned each fishery to one of five tiers (Tier 0 to Tier 4). Fisheries classified in Tier 0 typically had no bycatch data collection or estimation method, while fisheries classified in Tier 4 had reliable bycatch estimates based on long-term observer data. The tiers are described in Section 3.2.2. The tier classification process was carried out for three separate groups of marine species:

- all fish and invertebrate stocks managed under the MSA (“MSA fish stocks”)

- all marine mammal stocks (“marine mammals”)
- all other protected species: includes all ESA-listed fish, sea turtle, and seabird populations (“other protected species”)

These categories ensured that the tier classifications within each grouping reflect the data and methods used to estimate bycatch.

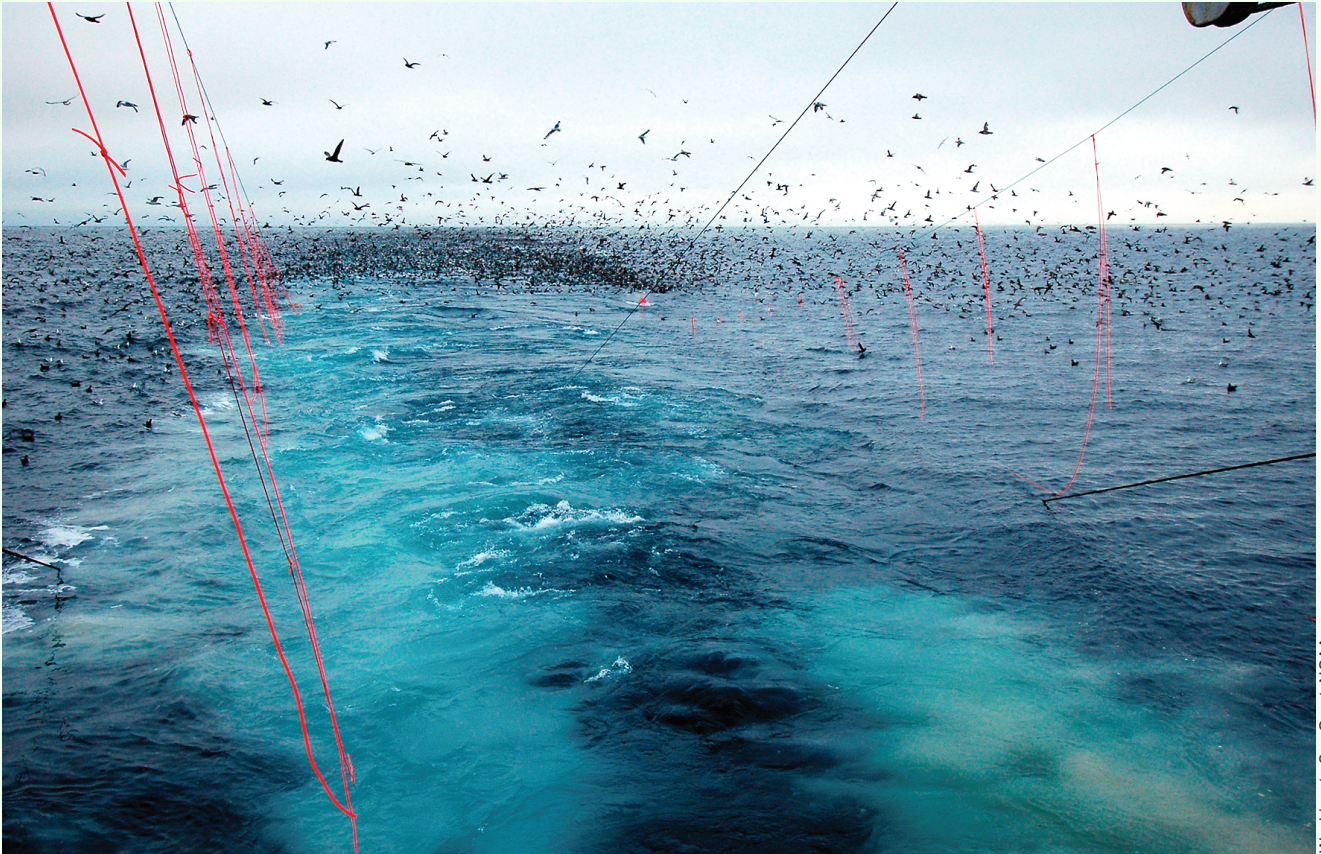
The criteria used in the tier classification system were developed through a national workshop with participation from all regional National Marine Fisheries Service (NMFS) Science Centers and Regional Offices, as well as Headquarters Offices. The initial design of the classification system was based on a similar system applied to the evaluation of fish stock assessments (NMFS 2001). The criteria were based on the critical components required to provide reliable and accurate bycatch estimates. The classification system was tested on several regional fisheries during the workshop to ensure that the scoring system worked for the full range of fisheries. A team of regional experts (Appendix F) applied the standardized criteria to score all fisheries within their regions. A second workshop was conducted to review the initial regional scores from a national perspective. Modifications and clarifications were made to the criteria to ensure consistency. The final submitted scores were reviewed by the National Observer Program and the National Bycatch Report Steering Committee (Appendix G) and discrepancies were reconciled with the relevant regional teams.

The major criteria used in the tier classification system (Table 3.1) were:

- 1) adequacy of bycatch data, which evaluated bycatch data collected through observer programs and self-reported industry logbooks;
- 2) availability of supplemental data used as extrapolation factors for unobserved components of the fishery, for stratification and imputation (a way of filling in missing data), as model covariates, and to verify self-reported industry data;
- 3) adequacy of database and information technology (IT) considerations (used to link data to generate timely bycatch estimates); and
- 4) quality of analytical approaches (bycatch estimation method assumptions, peer reviews, statistical bias of estimators, and development of uncertainty estimates).

The scoring system for each of these criteria was developed to provide higher scores for higher-quality bycatch data and for more robust and reliable estimation methods. The major criteria were also weighted to provide higher scores for those criteria that are more important to the development of reliable bycatch estimates; for example, observer bycatch data were weighted more heavily than self-reported industry bycatch data because they are more reliable.

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Washington Sea Grant, NOAA

Seabirds hover above the water near long, baited fishing lines deployed from the stern of a ship. The red streamers flap in the wind to discourage the birds from coming after the baited hooks.

The majority of the criteria used in the tier classification system were quantifiable. The longevity of observer programs, sampling design, availability of industry and supplemental data, peer review and/or publication of sampling design and analytical methods, and development of measures of uncertainty could all be evaluated and scored through the tier classification system in a systematic and standardized manner (Table 3.1). However, several of the criteria were more subjective, such as vessel-selection and observer bias, spatial and temporal coverage, database and IT considerations, and statistical bias of estimators. Guidance on the more subjective criteria was provided by the National Bycatch Report Steering Committee to ensure consistency in scoring among regions. Evaluations of vessel selection and observer bias were based on a formal review of bias in NMFS observer programs (Vølstad and Fogarty 2006). Spatial and temporal coverage levels were evaluated as either limited or synoptic based on the geographic and temporal

scope of the program. Limited observer programs were defined to be of a lesser geographic and temporal scope than the scope of the fishery. Database and IT considerations were evaluated in the context of linking observer data with supplemental data to facilitate timely generation of bycatch estimates. Biases associated with the estimators used in the analytical methods were evaluated based on measures of association, cross validation, and other factors. The guidance provided on these criteria was intended to ensure consistency; however, the evaluation and scoring were also based on the in-depth knowledge of the biologists and assessment scientists within each region.

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**Table 3.1**

Criteria and scoring used to evaluate bycatch data quality and estimation methods through the tier classification system. Details are provided in Appendix H.

TIER CLASSIFICATION CRITERIA	SCORES
<b>ADEQUACY OF BYCATCH DATA</b>	
<b>Observer Data</b>	<b>33 points total maximum score, broken down as:</b>
<b>Longevity of Observer Data</b>	
0 = No observer program has ever been implemented.	5 points
1 = Observer program was conducted prior to 1995.	
2 = Observer program was conducted on one or more occasions during 1995–2000, but not annually.	
3 = Observer program was conducted annually during 1995–2000 and not subsequently.	
4 = Observer program was conducted on one or more occasions from 2001 to present, but not annually.	
5 = Observer program has been conducted annually from 2001 to present.	
<b>Sampling Frame</b>	
0 = No sampling frame	3 points
2 = Partial sampling frame	
3 = Complete sampling frame	
<b>Sampling Design</b>	
Sampling of Vessels/Permits/ Licenses	
0 = No observer program, or sampling design does not support bycatch or total catch estimation.	4 points
1 = Opportunistic or haphazard sampling, including voluntary observer programs, to support bycatch or total catch estimation.	
2 = Random sampling scheme or probability-based sampling with moderate observer coverage levels to support bycatch or total catch estimation.	
3 = Random sampling scheme or probability sampling with adequate observer coverage levels to support bycatch or total catch estimation.	
4 = Near-census of vessels with estimation required, or census of vessels with no estimation required.	
Sampling of Trips	
0 = No observer program, or sampling design does not support bycatch or total catch estimation.	4 points
1 = Opportunistic or haphazard sampling, including voluntary observer programs, to support bycatch or total catch estimation.	
2 = Random sampling scheme or probability-based sampling with pilot/baseline observer coverage levels to support bycatch or total catch estimation.	
3 = Random sampling scheme or probability sampling with adequate observer coverage levels to support bycatch or total catch estimation.	
4 = Near-census of trips with estimation required, or census of trips with no estimation required.	
Sampling of Hauls	
0 = No observer program, or sampling design does not support bycatch or total catch estimation.	4 points
1 = Opportunistic or haphazard sampling, including voluntary observer programs, to support bycatch or total catch estimation.	
2 = Random sampling scheme or probability-based sampling to support bycatch or total catch estimation.	
3 = Near-census of hauls with estimation required.	
4 = Census of hauls with no estimation required.	
<b>Design Implementation</b>	
Spatial Coverage	
Add 0 points if no observer program has ever been implemented.	2 points
Add 1 point if spatial coverage is limited.	
Add 2 points if spatial coverage is synoptic.	

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Table 3.1 (continued)

TIER CLASSIFICATION CRITERIA	SCORES
<b>ADEQUACY OF BYCATCH DATA</b>	
<b>Observer Data (cont.)</b>	<b>33 points total maximum score, broken down as:</b>
Temporal Coverage	2 points
Add 0 points if no observer program has ever been implemented.	
Add 1 point if temporal coverage is limited. Add 2 points if temporal coverage is synoptic.	
Vessel-Selection Bias	2 points
Add 0 points if vessel-selection bias is high or unknown Add 2 points if vessel-selection bias is negligible or no bias exists.	
Observer Bias	2 points
Add 0 points if observer bias is high or unknown. Add 2 points if observer bias is negligible or no bias exists.	
<b>Data Quality Control</b>	
0 = No observer program, or no data quality control.	5 points
1 = Limited or incomplete observer training, no debriefing or other quality control.	
2 = One-time observer training, no debriefing or other quality-control measures.	
3 = Periodic observer training, minimal quality-control measures.	
4 = One time observer training, comprehensive quality-control measures. 5 = Periodic observer training, comprehensive quality-control measures.	
<b>Industry Bycatch Data</b>	<b>2 points total maximum score, broken down as:</b>
0 = No industry bycatch data are available, or industry bycatch data are not used as a basis for bycatch estimates.	2 points
1 = Industry bycatch data available prior to 2000 are used as a basis for bycatch estimates.	
2 = Industry bycatch data available from 2000 to present are used as a basis for bycatch estimates.	
<b>Supplemental Data</b>	<b>10 points total maximum score, broken down as:</b>
<b>Data available for use as expansion factors for unobserved components of the fishery.</b>	
Add 0 points if supplemental data are not available as expansion factors.	2 points
Add 1 point if limited supplemental data are available as expansion factors.	
Add 2 points if extensive supplemental data are available or data are not necessary as expansion factors.	
<b>Data available for stratification.</b>	
Add 0 points if supplemental data are not available for stratification.	2 points
Add 1 point if limited supplemental data are available for stratification.	
Add 2 points if extensive supplemental data are available or data are not necessary for stratification.	
<b>Data available for imputation.</b>	
Add 0 points if supplemental data are not available for imputation.	2 points
Add 1 point if limited supplemental data are available for imputation.	
Add 2 points if extensive supplemental data are available or data are not necessary for imputation.	
<b>Data available for model covariates.</b>	
Add 0 points if supplemental data are not available for model covariates.	2 points
Add 1 point if limited supplemental data are available for model covariates.	
Add 2 points if extensive supplemental data are available or data are not necessary for model covariates.	

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Table 3.1 (continued)

TIER CLASSIFICATION CRITERIA	SCORES
<b>ADEQUACY OF BYCATCH DATA</b>	
<b>Supplemental Data (cont.)</b>	<b>10 points total maximum score, broken down as:</b>
<b>Industry data verified.</b>	
Add 0 points if industry data are not verified or no industry data are available.	2 points
Add 1 point if some relevant industry data are verified.	
Add 2 points if all relevant industry data are verified.	
<b>Database / IT Considerations</b>	<b>2 points total maximum score, broken down as:</b>
0 = No observer data and/or supplemental data are available.	2 points
1 = Analytical approach is constrained because of database/IT considerations.	
3 = Analytical approach is not constrained because of database/IT considerations.	
<b>QUALITY OF THE BYCATCH ESTIMATE</b>	
<b>Analytical Approach</b>	<b>25 points total maximum score, broken down as:</b>
<b>Assumptions Identified, Tested, and Appropriate</b>	
0 = No bycatch estimation methodologies.	10 points
1 = Assumptions not identified or tested.	
3 = Assumptions identified and tested, but no assumptions have been resolved.	
5 = Minor assumptions identified, tested, and determined to be appropriate or resolved.	
8 = Critical assumptions identified, tested, and determined to be appropriate or resolved.	
10 = All assumptions identified, tested, and determined to be appropriate or resolved.	
<b>Peer Reviewed / Published</b>	
Observer Program Sampling Design	4 points
Add 0 points if the observer program sampling design has not been peer reviewed, or if the sampling design is found to be seriously flawed during peer review.	
Add 2 points if the observer program sampling design has been internally peer reviewed, or if problems were found during a peer review but they have not been fully addressed. Add 4 points if the observer program design has been externally peer reviewed.	
Analytical Approach	4 points
Add 0 points if the analytical approach has not been peer reviewed, or if the analytical approach is found to be seriously flawed during peer review	
Add 2 points if the analytical approach has been internally peer reviewed, or if problems were found during a peer review but they have not been fully addressed. Add 4 points if the analytical approach has been externally peer reviewed.	
<b>Statistical Bias of Estimators</b>	
0 = No bycatch estimation methodologies, or statistical bias is unknown.	4 points
2 = Estimators have high statistical bias.	
4 = Estimators have negligible statistical bias or are not statistically biased, or census sampling.	
<b>Measures of Uncertainty</b>	
0 = No bycatch estimation methodologies.	4 points
1 = Measures of uncertainty are not calculated.	
2 = Measures of uncertainty are calculated, but not at all levels (vessel/permit/license, trip, and haul).	
3 = Measures of uncertainty are calculated at all levels (vessel/permit/license, trip, and haul).	



### 3.2.2 General Description of Tiers

The following provides a general description of the five tiers used to classify fisheries for each of the three stock or population groups. Tier descriptions were based on quality of bycatch and supplemental data and the reliability of the methods used to estimate bycatch.

**Tier 0 (total score = 0).** Bycatch data collection programs have not been implemented for Tier 0 fisheries; therefore, neither a method for estimating bycatch nor estimates of bycatch are available.

**Tier 1 (total score = 1–31).** The bycatch estimates calculated for Tier 1 fisheries were typically based on outdated or unreliable information. Observer data were not available, or had not been collected during the last ten years, or serious deficiencies or limitations in the design of the observer program were identified. Design deficiencies for Tier 1 fisheries with observer programs may include the lack of a complete sampling frame; inadequate temporal or spatial coverage; or opportunistic selection of vessels, trips, or hauls. Bias associated with vessel selection or observer sampling may be high or unknown in Tier 1 observer programs, and bycatch data quality-control systems were generally absent or inadequate. Self-reported data were used in place of or to supplement observer program data in approximately 50% of Tier 1 fisheries for which bycatch estimates were available. In other Tier 1 fisheries, supplemental data were unavailable or inadequate.

The majority of Tier 1 fisheries did not utilize analytical approaches for the calculation of bycatch estimates, or employed methods with outstanding issues which should be resolved. Where analytical approaches were implemented to estimate bycatch, they had generally not been peer reviewed, or had been reviewed only internally. For the majority of Tier 1 fisheries with bycatch estimates, assumptions in the analytical approach had been identified and tested, and some minor assumptions may have been resolved. Of the Tier 1 fisheries with an analytical approach, about half had high statistical bias. Measures of uncertainty were calculated for the majority of bycatch estimates, but typically those measures did not recognize uncertainty for all levels (vessel, trip, and haul). A few fisheries in Tier 1 did not have estimates of uncertainty associated with their bycatch estimates.

**Tier 2 (total score = 32–48).** Bycatch estimates calculated for Tier 2 fisheries were typically based on inconsistent or unreliable information. Bycatch data for the majority of these fisheries were derived from self-reported logbooks. Current or recent observer data were available for some of these fisheries. In those fisheries with observer programs, sampling frames were usually partial or complete but sampling designs were inadequate. Sampling at all levels (vessel, trip, and haul) may have been inadequate or inconsistent,

with approaches ranging between opportunistic and census. Spatial or temporal coverage in the observer programs may have been limited or synoptic, and programs were often characterized by high or unknown levels of vessel selection and observer bias. Observer training, with an emphasis on data quality, occurred in the majority of observed Tier 2 fisheries. However, data quality control may have been lacking or absent. Supplemental data availability in Tier 2 fisheries varied in quality and scope; some supplemental data were available for most, but not all of these fisheries.

Analytical approaches to developing bycatch estimates in Tier 2 fisheries were generally deficient in several aspects. Methods employed in about half of those Tier 2 fisheries for which bycatch levels were estimated had not been peer reviewed, while the remainder had been peer reviewed internally or externally. In many cases, the analytical approach was constrained by database or other computational considerations (e.g., logbook and observer databases not linked). In most cases, assumptions were identified and tested, but problems with the assumptions were not resolved. Measures of uncertainty were calculated for the majority of the bycatch estimates, although they may not have accounted for uncertainty at all levels in the process (vessel, trip, and haul). For a small number of Tier 2 fisheries, bycatch estimates were available without measures of uncertainty, or were not available at all.

**Tier 3 (total score = 49–65).** Observer program data collection had occurred in 2001–2005 in the majority of Tier 3 fisheries, although not necessarily on an annual basis. Only older observer data were available for some fisheries in this tier, and observer data were not available at all in a few instances. Where observer data were available, sampling frames were either partial or complete. However, sampling designs varied markedly. While the majority of the sampling designs included either random or probability-based sampling with moderate observer coverage at all sampling levels, opportunistic and census or near-census sampling designs were also found. Sampling designs had been externally peer reviewed and determined to be appropriate for most Tier 3 fishery observer programs. Spatial and temporal coverage of observer programs was often limited or synoptic, and in most cases there was little to no vessel-selection or observer bias. For most Tier 3 fisheries, supplemental data were extensive or not required by the bycatch estimation process, although self-reported bycatch data were available in many cases. Data quality-control systems in Tier 3 fisheries varied, ranging from minimal observer training and data quality control to frequent training and comprehensive data quality controls.

The bycatch estimates calculated for Tier 3 fisheries were based on reliable observer program information or recent logbook data. Overall, the analytical approach for Tier 3 fisheries was typically robust and had been peer reviewed (internally or externally), but some analytical concerns

might remain. Analytical assumptions were identified, tested, and, in most cases, any problems with the assumptions had been resolved. Although estimators employed in the majority of analytical approaches had little to no statistical bias, high statistical bias did occur in some cases. Bycatch estimates typically included associated measures of uncertainty, although these measures may not have incorporated uncertainty associated with all levels in the sampling and estimation process (vessel, trip, and haul).

**Tier 4 (total score = 66–73).** Bycatch estimates were calculated for all Tier 4 fisheries. These estimates were based on reliable observer program data collected on an annual basis for at least the past five years. Design deficiencies in these programs were negligible or nonexistent. Sampling frames were partial or complete. Although a variety of sampling schemes was utilized, in all cases observer coverage was adequate at the vessel, trip, and haul sampling levels. In Tier 4 fisheries, sampling designs were externally peer reviewed and determined to be appropriate. Spatial and temporal coverage in the observer programs was synoptic, and vessel-selection and observer bias were negligible or absent. Appropriate supplemental data were available to extrapolate the observed bycatch to total fishery bycatch where not all fishing activities were observed. Comprehensive data-quality controls were in place, and integrated databases for the various data sources facilitated analytical procedures in most cases.

The analytical approaches used to estimate bycatch in Tier 4 fisheries were considered to be appropriate and defensible. In addition to being externally peer reviewed, all or at least the critical assumptions of the analytical methods had been addressed and determined to be acceptable. Statistical bias was negligible or absent in the estimators, and measures of uncertainty were calculated for the majority of bycatch estimates (though not necessarily incorporating the uncertainty associated with all levels of the process).

### 3.2.3 Application of the Tier Classification System

Scores derived from the tier classification system provided a method to evaluate bycatch data quality in relation to the reliability of bycatch estimates (Figure 3.2). A maximum score of 48 points was possible for bycatch data quality: the sum of Adequacy of Observer Bycatch Data + Adequacy of Industry Bycatch Data + Supplemental Data + Database / IT Considerations (Table 3.1). A maximum of 25 points was possible for the reliability of the bycatch estimation method (total score for Analytical Approach; Table 3.1). Scores for all three groups (MSA fish stocks, marine mammals, and other protected species) were included in the analysis. Fisheries classified as Tier 0 had no bycatch data and no bycatch estimation methods; therefore, the scores for both these criteria were zero. Due to the variations of scoring combinations that can occur when applying these criteria to

individual fisheries, the range of overall scores for fisheries in Tier 1 through Tier 3 is broad. However, there is a general increasing trend in the reliability of the bycatch estimates as quality of the bycatch data improves (Figure 3.2).

To further illustrate the application of the tier classification system, and to show the range of possible tier scores, the cases of five individual regional fisheries are presented in Table 3.2. The examples provide information related to fish stocks only, but the application of the method was similar for the other resource categories (marine mammals and other protected species).

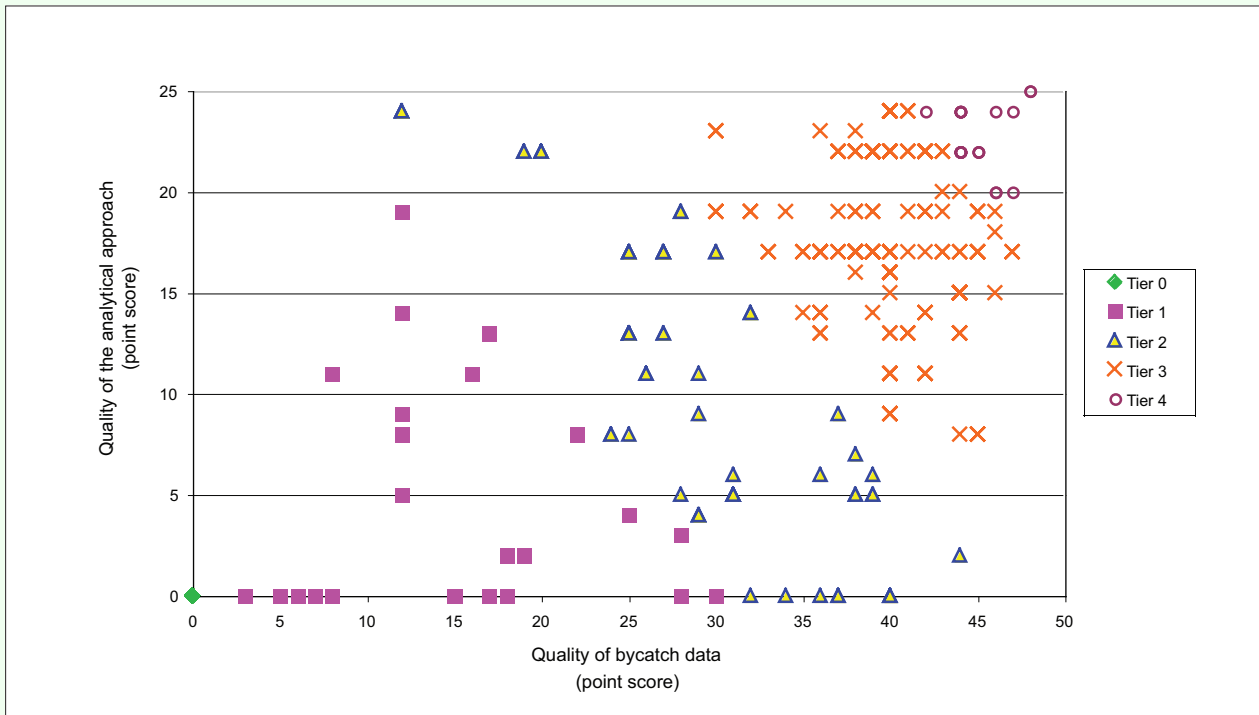
The California herring gillnet fishery (column 3 in Table 3.2) did not have any bycatch data collection programs or bycatch estimation methods. Therefore, this fishery scored zero for all criteria, which resulted in classification in Tier 0. The South Atlantic snapper–grouper handline fishery (column 4 in Table 3.2) has bycatch estimates developed from logbook data. However, given the lack of observer data, the overall score for this fishery was low—only 19. This resulted in classification in Tier 1.

The West Coast groundfish non-endorsed fixed gear fishery (column 5 in Table 3.2) has a recent long-term observer program and a self-reported industry program for the collection of bycatch data. However, the observer program does not have a sampling frame and the sampling design has problems with spatial and temporal coverage and bias associated with vessel selection. The methods for estimating bycatch in this fishery are not fully developed, which resulted in a lower score for analytical approach (4 out of a maximum of 25). Therefore, the overall score for this fishery was 33, resulting in placement in Tier 2.

The mid-Atlantic extra-large-mesh gillnet fishery (column 6 in Table 3.2) has a long-term observer program and a self-reporting program for collection of bycatch data. Supplemental data are available and the analytical approach received a high score. This fishery was classified as Tier 3, with an overall score of 62. However, the cutoff score between a Tier 3 and a Tier 4 fishery is 66. Therefore, only slight modifications would be required to move this fishery into Tier 4. This example illustrates the need to evaluate the overall score for each fishery, rather than simply relying on its placement in a certain tier.

The Bering Sea/Aleutian Islands pollock trawl fishery (column 7 in Table 3.2) has scores similar to the mid-Atlantic extra-large-mesh gillnet fishery, with a slightly higher overall score of 67. This fishery was classified in Tier 4.

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**Figure 3.2**  
Quality of bycatch data and estimation method, and resulting tier classifications of fisheries included in the U.S. National Bycatch Report ( $n = 400$ ).



Photo credit: Lee Beneka, NMFS

Skate bycatch off New England.

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**Table 3.2**

Tier classification of fisheries on the basis of scores for bycatch data collection and estimation, illustrated for five selected fisheries. The examples provide tier scores for fish bycatch estimates only.

Scoring criteria	Maximum possible points	California herring gillnet	South Atlantic handline	West Coast groundfish non-endorsed fixed gear	Mid-Atlantic extra-large-mesh gillnet	Bering Sea/ Aleutian Islands pollock trawl
<b>Adequacy of Observer Bycatch Data</b>						
Longevity of observer program	5	0	0	5	5	5
Sampling frame	3	0	0	0	2	3
Sampling design						
Vessels / Permits / Licenses	4	0	0	1	2	4
Trips	4	0	0	3	2	4
Hauls	4	0	0	3	3	3
Design implementation						
Spatial coverage	2	0	0	1	2	2
Temporal coverage	2	0	0	2	1	2
Vessel-selection bias	2	0	0	0	2	2
Observer bias	2	0	0	0	2	2
Data-quality control	5	0	0	5	5	5
SECTION TOTAL	33	0	0	20	26	32
<b>Adequacy of Industry Bycatch Data</b>						
SECTION TOTAL	2	0	2	2	2	2
<b>Supplemental Data</b>						
Extrapolation factors for unobserved components of the fishery	2	0	1	2	2	2
Stratification	2	0	1	1	2	2
Imputation	2	0	1	1	2	2
Model covariates	2	0	1	1	2	2
Industry data verification	2	0	1	1	1	2
SECTION TOTAL	10	0	5	6	9	10
<b>Database / IT Considerations</b>						
SECTION TOTAL	3	0	1	1	3	3
<b>Analytical Approach</b>						
Assumptions	10	0	5	3	8	8
Peer review / Publication						
Observer program sampling design	4	0	2	0	4	4
Analytical approach	4	0	2	0	4	4
Statistical bias of estimators	4	0	2	0	4	3
Measures of uncertainty	3	0	2	1	2	1
SECTION TOTAL	25	0	11	4	22	20
OVERALL SCORE	73	0	19	33	62	67
TIER	4	0	1	2	3	4

### 3.3 Identification of Key Stocks

Bycatch estimates for individual fish stocks and marine mammal, sea turtle, and seabird populations were calculated for all fisheries where bycatch data and estimation methods were available. Standardized criteria were applied to all stocks with bycatch estimates to identify key stocks: those stocks that have high bycatch levels, are important to management, and/or for which there are stock status concerns. Bycatch of key stocks was used as one of the triggers to identify fisheries of focus (discussed in Section 3.4). Bycatch estimates from these key stocks will also be used to monitor stock, population, and regional bycatch trends over time.

The identification of key stocks was based on three criteria (details in Table 3.3 and Figure 3.3):

- bycatch level of the stock
- management importance of stock or population
- overall stock or population status

The criteria for evaluating management importance and overall stock or population status are partially linked, in particular for marine mammals. However, it was necessary to evaluate both criteria, since a fish stock may be important to management but not be overfished or experiencing overfishing. In this case, the stock would not be identified as a key stock even though it is important to management.

These three criteria were evaluated separately for MSA fish stocks, marine mammal stocks, seabird populations, and ESA populations. The initial process was based on a quantitative evaluation of stock or population bycatch estimates. Since bycatch estimates were not available for all stocks or populations, a qualitative process was also developed to help determine whether stocks or populations should be classified as key stocks. This was necessary since stocks that do not have bycatch estimates may still be of bycatch concern.

#### 3.3.1 Evaluation of Stock Bycatch Level and Stock Bycatch Ratio

Bycatch estimates were evaluated using standardized criteria to identify whether a potential bycatch concern existed. Separate sets of criteria were developed for ESA populations, marine mammals, seabirds, and fish stocks.

ESA populations—all were designated as key stocks, regardless of bycatch levels.

Marine mammals—stocks for which the calculated bycatch level exceeded the zero mortality rate goal (ZMRG) (At this level the rate of incidental mortality and serious injury incidental to fishing is estimated to be insignificant, i.e. approaches a zero serious injury and mortality rate).

**Table 3.3**  
Sources of criteria for identifying key stocks.

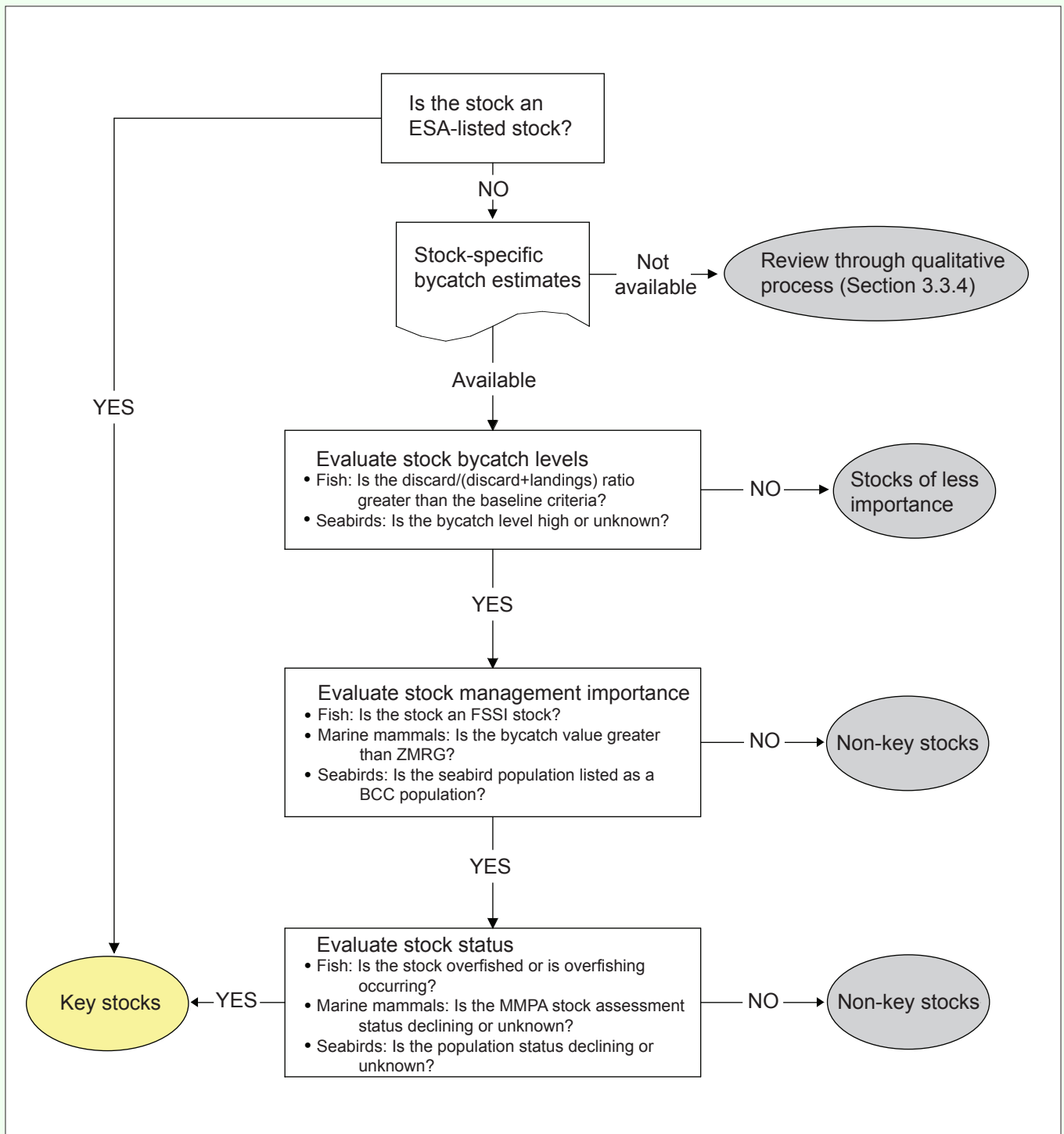
Stock/population	Evaluation of potential bycatch problems	Evaluation of management importance	Evaluation of stock/population status
ESA populations	All ESA populations are designated as key stocks		
MSA fish stocks	Ratio of discards to (discards + landings)	FSSI-listed species (Y/N) <sup>a</sup>	FSSI stock status <sup>a</sup>
Marine mammal stocks	Bycatch level greater than ZMRG <sup>b</sup>	ZMRG <sup>b</sup>	Marine mammal stock assessment stock status determinations
Seabird populations	Based on information provided by USFWS <sup>c</sup>	USFWS BCC <sup>c</sup> list	Based on information provided by USFWS <sup>c</sup>

<sup>a</sup> The Fish Stock Sustainability Index (FSSI) identifies high priority stocks for management purposes. See <http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm>.

<sup>b</sup> Zero mortality-rate goal (ZMRG) is the common term for the “insignificance threshold,” defined as 10% of a stock’s potential biological removal level. See <http://www.nmfs.noaa.gov/pr/interactions/zmrng>.

<sup>c</sup> The U.S. Fish and Wildlife Service (USFWS) Birds of Conservation Concern (BCC) list identifies seabird species of management importance; the BCC list from 2002 (USFWS 2002) was used in this edition of the U.S. National Bycatch Report. See <http://www.fws.gov/migratorybirds/>.

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**Figure 3.3**  
Quantitative process used to identify key stocks.

**Seabirds** – stocks identified by USFWS and NMFS scientists, based on documented interactions, research, and whether the population status was declining (yes, no, or unknown).

**MSA fish stocks** – stocks for which the ratio of fish discards to total fish catch (fish discards + fish landings) was above a certain level. See Section 3.3.1.1 for details on development of the cutoff point.

### Stock Bycatch Ratios

Bycatch ratios were developed for fish stocks as  $d_s / (l_s + d_s)$  where  $d_s$  is the estimate of total bycatch of stock  $s$  in a given region and  $l_s$  is the estimate of total landings<sup>1</sup> of stock  $s$  in that region, where estimates of both discards and landings were available. Landings used to develop the stock bycatch ratio were obtained from the NMFS commercial landings database, in order to maintain a standard reference for commercial catch data included in this report.<sup>2</sup> Landings were associated with bycatch data based on NMFS region, stock names, and data years used in estimating bycatch (2005, except in the case of some rare-event species for which multiple years of data were used). This ratio was used because it provides a measure of the contribution of fish bycatch to the total fishing mortality of a stock.

The stock bycatch ratios are presented in a summary table at the end of each regional section (Section 4). A frequency analysis of all stock bycatch ratios was conducted to select the cutoff for determining whether to consider designating a stock as a key stock (Figure 3.4). The median of the frequency distribution (0.127) was selected as the cutoff point. All fish stocks with bycatch ratios greater than 0.127 were advanced to the next stage for consideration as key stocks (i.e., evaluation of importance to management).

For example, if the estimated bycatch for a stock was 50,000 lbs and total catch was 550,000 lbs, then the bycatch ratio was 0.09. Since this is less than the cutoff of 0.127, the stock was not further considered for key stock status. For this stock, improving the estimate of bycatch would have a minor effect on the estimate of total fishing mortality. Conversely, if the bycatch estimate for a stock was 400,000 lbs and total catch was 900,000 lbs, then the bycatch ratio was 0.44. This stock would move to the next step in the process, evaluation of stock status, since the bycatch ratio of 0.44 was higher than the cutoff of 0.127.

### 3.3.2 Evaluation of Management Importance

Management importance was evaluated for each category

<sup>1</sup> Landed catch data used to develop a stock bycatch ratio represented commercial catch sold (i.e., not for personal use, etc.).

<sup>2</sup> <http://www.st.nmfs.noaa.gov/st1/commercial>

of marine resource, based on standardized criteria. Separate sets of criteria were used for marine mammals, seabirds, and fish stocks.

**MSA fish stocks**—The Fish Stock Sustainability Index (FSSI) was used as the criterion for evaluating management importance of MSA fish stocks. The FSSI is based on a set of 230 priority fish stocks selected for their importance to commercial and recreational fisheries. Criteria for selection of FSSI stocks include whether they are primary target species (landings greater than 200,000 pounds), whether they are overfished or subject to overfishing, whether they have assessments scheduled, whether they have previously been identified as important to management, or other factors as appropriate. These FSSI stocks represent about 90% of all commercial and recreational landings in the U.S. The process used in this edition of the report was based on the first quarter 2008 FSSI list of stocks, which was the most recent information available when the report was developed.

**Marine mammal stocks**—Marine mammal stocks of management importance were identified based on whether the bycatch levels were greater than ZMRG.<sup>3</sup> This criterion is the same as that used to evaluate bycatch level, so it was applied once in the process to evaluate both bycatch level and management importance.

**Seabird populations**—Seabird populations of management importance were those identified on the USFWS BCC list (USFWS 2002).

### 3.3.3 Evaluation of Stock or Population Status

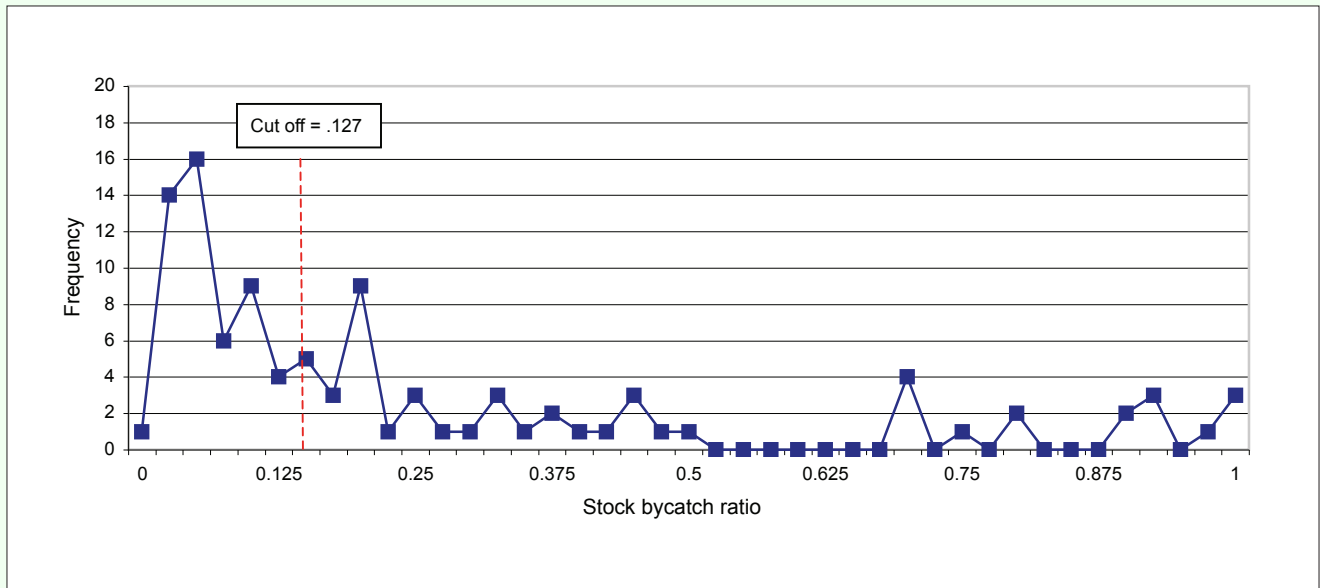
Stock or population status was evaluated for each category of marine resource based on standardized criteria. Separate criteria were used for marine mammals, seabirds, and fish stocks. The evaluation of stock or population status was partially linked to the evaluation of management importance, in that management of stocks or populations with declining stock status may benefit from improved bycatch estimates.

**MSA fish**—Stock status for MSA fish stocks was determined from the first quarter 2008 FSSI stock list. Stock status was categorized according to overfished status (yes, no, unknown, undefined) and whether overfishing was occurring (yes, no, unknown, undefined).

→If the stock was overfished or overfishing was occurring as of the first quarter 2008, the stock was identified as a key stock.

<sup>3</sup> Under the MMPA, NMFS is directed to reduce bycatch below ZMRG, therefore stocks with bycatch levels greater than ZMRG are considered a management priority.

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**Figure 3.4**

Distribution of stock bycatch ratios (ratios of fish discards to total catch) for all fish bycatch estimates included in the U.S. National Bycatch Report ( $n = 102$ ). The red dotted line indicates the median of the frequency distribution, above which a stock was further considered for designation as a key stock.

**Marine mammals**—Stock status for marine mammals was determined from current marine mammal stock assessments.<sup>4</sup> Stock status was categorized as declining, stable, increasing, or unknown.

→If the stock status was declining or unknown, the stock was identified as a key stock.

**Seabirds**—Population status for seabird populations was determined in consultation with the USFWS. Population status was categorized as declining, stable, increasing, or unknown.

→If the stock status was declining or unknown, the stock was identified as a key stock.

### 3.3.4 Qualitative Evaluation of Key Stocks

Regardless of whether individual stocks or populations were classified as key stocks through this process, they

<sup>4</sup> In this report, the most recent marine mammal stock assessment report as of 2007 was used to evaluate stock status for marine mammals. NMFS marine mammal stock assessments are posted at <http://www.nmfs.noaa.gov/pr/sars/>.

were also evaluated against a set of standardized criteria that took into account an additional range of considerations. This qualitative process was important since many stocks and populations included in this report do not have bycatch estimates (i.e., these stocks would have automatically been classified as non-key stocks). Possible factors that could be considered as part of the qualitative process included:

- The FSSI stock status was used to identify fish stocks that were not overfished but were close to the threshold. These fish stocks were considered for addition to the list of key stocks since they had the potential to become overfished.
- Fish stocks that were not overfished but had a high bycatch ratio were considered for addition to the list of key stocks.
- Biological concerns, such as localized overfishing/overfished stocks, fish stocks important as prey species, recent declines in abundance trend, restrictions in geographic range of distribution, and other ecological issues, were considered even for fish stocks that were not overfished or experiencing overfishing, and for protected species with low known bycatch levels. These stocks were considered for addition to the list of key stocks.
- Biological opinions pursuant to ESA Section 7 may re-



quire monitoring of a more abundant species as a proxy for species rarely caught in commercial or recreational fisheries. These proxy species were considered for addition to the list of key stocks.

- Regional consistency was ensured by evaluating the list of key stocks for adjacent regions. If a stock was distributed across adjacent regions (e.g., Gulf of Mexico and South Atlantic) or regional boundaries (e.g., Northeast and Southeast NMFS regions), the stock was considered for listing as a key stock in both areas.
- Any stock for which there were concerns regarding public perception and/or high visibility of a bycatch problem was considered for addition to the list of key stocks.

All changes based on the qualitative process, as well as the reasoning behind decisions to either add or remove stocks from the list of key stocks, are summarized in the regional sections. This information was reviewed by the National Observer Program and the National Bycatch Steering Committee to ensure consistency in application of these criteria across regions.

### 3.4 Identifying Fisheries of Focus

A fishery of focus is a fishery that takes one or more key stocks as bycatch, and/or has high total levels of fish bycatch. Fisheries for which bycatch estimates were available were initially evaluated through a quantitative process to determine the overall fishery bycatch ratio and/or determine whether key stocks were taken as bycatch within the fishery (Figure 3.5). Note that the fishery bycatch ratio is different from the stock bycatch ratio (discussed above), in that the formula used to develop a fishery bycatch ratio was  $d_f / (l_f + d_f)$  where  $d_f$  represents the total fish bycatch of fishery  $f$ , and  $l_f$  represents the total landings of fishery  $f$ . The fishery landings data were obtained from previously published data used by NMFS regions to manage fisheries. In the majority of cases, it was possible to calculate fishery bycatch ratios. However, in some fisheries, some or all of the fish bycatch estimates were available only as numbers of fish; because associated landings were provided only as weights, it was not possible to calculate a fishery bycatch ratio. Confidentiality provisions also precluded calculation of fishery bycatch ratios in some instances. These instances are noted in the regional sections.

A frequency analysis of all fishery bycatch ratios was generated to determine the cut-off value for determining whether to designate a fishery as a fishery of focus (Figure 3.6). The median of the frequency distribution (0.17) was chosen as the cutoff. Fisheries with bycatch ratios greater than 0.17 were identified as fisheries of focus.

#### 3.4.1 Qualitative Evaluation of Fisheries of Focus

Regardless of whether a fishery was identified as a fishery of focus through the quantitative process, all fisheries included in this report were also evaluated against a set of standardized criteria, that took into account a range of additional considerations. This qualitative process was important since bycatch estimates are not available for many fisheries included in this report (i.e., these fisheries would have been automatically classified as not being fisheries of focus). The additional criteria used in this qualitative process were:

- Fisheries with suspected or unknown bycatch might require pilot observer programs to provide more detailed bycatch information. These fisheries were considered for addition to the list of fisheries of focus.
- Fisheries where the standard error of the bycatch estimate exceeded the management goal or where uncertainty estimates were not currently calculated were considered for addition to the list of fisheries of focus.
- Fisheries using gear with potentially high bycatch were considered for addition to the list of fisheries of focus (e.g., gillnet fisheries).

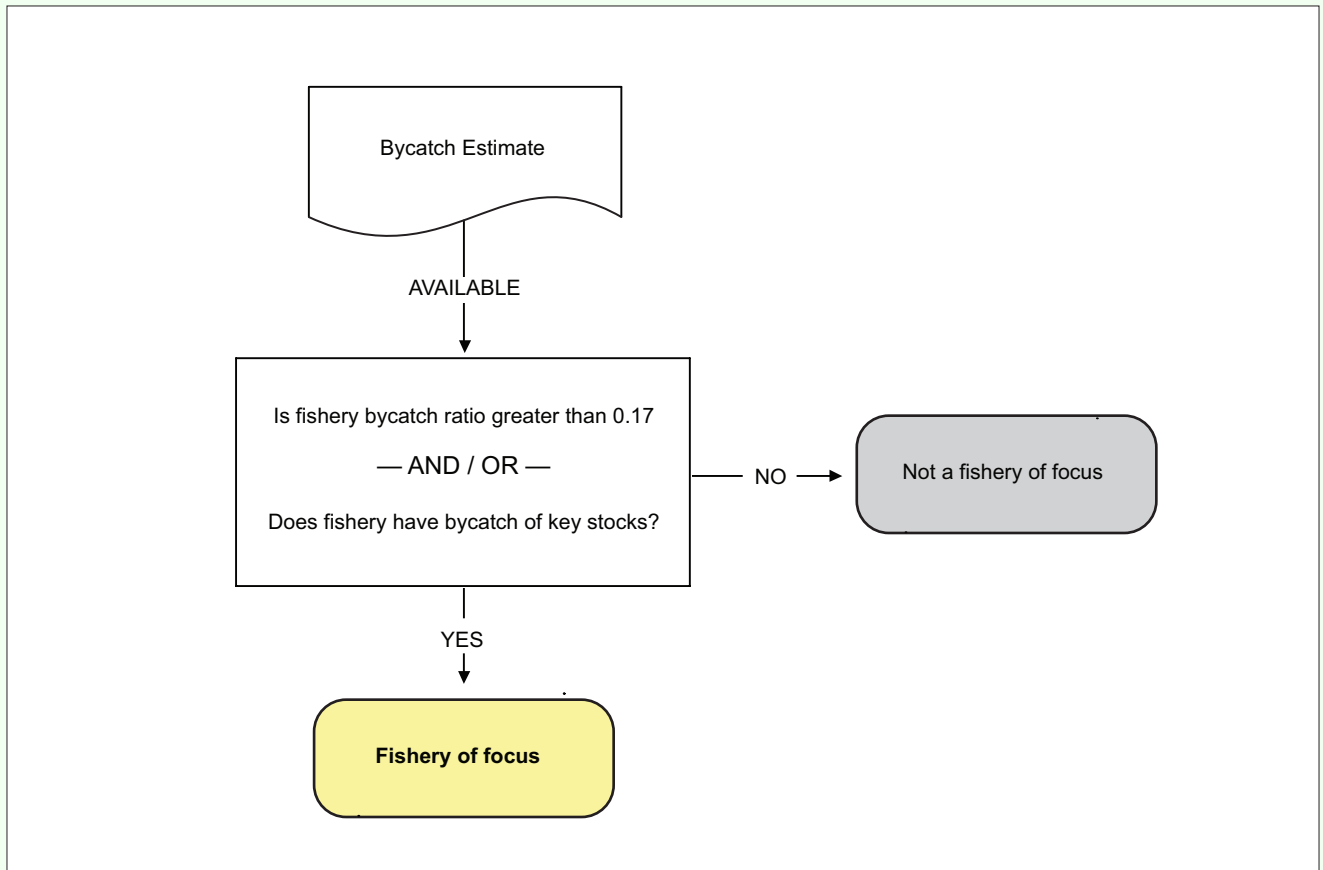
All changes based on the qualitative process, as well as the reasoning behind decisions to either add or remove fisheries from the list of fisheries of focus, are summarized in the regional sections. This information was reviewed by the National Observer Program and the National Bycatch Steering Committee to ensure consistency in application of these criteria across regions.

#### 3.4.2 Fishery Bycatch Estimation Improvement Plans

Fishery bycatch estimation improvement plans were developed for all fisheries of focus. The improvement plans provided documentation on each individual fishery, including its current tier, relevant management issues, deficiencies in bycatch data collection and estimation, and recommendations for improvements to bycatch data collection and estimation. A standard format was developed and applied to each fishery requiring an improvement plan, to ensure consistency across regions. The specific components of the improvement plans were:

- fishery name—the name of the fishery as listed in the regional list of fisheries included in the U.S. National Bycatch Report;
- fishery tiers—tiers assigned for each category (MSA fish stocks, marine mammals, and other protected species);
- relevant management issues—issues that may influence the collection of bycatch data or bycatch estimation within the fishery (e.g., management under bycatch quotas);

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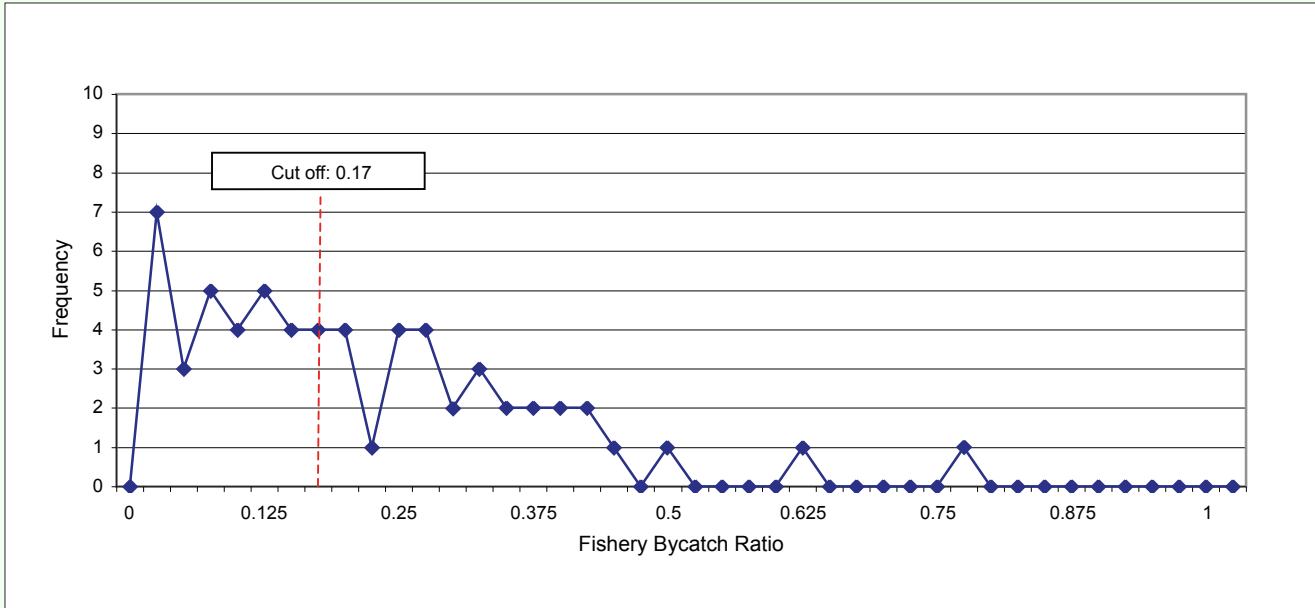
**Figure 3.5**  
Quantitative process used to identify fisheries of focus.

- bycatch data collection and estimation deficiencies;
- recommendations for improving bycatch data collection and estimation—including information on feasibility, staffing requirements, and data collection needs. Recommendations were focused solely on improvements to bycatch data collection and analytical approaches, and did not consider possible management strategies for reduction of bycatch.

The recommendations in the fishery bycatch estimation improvement plans will be used by NMFS in budgeting and setting priorities. As recommendations are implemented, the quality of bycatch estimates will be greatly improved. Implementation of these recommendations and associated improvements in data quality can be monitored through the performance measures developed in this report:

- trends in bycatch over time for key stocks;
- improvements in the tier scores for individual fisheries.

# REPORT METHODS



**Figure 3.6**

Distribution of bycatch ratios, for all fisheries in which fish bycatch estimates in pounds were included in the U.S. National Bycatch Report ( $n = 63$ ). The red dotted line indicates the median of the frequency distribution, above which a fishery was designated as a fishery of focus.

