

## IV. Resource Requirements

### A. Programmatic Needs: Responses to questionnaires

In preparation for addressing the question of resource requirements for improving stock assessments, the Task Force prepared a questionnaire and administered it to working stock assessment scientists and to managers of stock assessment programs. Not surprisingly, programmatic needs varied by program with, for example, some assessment groups having reasonable fishery-independent data but poor fishery-dependent data, and others the reverse. Thus, on average, all types of data commonly required as input to assessment models are lacking (**Figure 9**).

Overall, the need for fishery-independent indices of relative abundance is the greatest of all, although less so in the Northeast Center. Information on target catch appears to be relatively the least problematic except that the Northeast Center identifies it as its most important programmatic need (**Figure 9**). Similarly, the lack of a reliable fishery-independent index is the greatest impediment to producing high-quality stock assessments, particularly in the southeast, although less so in the northeast (**Figure 10**).

On average, lack of adequate data seemed to be only slightly more of an impediment than staffing levels to the quality of assessments but again this varies considerably by program. Data and research needs for recreational fisheries were low in Alaska where such fisheries are relatively much less important (**Figure 10**). Overall, observer programs and analyses of biological samples were identified as the two most important fishery-dependent data needs, with improved information on recreational catch monitoring and commercial fishing effort being relatively the least important, although still in need of substantial improvement (**Figure 11**). Overall, tagging programs and staff to process biological samples were identified as the two most important fishery-independent data needs, with training in species identification and improved understanding of benthic habitat associations being relatively the least important (**Figure 12**).

The general conclusion from these questionnaire summaries is that, overall, no single activity stands out as being disproportionately deficient; however, it is equally true that none of the inputs to stock assessments approach the ideal situation of “no real need for improvement.”

**Figures 9-12** give a qualitative indication of the variation in data and staffing needs between Science Centers, but the raw data (not included with this report, but available on request) indicate that there is greater variability in data and staffing needs between programs than there is between Centers.

### B. Three Tiers of Assessment Excellence

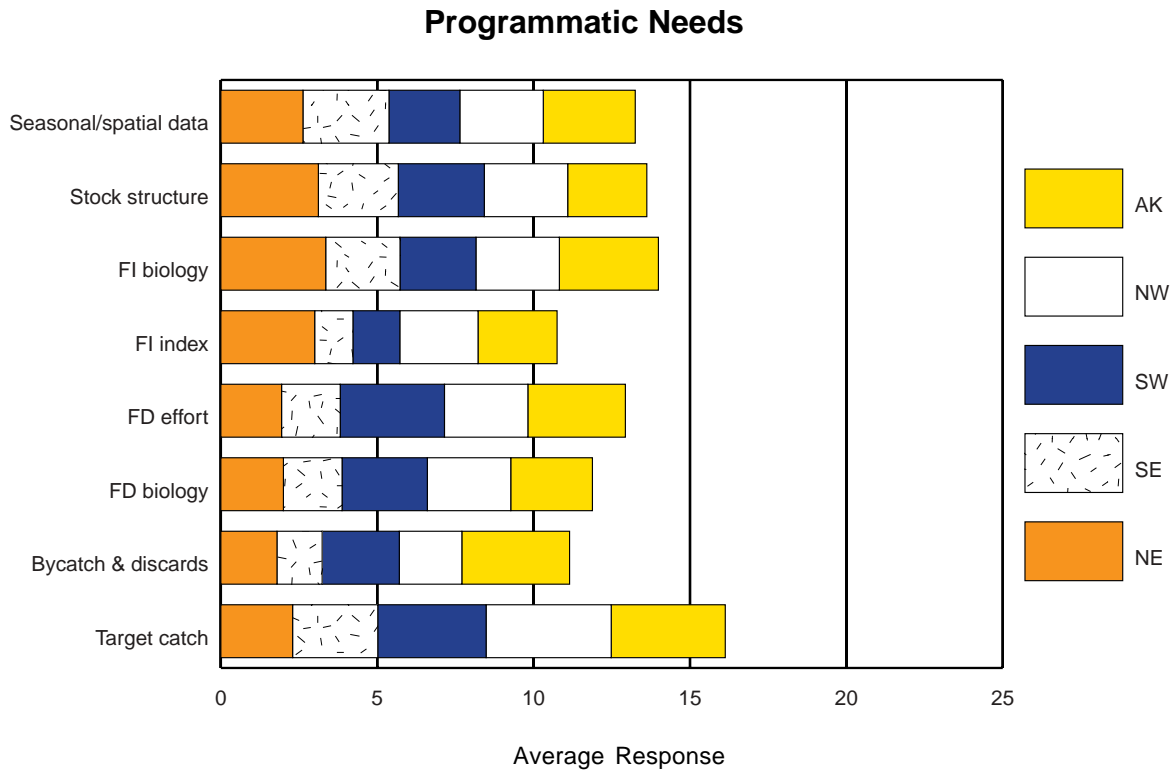
The Task Force developed three scenarios to consider in the analysis of the resources required to improve stock assessments. These are detailed below and summarized in **Figure 13**.

#### ***Tier 1 – Improve stock assessments using existing data***

*(a) for core species, conduct assessments that are more comprehensive, more thorough, more timely, better quality controlled, and better communicated;*

*(b) for species of currently “unknown” status, mine existing databases of research vessel survey data and/or commercial and recreational statistics for archival information for new analyses to evaluate status determination criteria.*

Tier 1 essentially addresses the question of what improvements in stock assessments can be made without initiating new data collection programs. Although the Task Force agreed that new and/or expanded data collection programs are of paramount importance to the improvement of stock assessments, it was concluded that a certain limited amount could be accomplished even in the absence of new programs. Although most data collected by NMFS are analyzed in a timely manner, there are many databases that have not been examined exhaustively. In particular, there may be considerable unanalyzed data for “minor” or non-target species. In some cases, there may even be historical data that has never been computerized, thus necessitating “data-rescue” operations. One reason that some data have been left unedited or unanalyzed is simply a lack of technical and quantitative staff to do the work. Inadequate staffing levels have also compromised the timeliness, quality and thoroughness of assessments conducted to date. Thus, the main requirements for Tier 1 are increased staffing levels, particularly database managers, statisticians, technicians, and assessment scientists.



**Figure 9.**

Programmatic needs averaged over responses from assessment scientists within each Science Center. An average response of 1 for a given Science Center indicates that the lack of a given program is a major impediment to producing credible assessments and has high priority for improvement; 2 indicates a major impediment, but not amongst the highest priorities; 3 indicates adequate for accuracy but not for sample size; 4 indicates that relatively fine tuning is needed; and 5 indicates that the current program is adequate with no real need for improvement. Thus, for the five stacked histograms combined, a total of five would represent the greatest need and 25 would indicate the least need. The difference between 25 and the summed histograms is an overall indication of the need for improving the specified programs. FI=Fishery-independent; FD=Fishery-dependent.

**Tier 2 – Elevate stock assessments to new national standards of excellence**

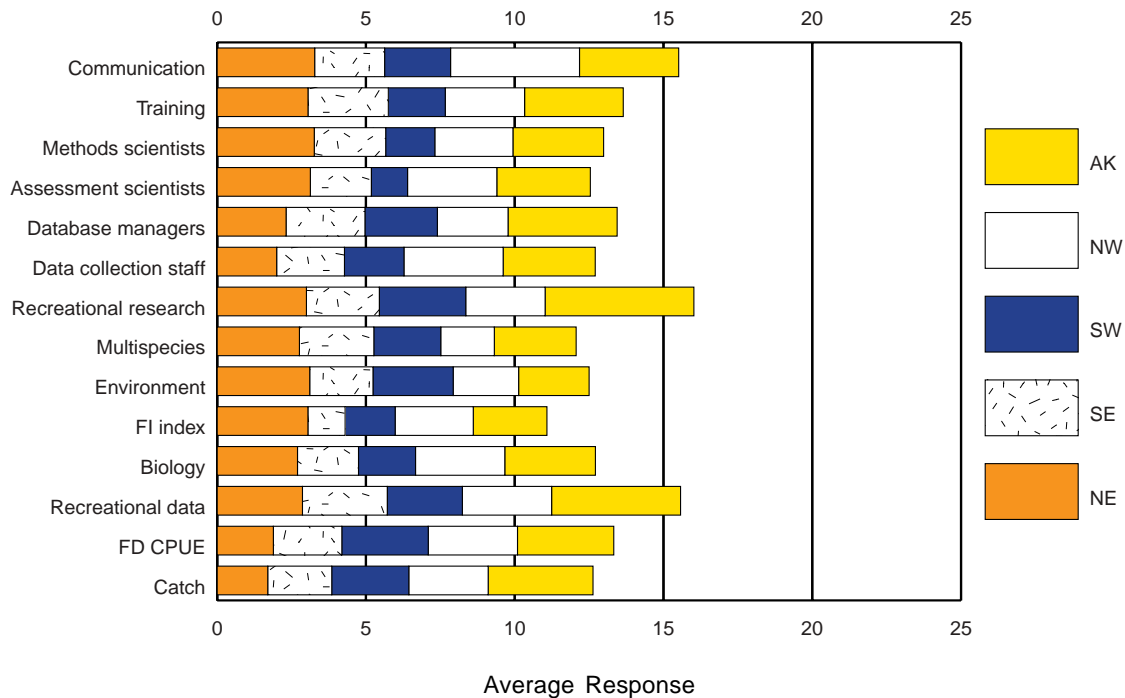
*(a) upgrade assessments for core species to at least Level 3;*

*(b) conduct adequate baseline monitoring for all federally-managed species (including rare species)*

The focus for Tier 2 is new or expanded data collection and research initiatives. The task of upgrading assessments for core species to at least Level 3 would likely be relatively simple if there were adequate baseline monitoring for all federally-managed species. A key question is, “what is ‘adequate’?” The definition of “adequate” will differ by species or stocks and will depend on their geographic range, extent of migration, and magnitude of inter-annual variations in stock size and recruitment. The

Task Force agreed, however, that in most cases adequate coverage would require sampling throughout the range of a species or stock at least every 1-3 years, and preferably at least every 1-2 years. For most species, fishery-independent research surveys are the method of choice; for some species, tagging experiments may be more practical; and where neither of these are possible, fishery-dependent surveys may suffice. There are currently very few stocks that can be characterized as having adequate baseline monitoring (**Appendix 1** and **Table 1**). In addition, a minimal requirement for conducting ecosystem-based management and for fully satisfying the standards set forth in the Sustainable Fisheries Act (e.g. standards associated with bycatch issues) is that there be adequate baseline monitoring of all commercial and recreational species and also all associated species, not just federally-managed species.

## Impediments to Quality of Assessments



**Figure 10.**

Impediments to the quality of assessments averaged over responses from assessment scientists within each Science Center. An average response of 1 for a given Science Center indicates that the quantity or quality of data and staff resources is a major impediment to producing credible assessments and has high priority for improvement; 2 indicates a major impediment, but not amongst the highest priorities; 3 indicates adequate for accuracy but not for sample size; 4 indicates that relatively fine tuning is needed; and 5 indicates that the current program is adequate with no real need for improvement. Thus, for the five stacked histograms combined, a total of five would represent the greatest need and 25 would indicate the least need. The difference between 25 and the summed histograms is an overall indication of the need for improving the specified data collection programs or staffing levels. FI=Fishery-independent; FD=Fishery-dependent.

### **Tier 3 – Next generation assessments**

*(a) assess all federally-managed species or species groups at a minimum Level of 3, and all core species at a Level of 4 or 5;*

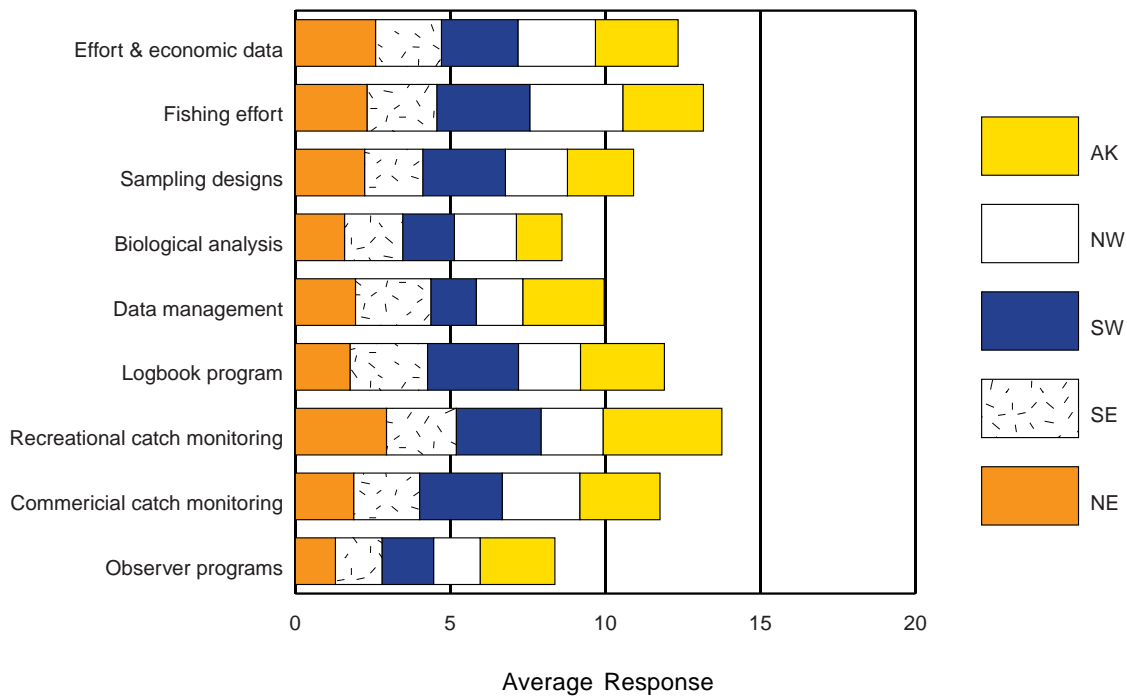
*(b) explicitly incorporate ecosystem considerations such as multispecies interactions and environmental effects, fisheries oceanography, and spatial and seasonal analyses*

The Task Force struggled to define reasonable limits to Tier 3. The most recent Report to Congress on the Status of Fisheries of the United States (NMFS 2001a) lists 905 federally-managed stocks, most of which are not routinely monitored, and many of which may not even be identified to species in commercial or recreational landings. The number of data collection activities and staff resources required to enable 900+ assessments of stock status to be undertaken on a regular (e.g. annual) basis is enormous. Addi-

tionally, if associated species and other ecosystem considerations were to be taken into account, the task is mind boggling. It then becomes necessary to ask the question, what would be the utility of having 900+ annual assessments; is this a reasonable long-term objective? Would this substantially enhance fisheries management, or are there simpler ways of achieving a similar result? Certainly, it is hard to imagine that 900+ catch quotas would therefore be set, monitored and enforced simultaneously.

From a management perspective, a more realistic aim would be to manage only the primary (core) species by catch quotas, effort controls, or similar high maintenance management methods, and to manage other species using closed areas (e.g. marine protected areas, MPAs), closed seasons, gear restrictions and other indirect management measures. From a stock assessment perspective, a more realistic aim would be to assess groups of species from within the same fishery or geographic area in an aggregate Level 3 assessment, but to also have separate fishery-in-

## Fishery-dependent Data Needs



**Figure 11.**

Fishery-dependent data needs averaged over responses from assessment scientists within each Science Center. An average response of 1 for a given Science Center indicates that a new or greatly expanded data collection program of the specified type would greatly enhance the ability to produce accurate, precise, and timely assessments; 2 indicates that the program would help moderately; 3 indicates that the program would only help marginally; and 4 indicates that the program would not help or is irrelevant. Thus, for the five stacked histograms combined, a total of four would represent the greatest need and 20 would indicate the least need. The difference between 20 and the summed histograms is an overall indication of the need for improving the specified data collection programs or staffing levels.

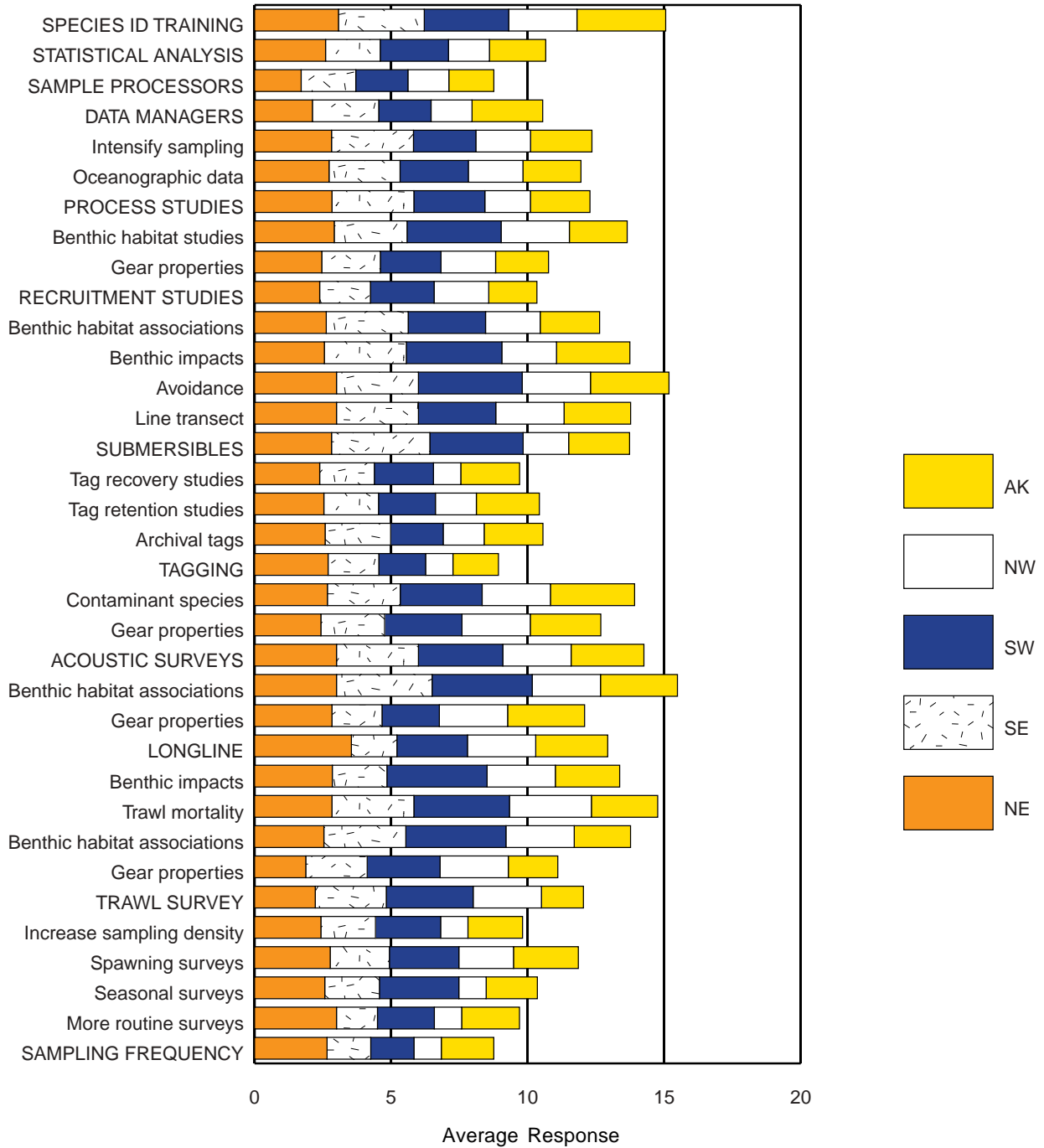
dependent indices of relative abundance that could be monitored over time to make sure that no individual species was becoming severely depleted. Nevertheless, it is obvious that any reasonable attempt to even partially satisfy the objective of assessing all federally-managed species at a level of 3-5 will require substantial new or expanded data collection and research initiatives, and staff to collect, manage, process, and analyze the data, and to communicate the results.

In essence, Level 4 assessments can be considered “state-of-the-art,” while Level 5 assessments are “next generation assessments.” Level 4 stock assessments are the standard to which NMFS Science Centers currently strive for the stocks of primary importance. Level 4 assessments comprise analytical age, size, or stage-based calculations that provide relatively precise time series of stock abundance estimates, estimates of exploitation rates and the distribution of the exploitation across size or age groups. From such analyses, short- and medium-term stock and

fishery projections and detailed analyses of alternative management scenarios can ensue.

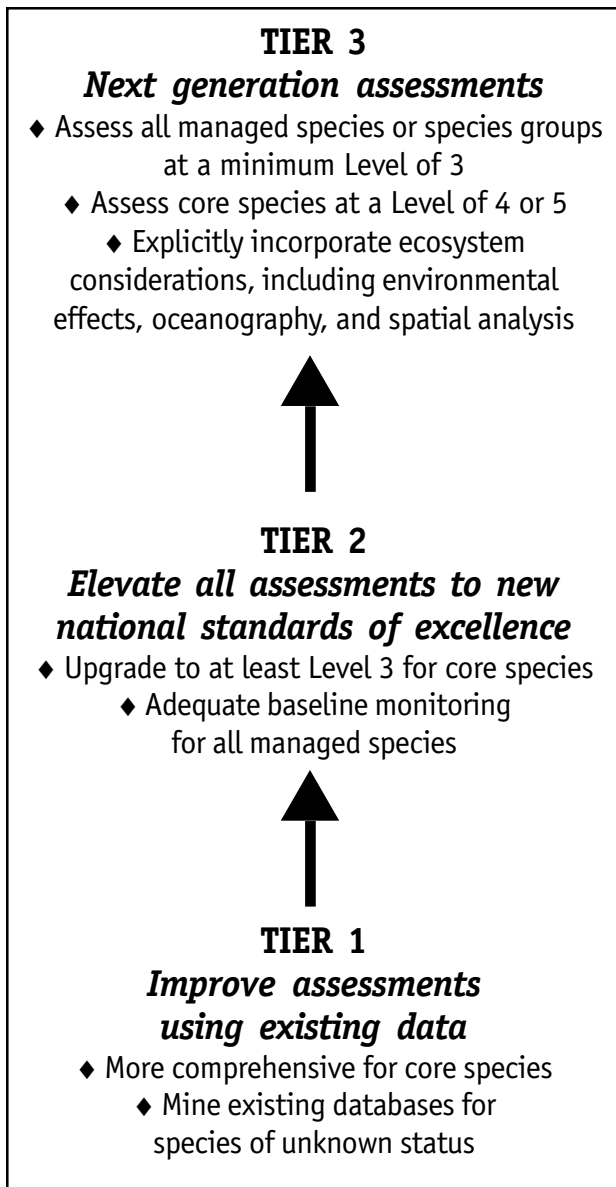
One goal of the Stock Assessment Improvement Plan is to increase the proportion of stocks that can be evaluated with Level 4 stock assessments. This step alone will require a major commitment of resources to enhance data collection activities and analysis functions. However, it is important to consider enhancements beyond high quality single species stock assessments, recognizing longer-term needs of fishery management and emerging issues related to management of species assemblages, communities and ecosystems. Clearly, there is increasing demand for information to allow finer scales of management in space (geographic distribution) and time (seasonally, monthly, and even weekly) than are typically provided in Level 4 assessments. In many cases, these needs are immediate, as managers attempt to manipulate the spatial and temporal pattern of fishing effort to change exploitation rates and patterns on individual stocks, to harmonize the management

## Fishery-independent Data Needs



**Figure 12.**

Fishery-independent data needs averaged over responses from assessment scientists within each Science Center. An average response of 1 for a given Science Center indicates that a new or greatly expanded data collection program of the specified type would greatly enhance the ability to produce accurate, precise, and timely assessments; 2 indicates that the program would help moderately; 3 indicates that the program would only help marginally; and 4 indicates that the program would not help or is irrelevant. Thus, for the five stacked histograms combined, a total of four would represent the greatest need and 20 would indicate the least need. The difference between 20 and the summed histograms is an overall indication of the need for improving the specified data collection programs or staffing levels. To group main headings (upper case labels) and subheadings (lower case), it is necessary to read from bottom to top on the y-axis.



**Figure 13.** Summary of the key features of the three Tiers of Assessment Excellence.

of co-occurring stocks, and to deal with allocation issues. There is also growing interest and need for quantitative information on predator-prey and competitive interactions among managed stocks and associated species. Assessments incorporating biological interactions will become increasingly important because of the requirements of the Sustainable Fisheries Act to maintain all managed stocks near or above biomass levels that can support MSY. The feasibility of achieving this simultaneously for all stocks warrants further investigation, as do the trade-offs between fishery yields and stock sizes that will accrue due to manipulation of the abundances of interacting species. Such models are now available in limited situations, primarily as

research tools, but the next generation of assessment models will be required to allow more detailed management scenario analyses of such trade-offs for a wider diversity of situations.

Next-generation assessments are also envisaged as providing the foundation for ecosystem-based management. While considerable work on incorporating ecosystem considerations into assessment models and management advice is currently underway, both within and outside of NMFS, ecosystem science is still in its infancy. Ecosystem research is also prohibitively expensive and labor-intensive. The U.S. Global Ocean Ecosystem Dynamics (GLOBEC) program on Georges Bank serves as an example. Planning for this program was initiated in 1991 with preliminary studies in 1993, and a full program including broad-scale monitoring of physical and biological variables and fine-scale process-oriented studies was conducted over the period 1994-99. During this period, research vessels were deployed on Georges Bank for about 250 vessel-days per year, with data collection and analysis involving about 70 scientists, plus support staff, at an overall cost of about \$5 million per year. It is projected to take at least another four years to process all of the ichthyoplankton samples, analyze the data, and synthesize the results. Although this program went well beyond simple monitoring of species and collected considerable physical oceanographic data as well as investing in new technologies, for practical and logistic reasons, the program focused only on a few target species: cod and haddock (primarily only at the egg and larval stages), and two species of calanoid copepods. Even accounting for the transferability of knowledge gained from the process-oriented studies and technological spin-off benefits, a data collection program of this intensity would hardly be practical if the targeted species included all species inhabiting Georges Bank.

Thus, the goal of performing frequent individual assessments for all 900+ FMP species, incorporating ecosystem considerations for as many stocks as possible, and considering the effects on associated non-FMP species, is probably not realistic. It is highly likely that the cost of conducting this amount of research would far exceed the landed value of the fisheries. This would not necessarily mean that the overall benefit of such research was negative because research on marine ecosystems has utility beyond simply providing advice on optimal harvest levels. However, there are many competing priorities for government spending. Even if this stock assessment improvement plan and related initiatives are aggressively pursued and actively supported by stakeholders, it is unlikely that NMFS will ever have sufficient data collection and analysis capabilities to conduct more than double the number of assessments currently undertaken per annum, meaning that

some species will probably always be assessed either infrequently or as part of a larger group. However, with sufficient resources, it will be possible to also conduct better assessments for the core species. In particular, it may be feasible to anticipate conducting Level 5 assessments (incorporating some but not necessarily all elements listed under Level 5) for as many as 4-8 core species per region. Ecosystem-based research is also likely to yield useful ancillary information about associated species, as well as improving our understanding of the dynamics of marine ecosystems.

Another important future consideration for next-generation stock assessment models is that people and groups influenced by the results of such models (commercial fishers, recreational fishers, environmental groups, and managers) will increasingly request greater access to the data and models themselves, and greater participation in data collection and analysis functions. In the next generation, user-friendly models to analyze the implications of alternative management strategies (e.g. stock projection models simulating the biological and economic consequences of various patterns of future catches or exploitation rates) should be developed and made available to the public so that affected parties can conduct their own analyses of alternative management scenarios. While all of this is possible with current technology and agency expertise, the resources required to develop the necessary interfaces with the public at large are not inconsequential. Greater flexibility in analysis options should be one of the hallmarks of next-generation assessment models, as should access to data and models over distributed computer networks. An important element of improving NMFS' stock assessments is planning for and moving forward with the next-generation of stock assessments immediately, consistent with these considerations.

In conclusion, models addressing more species, and more detailed spatial, temporal, environmental and species interactions questions will require significantly more precise, timely and comprehensive fishery-dependent and fishery-independent data. Next generation models will be extremely data-intensive, requiring much-augmented, comprehensive monitoring data. Gathering and analyzing such data will require even greater cooperation from harvesters, fish dealers, and others, more agency staff and funding, and more partnerships and cooperative research programs with other federal and state government agencies, academic institutions, private foundations, fishers, and environmental groups with a vested interest in similar or related data. Many such partnerships already exist (**Appendix 21**), but many more are needed. Recent initiatives to develop cooperative research programs with the fishing industry (**Appendix 22**) are showing considerable promise as a mecha-

nism for augmenting existing programs to collect data of relevance to stock assessments, and a National Cooperative Research Program is now being developed. It may also be fruitful to pursue participation in broad-scale programs such as NOAA's Ocean Exploration Program (**Appendix 23**), the Census of Marine Life (**Appendix 24**), and other initiatives involving science policy, data collection and scientific research (**Appendix 25**).

### **C. Timeframes and Relationships Between the Tiers**

Attainment of the three Tiers of Assessment Excellence involves both short and long-term horizons which, in turn, are dependent upon other complementary programs and initiatives being put in place, and the ability to recruit qualified personnel for the various tasks at hand.

**Tier 1:** With adequate additional trained staff, most useful work based on existing data will probably have been completed within 3-4 years, by which time new data from Tiers 2 and 3 would hopefully be beginning to become available for additional species. Tier 1 benefits will be almost immediately obvious as data on species of currently "unknown" stock status are analyzed; however, moving certain species from "unknown" to "known" status may not be the highest priority. For example, improved analysis of major target stocks, currently overfished stocks, or new or expanded data collection programs for such species may take precedence.

**Tier 2:** Contingent on initiation of needed new data collection programs and appropriate additional staff, benefits would become obvious within 5-10 years as time series develop to sufficient length to be of use in stock assessment models. There are also likely to be some immediate benefits; e.g. immediate improvements in the knowledge of the fine-scale distribution of some species and assemblages which could improve management decisions.

**Tier 3:** Next generation assessments represent a long-term (10+ years) objective and investment because considerable research and development is required and because new time series of consistent data collection must be initiated. In addition, Tier 3 is dependent upon an adequate, purpose-built fleet of dedicated research vessels, continued development of advanced technology that will facilitate sampling of marine organisms, and development of partnerships and cooperative research programs with other federal agencies, state agencies, private foundations, universities, commercial and recreational fishing organizations and individuals, environmental groups, and others with a vested interest in collecting similar types of data, although often for different purposes.

#### D. Region-Specific Needs to Achieve the Three Tiers of Assessment Excellence

The number of species covered by FMPs differs substantially between regions. This is less a reflection of regional differences in species diversity or fishing intensity than it is of regional differences in the philosophy of which species to include in FMPs. For example, the Gulf of Alaska groundfish plan includes 100 species, but most of the landings are comprised of only a dozen or so species; in contrast, in the New England and Mid-Atlantic regions, less than two dozen of the nearly 200 shelf species are explicitly included in FMPs. For the purposes of reporting on the status of U.S. fisheries, tracking progress in conserving or restoring resources, and comparing region-specific needs and achievements, it would be useful to have greater consistency. However, for the purposes of this plan, the authors all approached the question of region-specific needs in a similar way, regardless of differences in regional philosophies about the degree of inclusiveness. Core species are those with the highest value, highest volume, or highest profile. Minor species are those that contribute little or nothing to landings, but need to be considered in some way in an ecosystem context, regardless of whether or not they are explicitly included in FMPs.

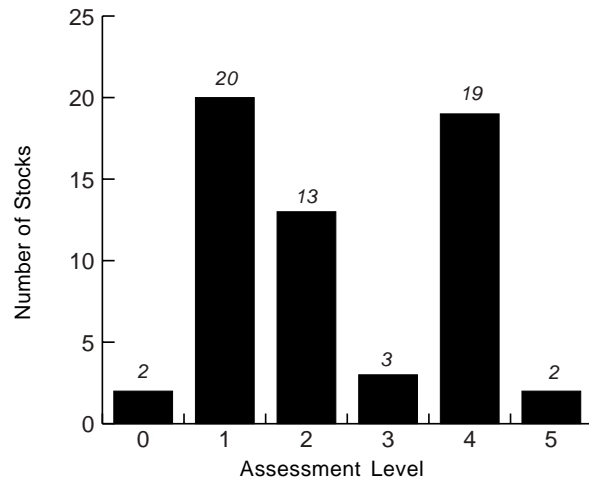
Unless otherwise specified, the current and required resources detailed in this section apply as of January 2000. In some cases, there have been several staff hired or contracted to perform assessment-related activities subsequently. These are highlighted in the appropriate sections.

##### ***Northeast Fisheries Science Center***

The following two sections contain an analysis of the current staffing and status of assessments in the northeast region relative to defined assessment levels, and an analysis of the staffing resources necessary to meet the three Tiers of Assessment Excellence based on data and resources currently used in the region. It should be noted that these analyses apply only to staffing levels and other resources contributed on the federal side; however, for many of the region's resources, data and analyses are undertaken by staff in state marine fisheries organizations. Thus, existing and required staffing resources should be considered minimum.

##### ***NEFSC current situation***

A total of approximately 172 staff involved in stock assessment related activities within the Northeast region (**Section III, part I and Figure 8**) currently provide advice on 59 managed or otherwise important species/stocks (**Figure 14**).



**Figure 14.**

Number of stocks (N=59) assessed by assessment level at the Northeast Fisheries Science Center.

The distribution of these stocks is bimodal with respect to “assessment level,” with 24 stocks assessed at Level 3 and above, and 35 stocks at Level 2 and below. This mix of assessment quality and completeness is primarily a function of historical interest in various species (e.g. groundfish, summer flounder, and surfclams), an increasing need for higher-level assessments to support management programs, and new legal requirements for population biology data. The situation is not static, with managers increasingly requesting more frequent assessment updates, with more extensive “terms of reference.”

In particular, stock assessments are now often required to incorporate discussion and evaluation of “control rules” used by management to meet the requirements of the MSFCMA. These control rules provide managers with a formulaic approach to scientific advice, pre-specifying the relationship of target fishing mortality rates to biomass conditions in the stocks. The construction and testing of control rules makes use of absolute biomass and fishing mortality rate estimates, or proxies for these quantities, if adequate approaches can be developed. As part of this effort, medium term simulations of the performance of control rules in recovering and maintaining stocks are required so as to evaluate the efficacy of a proposed control rule in meeting the 10-year or one generation time constraints imposed by the MSFCMA. Center stock assessment scientists have been involved in developing proposed control rule strategies for various species, and in scientific research for providing realistic simulations of the performance of stocks in relation to control rule management (e.g. simulating population status in the medium term using various approaches for determining recruitment responses). As the



**Table 2.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for the Northeast Fisheries Science Center. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and “other,” which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current In-house / Contract / Other</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>
Commercial Catch & Biological Sampling	30	19			10	<b>10</b>	
Recreational Catch & Biological Sampling	47	3			5	<b>5</b>	
Observer Programs	3	11			13	<b>13</b>	
Fishery-independent Surveys	8	7	10		5	<b>5</b>	2
Process Biological Samples (age, growth, maturity, etc.)	8	3	3	5	5	<b>10</b>	5
Data Management & Preprocessing of Data	4	1		7	2	<b>9</b>	5
Conduct Assessments	13	4	3	2	1	<b>3</b>	5
Assessment Methods Research	3			2	1	<b>3</b>	5
Communication of Results & Follow-up Evaluations	7	1		2	1	<b>3</b>	3
<b>Subtotal (Assessment scientists)</b>	<b>23</b>	<b>5</b>	<b>3</b>	<b>6</b>	<b>3</b>	<b>9</b>	<b>13</b>
<b>Subtotal (Others)</b>	<b>100</b>	<b>44</b>	<b>13</b>	<b>12</b>	<b>40</b>	<b>52</b>	<b>12</b>
<b>Total</b>	<b>123</b>	<b>49</b>	<b>16</b>	<b>18</b>	<b>43</b>	<b>61</b>	<b>25</b>

need for more complex stock assessments has been increasing, so has the need to upgrade index-level assessments to assessments incorporating age/size structure to support sophisticated simulations of control rule performance.

### ***NEFSC programs and staffing required to meet the three tiers of excellence***

Based on the current distribution of stock assessment levels, data and technical limitations, and staffing in data collection and analytical tasks, the following represents an analysis of augmented staffing levels required to meet the three Tiers of Assessment Excellence for Northeast stock assessments (staffing increases by activity are summarized in **Table 2**).

#### *Tier 1: Improve stock assessments using existing data*

The intent of upgrading assessments of Tier 1 is to more fully utilize existing information, to upgrade the synthesis of available data and to provide information to users on a more timely basis. In order to meet Tier 1 requirements for Northeast stocks, additional FTEs are required primarily in data management and synthesis activities (**Table 2**). Data

on species age and growth have been collected and archived, but not analyzed, for many stocks currently assessed in the “index level” category. A total of five additional FTEs in the Age and Growth activity will allow more complete biological data for assessments of some of these stocks. Additionally, this would enable more timely production of age data.

Improving Tier 1 assessments will also require additional staff to better archive and extract sea sampling information, and biological sampling data collected from commercial fisheries. Data management support is needed to maintain databases and improve access to a wider array of users. A modest increment in stock assessment and support staff is required to produce more frequent and improved assessments under this tier.

#### *Tier 2: Elevate stock assessments to new national standards*

The major increment in FTEs required under the stock assessment improvement plan occurs when moving to Tier 2 requirements to upgrade assessments for core species to at least Level 3 and for providing adequate baseline assessments for all managed species. In order to meet these

requirements, there needs to be major improvements in the quality and timeliness of commercial and recreational fisheries data and required biological sampling. Currently, biological sampling of catches is concentrated on a few core stocks, and sampling levels are barely adequate in many other cases. Improvements in the collection, management, and synthesis of fishery dependent data are needed. Ageing structures are not currently collected from recreational catches and this needs to be rectified. Likewise there is no universal sea sampling program providing routine estimates of discards and bycatch from the region's fisheries, and this needs to be improved. Increased biological sampling under these programs will require the processing of greater numbers of ageing structures, and data entry and manipulation. For some stocks not currently indexed by research vessel survey programs (e.g. tilefish, deep water fisheries and components too deep for surveying in current programs) additional types of fishery-independent data are required and will need to be developed. Additional stock assessment scientists are required to produce higher quality and more frequent assessments called for under this requirement.

### *Tier 3: Next generation assessments*

Next generation assessments are intended to provide more explicit accounting for biological and technological interactions, longer-range predictions and integration of biological and environmental data. A major component of these assessments will be the incorporation of feeding data into routine stock assessments and modeling and spatial dynamic models and data to examine the fine-scale implications of alternative management strategies. In order to support such requirements, additional data collections for biological analyses (e.g. stomach sampling) are required, as well as fishery oceanographic data bases, geographical information systems, and data management necessary to support these activities.

### **Southeast Fisheries Science Center**

The fisheries under the research jurisdiction of the Southeast Fisheries Science Center are diverse in both the species being exploited and the fishing sectors prosecuting these fisheries, including large recreational sectors and bycatch sectors, as well as commercial fisheries. In some fisheries, the productivity of many of the species being exploited is low, supporting relatively small catches (there are over 400 species within Southeast FMPs or international conventions). However, some of the species are extremely valuable and many are very important to local communities. Also, in aggregate the species catches are significant and the fisheries often have the capability to ex-

ploit a variety of species, switching target species as conditions change. These characteristics result in unique research and management requirements.

### ***SEFSC current situation***

The Southeast Fisheries Science Center has unique resource requirements to achieve each of the three Tiers of Assessment Excellence. This results largely from the diversity of fishery resources occurring within the Region. Current stock assessment efforts have focused on a small number of core species (those of greatest public interest and often of greatest political importance due to conflict between constituents). Thus, detailed assessments are conducted on 10-15 stocks, annually. However, there are a large number of stocks upon which little assessment work is done other than to monitor catches. The catches of any individual one of these unassessed stocks is often small and of small socioeconomic significance; however, in aggregate they are an important part of the fisheries economic sector and fishing communities.

Fisheries of the southeast are managed by the South Atlantic Fishery Management Council, the Gulf of Mexico Fishery Management Council and the Caribbean Fishery Management Council through fishery management plans on shrimp, reefish, snapper-grouper, spiny lobsters, coastal pelagics, red drum, stone crabs, corals and others. The number of FMPs requiring stock assessment data is increasing. Data collection in support of assessment of these species comes through the SEFSC efforts and through joint agreements with the individual states (plus Puerto Rico and the U.S. Virgin Islands) and with the Atlantic and Gulf States Marine Fisheries Commissions. Additionally, since the recreational sector is large in many fisheries (in some cases larger than the commercial sector), several joint agreements have been made to obtain recreational catch data from various survey mechanisms.

A major issue that impacts stock assessments in the southeast United States is bycatch, particularly discarded bycatch resulting from Gulf of Mexico shrimp trawlers. The mortality resulting from this activity impacts stocks of fish for which there are directed fisheries, therefore limiting the production from those fisheries. There are also major concerns with the impacts of gill-net fisheries on marine mammals, and hook and release mortality in the substantial recreational fisheries that exist in the region. Incorporating bycatch estimates into stock assessments requires a new level of commitment to data collection through observer programs. Initial *ad hoc* projects have been conducted to obtain estimates of bycatch, but the precision is lacking.

The Southeast Fisheries Science Center has the responsibility for providing the United States scientific support for assessing stocks of Atlantic tunas, swordfish and billfish in conjunction with the International Commission for the Conservation of Atlantic Tunas (ICCAT) of which the United States is a signatory nation. Assessments of the tuna, swordfish and billfish stocks are conducted jointly with scientists from various nations. The Southeast Fisheries Science Center has the responsibility for monitoring catch and scientific data from throughout the U.S. Atlantic coast and report these to ICCAT. The U.S. scientists, also, take a lead role in the joint assessment working groups within ICCAT's scientific committee.

### ***SEFSC programs and staffing required to meet the three tiers of excellence***

#### *Tier 1: Improve stock assessments using existing data*

The first Tier of Assessment Excellence is a goal of improving assessments with existing data for both core stocks and those stocks whose status is largely unknown. The core stocks for which detailed assessments are currently being conducted can be improved, even with existing data. Improvements can be achieved largely through more comprehensive characterization of the uncertainty associated with various management parameters arising from the assessment. Characterizing the uncertainty requires stochastic modeling activities which are time consuming both in their development and in the actual running of the models. Uncertainty characterization also requires extended interaction with managers and constituents in order to appropriately formulate the statistical questions.

The first Tier can be achieved for the "non-core" stocks by developing and organizing the data bases necessary for first pass assessments for these species. This will require statistical determinations of catch by size and other relevant strata, the collation of biological data and the analysis of appropriate survey and catch-effort trend data. In many cases some data exist within Federal, State and academic institute data bases on each of these aspects. But it remains to integrate the information and make "first-pass" assessments. These initial assessments are important for management, as they will allow initial overfishing/overfished determinations to be made; additionally, the results will be extremely useful in guiding further scientific prioritization of data collection activities for these stocks. Due to the large number of these stocks within the purview of the SEFSC, this will require increased monitoring by assessment scientists.

#### *Tier 2: Elevate stock assessments to new national standards*

The second Tier of Assessment Excellence expresses the goal of upgrading assessments of core species to a level in which dynamic changes in stock abundance are estimated and monitored over time; and that there should be a baseline monitoring of all managed species. To achieve this Tier, expanded data collection activities and extensive monitoring activities by assessment scientists will be required. Of particular importance is the need for fisheries-independent data. As noted above, catches for many stocks are relatively small; therefore, assessments with adequate levels of precision will require monitoring of appropriate abundance indices. SEFSC scientists indicate the high importance of developing fishery-independent indices within their responses to the questionnaire (**Section IV (A)**). The scientists' responses also placed emphasis on observer programs to address important issues of bycatch, discards, collection of biological data, and collection of better effort data. Thus, Tier 2 efforts should focus on developing and improving data collection mechanisms. Fishery independent efforts require extended ship time which is addressed in other initiatives. However, improvements will require more than simply conducting more trawl surveys. Extensive research is needed to explore avenues for monitoring stocks and life stages of stocks that are not conducive to trawl surveys; for example, mackerels and other coastal pelagics; billfishes and tunas; and reef dwelling species. This will require creative interaction between assessment scientists, survey statisticians, ecologists and gear-specialists in order to design appropriate survey strategies. Additionally, second Tier goals will also require improved characterization of bycatch, discards and other fisheries and biological data. Observer programs are essential for these activities. Management of statistically useful observer programs will require the close cooperation of biologists, assessment scientists, data managers and program management with the constituents.

#### *Tier 3: Next generation assessments*

The third Tier of Assessment Excellence expresses a goal of having minimal assessment levels (dynamic monitoring of abundance - production modeling) for ALL stocks with all core stocks being addressed by size, age, sex-structured assessments with possible inclusion of ecosystem factors. As noted above, the diversity of fishery stocks under SEFSC purview indicates the importance of ecosystem considerations. What effect are major ecosystem perturbations such as bycatch or environmental changes likely to have on species distributions? Can species shifts be predicted even in a probabilistic sense? Can management strategies be devised to avoid chances of deleterious so-

cioeconomic consequences of species shifts? Can management strategies be devised to achieve short term local objectives of the fishers? These questions pose important research goals. Steps to achieve these goals require extensive research, monitoring and data collection activities. In particular, spatial and temporal scales of data collection will need to be improved. This will require finer scale information on catches, survey abundances and oceanographic variability. Additionally, the monitoring of a large number of stocks (the components of the ecosystem) is needed to discern patterns of variability.

Specific resource requirements are outlined in **Table 3**. Note that resource requirements are additive; i.e., requirements for Tier 2 are additive to those in Tier 1.

### **Southwest Fisheries Science Center**

The NOAA Fisheries Southwest Fisheries Science Center’s area of responsibility encompasses a vast expanse of open

ocean and international waters, including the coastal waters of California, parts of the Antarctic, and the Hawaiian Islands, and the U.S. Territories of Guam and American Samoa. The SWFSC is responsible for the research and management of some of the nation’s most intriguing species, and is a major force in the nation’s effort to build international cooperation for the stewardship of these species. Research extends over an area of more than 64.2 million square miles of open ocean – greater than 18 times the size of the U.S. land mass – including 1.8 million square miles of EEZ. The Southwest Region is home to over 72 protected marine species, and 153 fishery stocks, of which the status of 101 remains unknown. In addition to the complexity of the marine ecosystems in this region, the international and domestic mix of culturally diverse fishing communities present complex challenges for managing species, conducting research, and collecting data necessary to ensure sustainable fishing practices. The collective value of tuna, swordfish, sharks, and billfish from U.S. Pacific water fisheries exceeds \$1.5 billion annually. Near shore

**Table 3.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for the Southeast Fisheries Science Center. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and “other,” which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>
	<i>In-house</i>	<i>Contract</i>	<i>Other</i>				
Commercial Catch & Biological Sampling	10	2	15		2	2	3
Recreational Catch & Biological Sampling	10	3	25		2	2	3
Observer Programs	4	10	4		22	22	11
Fishery-independent Surveys	8	7			2	2	6
Process Biological Samples (age, growth, maturity, etc.)	15	7		1	3	4	5
Data Management & Preprocessing of Data	9	1		7	4	11	1
Conduct Assessments	8		2	4	3	7	3
Assessment Methods Research	1			1	2	3	6
Communication of Results & Follow-up Evaluations	6			1	2	3	1
<b>Subtotal (Assessment scientists)</b>	<b>15</b>	<b>0</b>	<b>2</b>	<b>6</b>	<b>7</b>	<b>13</b>	<b>10</b>
<b>Subtotal (Others)</b>	<b>56</b>	<b>30</b>	<b>44</b>	<b>8</b>	<b>35</b>	<b>43</b>	<b>29</b>
<b>Total</b>	<b>71</b>	<b>30</b>	<b>46</b>	<b>14</b>	<b>42</b>	<b>56</b>	<b>39</b>

Note that the above table specifies the labor resources (FTEs) needed to address the three Tiers of Assessment Excellence for stock assessment responsibilities. The labor resources have an associated cost which is not addressed in the table. However, in addition to the labor costs there will be additional resources needed to conduct experiments to achieve Tiers 2 and 3. Vessel time on research vessels will, of course, be important, but this is discussed elsewhere. Activities which would likely be prominent in achieving Tiers 2 and 3 are archival tag experiments, stock identification sampling (mtDNA and microconstituents) and other activities.

landings of sardines, mackerel, tuna, rockfish, and flatfish in California and Hawaii totaled 370 million pounds in 1998 and were valued at \$173 million. During the same year, aquaculture in the Southwest Region produced 30 million pounds of fish and shellfish worth \$55.6 million to growers. From the recreational perspective, a quarter of a million saltwater anglers, 40 annual fishing tournaments, and prized game fish like marlin, tuna, wahoo, and mahimahi place Hawaii among the top 10 states adding significantly to the economy from sport fishing. California, with over a million recreational anglers, ranked second in the U.S. catching about 23 million pounds of fish.

The SWFSC supports two fishery management councils. The Western Pacific Fishery Management Council (WPFMC), located in Honolulu, Hawaii, manages the insular resources in the central and western Pacific. The Pacific Fishery Management Council (PFMC), located in Portland, Oregon, manages fishery resources along the U.S. west coast. Both councils manage highly migratory species.

#### ***SWFSC current situation – central and western Pacific***

The SWFSC has assessment responsibility for 56 species listed in the FMPs under the jurisdiction of the WPFMC. In terms of domestic and international market value, “core” species include the large pelagic fishes (tunas and billfish), and in terms of political interest blue sharks are added to the list. These species readily migrate far beyond the U.S. EEZ and into waters where they may be caught by fleets of other countries. Assessments of these stocks cannot be based solely on catch data within U.S. territorial waters from U.S. domestic fleets. Stock assessment work must be conducted in an international context, taking account of all catches that affect the population being assessed. The two Atlantic coast science centers face a prospect somewhat similar to the SWFSC in this respect, although assessment-related procedures in the Atlantic have long been defined by participation in well-established international agencies, such as ICCAT, that orchestrate collection of data and workshops involving scientists from member countries who conduct comprehensive stock assessments. To date there are no comparable fishery management agencies in the temperate and tropical Pacific beyond that covered by the Inter-American Tropical Tuna Commission (IATTC) in the eastern tropical Pacific.

In the absence of such management agencies in the central and western Pacific, it has been necessary for SWFSC scientists to forge their own cooperative arrangements with fishery scientists in other parts of that region. This takes considerable time and effort. Various international cooperative arrangements have operated on a relatively informal basis for the purpose of assembling fishery data from

disparate sources and conducting stock assessments. Foremost of late is the Standing Committee on Tunas and Billfish (SCTB) of the Secretariat of the Pacific Community (SPC) which for core tuna species has been fostering fishery data collection and high level stock assessments, with the participation of an international cadre of fishery scientists.

In the past few years, two prongs of diplomatic effort have been undertaken in the Pacific to formalize comprehensive, international management agencies for the region or a portion thereof. One, the Interim Scientific Committee (ISC), has met several times and established several subcommittees to promote assessment of various species and to establish a comprehensive fishery data base. The other effort, dubbed the Multilateral High Level Conference (MHLC), has met five times, is considerably more comprehensive in its membership than the ISC, and has the ambitious goal of establishing a fishery monitoring and management agency by June 2000.

At present, for most of the major fleets harvesting tuna species in the central and western Pacific (including U.S. fleets), catch and effort data are available to NMFS (or other) scientists for the purpose of conducting stock assessments thanks to the work of the SCTB and similar informal cooperative arrangements. The resolution in time and space is not always as fine as desired and there are some holes in the data, particularly catch at size data. Fortunately, good tag return data exist for the four major tuna species (skipjack, yellowfin, bigeye, and albacore) which in conjunction with the fishery data have enabled the high level stock assessments mentioned above. However, as sophisticated as the assessments have been, they have not had the benefit of regular survey data or other types of fishery independent abundance indices because no regular scientific surveys are conducted for pelagic fisheries in the region. Though scientific observer coverage has been very poor, it is improving with the observer requirements of the South Pacific Forum Fisheries Agency (FFA). Observer coverage on U.S. purse seine vessels in the region is 23%, and coverage of the Hawaii longline fleet is less than 5%.

For domestic insular fisheries for demersal fishes and crustaceans, the data coverage is mixed. Regular abundance index surveys for lobsters have been conducted in conjunction with release of tagged lobsters. In addition, there has been occasional observer coverage of the lobster fleet. Commercial catch/effort data for demersal fish are collected by the state of Hawaii, but data for significant amounts of “recreational” catch (much of it sold at roadside stands) are not collected.

The Honolulu Laboratory has seven stock assessment scientists, including those involved in conducting assessments, methods research, and follow-up activities such as input to plan development, for the 56 species in the WPFMC FMPs. These scientists are additionally charged with investigating the magnitude and gravity of interactions between domestic fisheries and protected species of turtles and sea birds. Assessment duties for tunas, blue marlin, swordfish, and blue shark are shared with scientists from other countries and agencies around the region, but many of the other pelagic species are neglected through necessity.

**SWFSC current situation – west coast**

The SWFSC has assessment responsibilities for four FMPs under the jurisdiction of the Pacific Fishery Management Council (PFMC). Under the Groundfish FMP, the SWFSC shares assessment responsibilities with the NWFSC. The SWFSC produces the assessments and the NWFSC provides data collection and overall coordination for 82 groundfish species, including over 40 species of rockfish distributed from Southern California to Canada. Only 26 of the 82

groundfish species have been assessed, and almost none from central California southward. Five species have been quantitatively assessed as overfished. This has caused a crisis due to severely reduced catch allocations. Many unassessed species are thought to be overfished as well, and there is at least one case where an unassessed stock may be threatened or endangered.

Under the Salmon FMP, the SWFSC has sole responsibility for assessing and developing recovery plans for 10 endangered salmon and steelhead runs from California affecting three species.

Under the Coastal Pelagics FMP, the SWFSC has sole responsibility for assessing sardine, Pacific and jack mackerel, northern anchovy, and market squid. This is done in cooperation with the State of California on an annual basis.

Under the Highly Migratory Species FMP currently being developed, the SWFSC will have sole responsibility for assessing six tuna and billfish species caught by fisheries originating from the U.S. west coast. This will be done using the same agreements and mechanisms described

**Table 4.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for the Southwest Fisheries Science Center. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and “other,” which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

Activity	Current			Tier 1	Tier 2	Tier 1+2	Tier 3
	In-house	Contract	Other				
Commercial Catch & Biological Sampling	1	6	5		4	4	2
Recreational Catch & Biological Sampling			2		2	2	1
Observer Programs	7				7	7	7
Fishery-independent Surveys	8	1	2		11	11	9
Process Biological Samples (age, growth, maturity, etc.)	21	2	2	6	11	17	14
Data Management & Preprocessing of Data	19	6	3	8	10	18	15
Conduct Assessments	12		10+*	6	8	14	10
Assessment Methods Research	3		2	2	3	5	5
Communication of Results & Follow-up Evaluations	9			5	4	9	3
<b>Subtotal (Assessment scientists)</b>	<b>24</b>	<b>0</b>	<b>12+</b>	<b>13</b>	<b>15</b>	<b>28</b>	<b>18</b>
<b>Subtotal (Others)</b>	<b>56</b>	<b>15</b>	<b>14</b>	<b>14</b>	<b>45</b>	<b>59</b>	<b>48</b>
<b>Total</b>	<b>80</b>	<b>15</b>	<b>26+</b>	<b>27</b>	<b>60</b>	<b>87</b>	<b>66</b>

\* A loosely determined number of collaborating assessment scientists at SPC, CSIRO, NRIFS and elsewhere.

above in the section on central and western Pacific and will include Mexico. Additionally, this FMP will include four pelagic shark species. None of these have been assessed. The complexities of coordinating international assessments are similar to those discussed for the central and western Pacific.

The SWFSC is currently assessing the white abalone population which has been petitioned to be listed as endangered under the Endangered Species Act. This species needs to be assessed throughout its range, which requires cooperation with Mexico.

The California recreational fishery bridges FMPs and complicates management, research and assessment efforts. This fishery is composed of both commercial passenger fishing vessels and private fishers and generates effort in millions of days annually. It targets many of the same species as commercial fleets, and is highly significant economically.

### ***SWFSC programs and staffing required to meet the three tiers of excellence***

The SWFSC currently has 24 assessment scientists with a total of 80 staff in the assessment processes (**Table 4**). The SWFSC is aided in commercial catch, recreational catch and biological sampling by various state agencies which independently or by contract conduct sampling. The jump to Tier 1 requires a large increase in stock assessment scientists, necessitated by the current low staffing of assessment personnel at the SWFSC. Movement to Tiers 2 and 3 is highlighted by the need for increases in methods research along with additional assessment capacity.

#### *Tier 1: Improve stock assessments using existing data*

Moving to the first Tier of Assessment Excellence, improving assessments with existing data, could be readily achieved by additional SWFSC scientists for many species. Current data collections, including indices of abundance and key biological data exist with various sources – state, federal, and international – and could be prepared for assessment use in relatively short order. In the Southwest Region, considerable numbers of species have not yet been assessed or have been inadequately assessed. These include some high profile species currently fished such as striped and blue marlins, all of the pelagic sharks caught in the Pacific coast HMS fisheries, and several tuna species such as skipjack and bigeye tunas. The rockfishes in central and southern California have large numbers of unassessed species including some mainstays of the recreational fishery such as Pacific bonito, vermillion rockfish and black abalone which are expected to be declared overfished once Tier 1 assessment are completed, or, as in the

case of the white abalone move directly from unassessed to endangered. The jump to Tier 1 requires appreciable increases in database managers and analysts to retrieve, audit and preprocess the data; biological technicians to process archived samples; and stock assessment scientists to conduct assessments, explore new methodologies appropriate to data-poor situations, and communicate the results (**Table 4**).

#### *Tier 2: Elevate stock assessments to new national standards*

Moving or upgrading assessments to Tier 2 where dynamic changes in stock abundance can be assessed and monitored for core species and all managed species are monitored will require expanded data collection as well as extensive monitoring by assessment scientists (**Table 4**). SWFSC scientists are engaged in developing advanced technology survey methodologies including, for example, ROV strip census, advanced acoustics, LIDAR strip census and integrated acoustic and net surveys for krill-sized organisms. These methods, as well as more established methods, will form the core for fishery-independent data monitoring. Considerable effort will be focused on providing the basic biological parameters needed to move assessments to age and size based methods from current Tier 1 efforts. Genetics will play an important role in developing early life stage indices from fishery-independent survey methods such as continuous underway egg and larval sampling for biomass, which was pioneered at the SWFSC. Coordination of creative interactions between the various stock assessment specialities will require careful management.

#### *Tier 3: Next generation assessments*

Tier 3 moves to the goal of providing basic assessments for all stocks with core stocks using age/size/sex structured methods and considering ecosystem effects. To reach this goal for core stocks, extended research to estimate key biological parameters will be needed. This will require substantially increased scientific effort (**Table 4**). The SWFSC at its Pacific Fisheries Environmental Laboratory is engaged in developing environmental data sets related to decadal climate shifts and shifts in ocean productivity, and researching methodologies for incorporating these effects into assessment models. Currently, SWFSC scientists have provided a management model to the Pacific Council which uses temperature as a forcing factor for determining harvest guidelines. Extension of these emerging methods for incorporating ecosystem effects will require interdisciplinary cooperation and facilitation between assessment scientists and other disciplines.

## **Northwest Fisheries Science Center**

### ***NWFSC current situation***

The Northwest Fisheries Science Center has lead responsibility for assessment of west coast groundfish and evaluation of recovery options for Pacific salmon. The demands for accurate scientific investigations for both groups of species are high and increasing. Groundfish and salmon are managed according to Fishery Management Plans developed by the Pacific Fishery Management Council (PFMC). Although the NWFSC has the lead role in coordinating assessment information for both FMPs, there are major contributions by other NMFS Science Centers and by the state fishery agencies of California, Oregon and Washington.

The status of Pacific salmon species on the west coast has been reviewed under provisions of the Endangered Species Act and 26 populations (Evolutionarily Significant Units) have been listed as threatened or endangered. A tremendous effort is being mounted by the NWFSC and the SWFSC to develop salmon recovery plans that incorporate all aspects of human and natural risks to salmon. Nearly all of the salmon escapement monitoring and run forecasting is based on in-river information and is done by the state and tribal agencies. These results are used by the Salmon Technical Team (STT) of the PFMC to develop harvest options for consideration by the PFMC. Because the assessments of salmon are primarily conducted by other agencies, and because the primary west coast salmon activity occurs under Protected Species, the salmon research and monitoring needs are not considered further in this document.

For groundfish, only 26 of the 82 species have ever been quantitatively assessed. Of these 26 species, several have experienced severe declines. Harvest rates, climate, and assessment precision all contributed to this decline. The default harvest rate during most of the 1990s (35% spawners per recruit), while conservative by global standards, was overly optimistic during what has become a 20-year regime of poor ocean productivity. The precision and frequency of stock assessments did not allow forecasting the magnitude or duration of the decline in recruitment until several stocks had already crossed into an overfished state. As of 2001, rebuilding plans are being developed for seven groundfish species. Even among the 26 assessed species, there are some for which there has not been sufficient information to adequately determine their status with respect to overfishing thresholds. There are concerns that others of the 60+ species with unknown status may be in danger of overfishing. Further, some populations of groundfish in

Puget Sound have declined to such low levels that their status was reviewed in 2000 for potential listing under the ESA.

The majority of shoreside groundfish catch monitoring is done by the state agencies with coordination through the Pacific States Marine Fisheries Commission which maintains a centralized database of fisheries data (PacFIN). Most resource surveys are conducted by NMFS, with the triennial bottom trawl and hydroacoustic surveys providing a major source of data for most assessments. Approximately six groundfish stock assessments are conducted each year by NMFS, state agencies, and others. The NWFSC coordinates a stock assessment review process in conjunction with the PFMC's SSC, that involves external peer-reviewers and public input.

Passage of the MSFCMA strengthened the mandate to improve the west coast stock assessment capability. Assessments need to be conducted for more of the groundfish species. The level of uncertainty in groundfish assessments and the current information on low productivity for these species needs to be combined in a sound precautionary approach to managing these species. Rebuilding plans, which are expected to take more than 10 years, need to be developed and subsequently monitored for several of these long-lived species. All of these will be extraordinarily difficult given the lack of a dedicated research vessel for these resources and the low level of current resource survey efforts. Further, increased stock assessment effort will primarily tell us what is occurring to these species. Knowing what is only the first step. In order to develop a better understanding of why these changes are occurring, programs need to be developed to investigate the role of decadal scale changes in ocean climate, and the role of ecosystem shifts such as the major increase in pinniped abundance that has occurred off the west coast.

### ***NWFSC programs and staffing required to meet the three tiers of excellence***

The great diversity of habitat, life history, and knowledge for west coast groundfish defies simple description of the data needs for improvement. The 82 species have a collective distribution which spans 1300 miles of coastline and from estuaries out to at least 1500 m bottom depth. Some species are schooling midwater, others are on the benthic continental slope, and others are associated with high-relief nearshore habitat. Species with the greatest accumulation of relevant stock assessment data tend to be those that have historically been targeted by the trawl fishery and are amenable to either trawl or hydroacoustic surveys. Species that have the greatest data needs tend to be those



that are associated with high relief habitat and are subject to growing commercial and recreational hook and line fisheries. Today, only 26 of the 82 groundfish species have ever been assessed, and many of these assessments have had insufficient data to allow adequate determination of the status of the species.

#### *Tier 1: Improve stock assessments using existing data*

Bringing all west coast groundfish species to a Tier 1 level will require additional stock assessment, data processing and ecological staff to make the best use of the limited existing data. Some groundfish assemblages have no fishery dependent or fishery independent index of abundance and limited biological sampling from the fisheries.

The Tier 1 focus of stock assessment modelers needs to be on developing a first-cut assessment for all species so that any overfishing can be identified and corrected. There are three general areas of improvements. One area will be in the development and application of relevant assessment methods for more of the species that do not have sufficient data to support current data-hungry quantitative assessment methods. This will require innovative use of stock assessment, biological and ecological data so that information from better known species can be used to develop proxies for poorly studied species. A second area of improvement is the development of assessment modeling protocols that better quantify and communicate the uncertainty in current assessments. Such improved models will structure implementation of a more formal precautionary approach to harvest management. A third area of improvement is in the spatial integration of fishery and survey databases, particularly through advances in linkage of fishery logbooks, landings data, and fishery biological samples.

#### *Tier 2: Elevate stock assessments to new national standards*

Medium-term improvements in major data sources can lead to substantial improvements in assessment precision within about 10 years. These include major programs such as periodic resource assessment surveys, more comprehensive fishery logbook programs and at-sea monitoring of total catch, collection of genetic stock structure data for more species, and evaluation of fish association with particular habitats. Beyond routine monitoring, survey effort also needs to be devoted to studies that will improve understanding of how environmental and other factors affect efforts to standardize surveys. Studies are needed to investigate bycatch mortality and gear impact studies. Many of these medium-term efforts are large scale and expensive, but have the greatest likelihood of significantly improving

the accuracy of the assessments and our ability to conduct assessments for all assemblages of groundfish. Current efforts are far from meeting Tier 2 assessment needs because:

1. The NWFSC has no dedicated fishery research vessel to do standardized resource assessment surveys or other field research;
2. Surveys to assess most of the continental shelf rockfish and lingcod are conducted only triennially, yet several of these species are overfished and their rebuilding plan calls for a biennial assessment;
3. A small coastwide observer program to assess bycatch and total mortality of target species was not implemented until 2001, yet estimates of discard for some target species range up to 30%;
4. Fishery monitoring has historically focused on the trawl fleet. There are no fishery logbooks and insufficient fishery-dependent data for the hook&line fishery which accounts for the majority of many nearshore rockfish species catch. Further, there are few if any fishery-independent data from which to assess the status of these species.

#### *Tier 3: Next generation assessments*

Further improvements in assessments can be made by increasing the frequency and precision of fishery-independent surveys, and by increasing the number of species for which there is age composition data from the fishery and surveys. However, major improvements in our ability to forecast future stock conditions and to provide assurance of ecologically safe harvest strategies will require qualitatively different kinds of information. Among these longer term efforts are recruitment surveys that will directly forecast changes in fish abundance, climate studies to provide longer-term predictions of average recruitment levels, and ecosystem studies that will provide better understanding of the interactions among species and with their habitat. For west coast groundfish, recruitment surveys are particularly relevant for species such as whiting which have tremendous variation in recruitment and recruit to the fishery at a young age. With a recruitment survey, we can better adjust harvest levels to track these short-term natural fluctuations in abundance. Recruitment surveys are also relevant for the very long-lived species that have delayed recruitment to conventional surveys and the fishery. Here the recruitment surveys will provide advance notice of longer-term shifts in abundance

caused by shifts in average recruitment levels. Climate monitoring and fishery-oceanography investigations will help interpret these shifts in recruitment and further advance predictive capability. The result of these ecosystem studies will be a better assessment of the ecological impact of fishing, better understanding of the impact of factors such as the increased abundance of piscivorous pinnipeds, and potential adjustment of fishing strategies to obtain the best multispecies yields from the system.

Specific resource requirements for west coast groundfish are outlined in **Table 5**. The information labeled “current” in **Table 5** describes the situation in January 2000. A partial step towards meeting Tier 2 needs occurred in 2001 when the NWFSC received funding to establish a small west coast groundfish observer program and conduct coastwide trawl and hydroacoustic surveys.

### **Alaska Fisheries Science Center**

The Alaska Fisheries Science Center is responsible for Gulf of Alaska, Bering Sea and Aleutian Island groundfish assessments. The Center conducts activities in support of these assessments that include fishery independent and fishery dependent data collection programs, and fisheries oceanographic studies. The Center is also responsible for conducting fishery independent surveys and research in support of Pacific salmon and Alaskan crab assessments.

Alaskan groundfish and crab are managed according to Fishery Management Plans developed by the North Pacific Fishery Management Council (NPFMC). For the Bering Sea / Aleutian Islands region, assessment scientists currently contribute to thirteen annual groundfish assessments: walleye pollock, Pacific cod, Atka mackerel, yellow-

**Table 5.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for the Northwest Fisheries Science Center. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and “other,” which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>
	<i>In-house</i>	<i>Contract</i>	<i>Other</i>				
Commercial Catch & Biological Sampling			20		6	<b>6</b>	
Recreational Catch & Biological Sampling			7		6	<b>6</b>	
Observer Programs		25 <sup>#</sup>			31 <sup>*</sup>	<b>31<sup>*</sup></b>	12 <sup>*</sup>
Fishery-independent Surveys	7	2			11	<b>11</b>	10
Process Biological Samples (age, growth, maturity, etc.)		3	5	1	5	<b>6</b>	8
Data Management & Preprocessing of Data	2	1	19	5	4	<b>9</b>	2
Conduct Assessments	6		5	4	4	<b>8</b>	4
Assessment Methods Research		1		1	2	<b>3</b>	2
Communication of Results & Follow-up Evaluations	3	1	3	2	5	<b>7</b>	1
<b>Subtotal (Assessment scientists)</b>	<b>9</b>	<b>2</b>	<b>8</b>	<b>7</b>	<b>11</b>	<b>18</b>	<b>7</b>
<b>Subtotal (Others)</b>	<b>9</b>	<b>31</b>	<b>51</b>	<b>6</b>	<b>63</b>	<b>69</b>	<b>32</b>
<b>Total</b>	<b>18</b>	<b>33</b>	<b>59</b>	<b>13</b>	<b>74</b>	<b>87</b>	<b>39</b>

1. This table is limited to resources devoted to stock assessment of groundfish and other marine fish. Significant additional NMFS and state resources are devoted to work on salmonids.

2. “Partner” column contains minimum PSMFC and WA, OR, CA personnel working on groundfish. Many of these are supported through federal grants, including PacFIN.

3. The in house staff column represents the total number of positions as of January 2000. New funding in FY2001 is allowing development of an observer program and expansion in survey and assessment programs. Approximately 15-20 Tier 1+2 positions will be filled.

# includes 25 observers and infrastructure hired in FY 2001

\* excludes 25 observers hired in FY 2001; includes a proposed additional 30 contract observers (20 in Tier 2 and 10 in Tier 3)

fin sole, Greenland turbot, arrowtooth flounder, rock sole, flathead sole, other flatfish, Pacific ocean perch, other rockfish, sablefish and squid and other species. For the Gulf of Alaska region, 11 assessments are produced annually: walleye pollock, Pacific cod, Atka mackerel, thornyhead, slope rockfish, pelagic shelf rockfish, demersal shelf rockfish, arrowtooth flounder, other flatfish, sablefish and other species. AFSC staff assist in the development and review of stock assessments for Bering Sea crab stocks. Staff represent the Center on numerous technical and decision making boards including the NPFMC Groundfish Plan Teams and Scientific and Statistical Committee, the North Pacific Anadromous Commission, the North Pacific Halibut Commission, and international technical committees dealing with trans-boundary stocks such as Pacific hake and Bering Sea pollock.

Bycatch limits for several species have been imposed to ensure that individual species quotas are not exceeded. Species that are designated as prohibited species include Alaskan crab (e.g. Tanner crab, blue and red king crab and snow crab), Pacific halibut, and some stocks of Pacific salmon (chinook, pink, sockeye, chum, coho and steelhead). Retention for sale of prohibited species is prohibited to dissuade any targeting by groundfish fishers. Gulf of Alaska and Bering Sea Aleutian Islands groundfish fisheries also have some bycatch and discard of unmarketable species and small sized fish that is typical of any multispecies fishery. There is some discard of marketable fish caused by the NPFMC management system for the groundfish fishery. When bycatch limits are exceeded for a species, the species can no longer be retained to discourage further catch of this species.

In-season catch composition is monitored by a major fishery-dependent data collection program. Catch is monitored by an observer program and shoreside data collection. Roughly 30,000 observer days (equivalent to 114 FTEs) are expended annually to collect data from the North Pacific groundfish fishery. All vessels capable of hosting an observer may be required to do so at the vessel's expense. As currently implemented, vessels over 125 feet length overall (LOA) are required to have an observer on board at all times when ground-fishing, vessels of 60 to 124 feet LOA are required to have observers on-board 30% of the time, and vessels under 60 feet LOA are generally exempt from the requirements for observer coverage. Most of the fishing vessels operating in the Bering Sea and Aleutian Islands exceed the 125 foot limit, while most of the fishing vessels in the Gulf of Alaska are smaller than 125 feet. The recreational harvest of groundfish in Alaskan waters is a minor component of the total catch. Observers collect biological data such as otoliths, length frequencies, stomach samples and maturity stage for a variety of species.

Conducting fishery independent surveys in Alaskan waters requires a major investment of shiptime and personnel. The continental shelves off Alaska make up about 74% of the total area (2,900,785 km<sup>2</sup>) of the United States continental shelf. The region is marked by adverse seasonal conditions that necessitate sophisticated equipment to ensure the safety of the crew and the accomplishment of the survey mission.

AFSC stock assessment scientists conduct research to improve the precision of their assessments, and provide technical support for the evaluation of potential impacts of proposed fishery management measures. Research activities are designed to improve the quality of stock assessments and to expand the scope of assessments to quantify the ecological impact of fishing on the Gulf of Alaska and Bering Sea ecosystems. Stock assessment scientists often serve a dual role acting as the scientific interface between the Alaska Fisheries Science Center and the North Pacific Fishery Management Council (NPFMC).

Numerous laws govern the implementation of fisheries in federal waters. AFSC staff often conduct research to evaluate the impact of fishing to comply with these legal requirements. The MSFCMA directs NMFS stock assessment scientists to provide annual status evaluations for all species managed under the NPFMC FMPs. AFSC stock assessment scientists also provide analytic assistance on many current fisheries management issues such as research activities leading to implementation of precautionary resource management, consultations and Biological Opinions regarding protected resources, and NEPA impact analyses regarding the effects of fishing on the marine environment.

The National Standard Guidelines for overfishing state that "If environmental changes affect the long-term productive capacity of the stock or stock complex, one or more components of the status determination criteria must be re-specified." This requirement necessitates new research on the mechanisms underlying shifts in production. Studies have demonstrated that several groundfish, crab and salmon stocks exhibit shifts in production that show marked similarity to the time scales of distant atmospheric forcing phenomena such as the El Nino Southern Oscillation and the Pacific Decadal Oscillation. To determine whether shifts are due to human actions or environmentally induced shifts in the productive capacity of a stock or stock complex requires new research to investigate the mechanisms underlying the apparent response of key species to decadal scale changes in ocean climate.

Several species protected under the provisions of the Endangered Species Act are present in the region. Among

these, the western stock of Steller sea lion has been listed as endangered. A tremendous effort is being mounted by AFSC and the North Pacific Regional Office to develop a Steller sea lion recovery plan that incorporates all aspects of human and natural risks to this marine mammal population. Principal prey items in the sea lion diet include Atka mackerel, Pacific cod, and walleye pollock. These species are also targets of large commercial fisheries. Efforts are underway to explore methods to reduce the potential for competition between commercial fisheries and Steller sea lions at crucial times of the year.

Court challenges underscore the demands on AFSC staff to conduct new research surveys, process oriented research, and assessment activities to improve our understanding of the mechanisms underlying recent declines in the Steller sea lion population and the potential role of commercial fishing in limiting its recovery. These decisions also underscore the need for additional staff to evaluate management alternatives to provide reasonable and prudent alternatives to current fishing practices.

#### ***AFSC current situation – Gulf of Alaska groundfish***

Among the 100 groundfish species covered by the GOA FMP of the NPFMC, 67 are assessed at a Level 1 or better (**Appendix 1**). These species have been the targets of fishery monitoring and resource survey programs that provide the basic information for quantitative stock assessments. Not all these assessments have the same level of information and precision. Of the 67 assessed species, only 8 are assessed using staged base models (Level 4 or above). In the case of 91 of the 100 species covered by the FMP, there is insufficient information to determine whether or not the stocks are overfished or approaching an overfished condition. Some of these species are targets of developing fisheries.

The 100 groundfish species can be roughly broken into four assemblages based upon their adult habitat and co-occurrence in the fishery. This breakout will facilitate discussion of fishery monitoring and resource survey programs:

1. Midwater schooling- Walleye pollock, eulachon and squid are amenable to acoustic survey methods. Walleye pollock supports a midwater trawl fishery with annual catch near 100,000 mt.
2. Deep slope (mostly trawlable habitat on shelf break and continental slope extending out to about 1500m bottom depth) includes primarily sablefish, dover sole, shortraker and roughey rockfish, shortspine thornyheads, longspine thornyheads, Pacific grenadier. This assemblage supports

a valuable trawl fishery, plus sablefish is a target of pot and hook&line fishers.

3. Demersal Shelf (mostly trawl caught species on continental shelf and upper slope, but many species occur over rocky habitat and some species have significant off-bottom tendencies). This assemblage includes rockfish species, flatfish, Atka mackerel and Pacific cod. The fishery is trawl for most species; however, Pacific cod is taken by hook&line and pot gear.

4. Pelagic shelf rockfish (mostly in high relief habitat) includes several of rockfish species.

#### ***AFSC current situation – Bering Sea / Aleutian Islands (BSAI)***

Among the 145 groundfish species covered by the BSAI FMP of the NPFMC, 133 are assessed at a Level 1 or better (**Appendix 1**). These species exhibit great diversity in life history traits. Many have been the targets of fishery monitoring and resource survey programs that provide the basic information for quantitative stock assessments. Not all these assessments have the same level of information and precision. Of the 133 assessed species, only 15 are assessed using staged base models (Level 4 or above). In the case of 128 of the 145 species covered by the FMP, there is insufficient information to determine whether or not the stocks are overfished or approaching an overfished condition. Some of these species are the target of developing fisheries.

The 145 groundfish species can be roughly broken into four assemblages based upon their adult habitat and co-occurrence in the fishery. This breakout will facilitate discussion of fishery monitoring and resource survey programs:

1. Midwater schooling- Walleye pollock, eulachon and squid are amenable to acoustic survey methods. Walleye pollock supports a midwater trawl fishery with annual catch near 1,000,000 mt.
2. Deep slope (mostly trawlable habitat on shelf break and continental slope extending out to about 1500m bottom depth) includes primarily sablefish, Greenland turbot, shortraker and roughey rockfish, and shortspine thornyheads. This assemblage supports a valuable trawl fishery, plus sablefish is a target of pot and hook&line fishers.
3. Demersal Shelf (mostly trawl caught species on continental shelf and upper slope, but many species occur over rocky habitat and some species have significant off-bottom tendencies). This assemblage includes rockfish, flat-

fish, Atka mackerel, crab and Pacific cod. The fishery for this assemblage is primarily trawl for most species however, Pacific cod are taken by hook&line and pot gear, and crab are taken with pot gear.

4. Pelagic shelf rockfish (mostly in high relief habitat) includes several of rockfish species.

Three crab stocks are currently listed as overfished: Bering Sea Tanner crab, Bering Sea snow crab and Saint Mathews Island Blue King Crab. Rebuilding plans need to be developed and subsequently monitored for these crab stocks. Building such plans will be difficult given the lack of life history and stage based information for these resources. Increased stock assessment effort will primarily elucidate the underlying factors contributing to recent declines in production.

### ***AFSC programs and staffing required to meet the three tiers of excellence***

#### *Tier 1: Improve stock assessments using existing data*

Bringing all Alaskan groundfish and crab species to a Tier 1 level will require additional stock assessment, data processing and ecological staff to make the best use of existing data. New personnel identified under Tier 1 (**Table 6**) would utilize existing fishery dependent and fishery independent data to facilitate the development of assessments for several new species and to improve existing assessments to the extent possible. To accomplish the first part of this objective, additional staff are needed to construct assessments for species where historical data is spotty or uncertain. AFSC scientists are exploring modeling approaches that draw on life history information from similar species to parameterize first generation assessments for poorly studied species. Additional assessment scientists

**Table 6.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for the Alaska Fisheries Science Center. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and "other," which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>
	<i>In-house</i>	<i>Contract</i>	<i>Other</i>				
Commercial Catch & Biological Sampling *			6				
Recreational Catch & Biological Sampling +							
Observer Programs	20	114			21	21	10
Fishery-independent Surveys	63.5	1	27		19	19	10
Process Biological Samples (age, growth, maturity, etc.)	21	3	7	7	8	15	21
Data Management & Preprocessing of Data	24.5	3	3	6		6	1
Conduct Assessments	10		3	10	10	20	2
Assessment Methods Research	8	1	3	3	3	6	4
Communication of Results & Follow-up Evaluations	7		5	5	5	10	3
<b>Subtotal (Assessment scientists)</b>	<b>25</b>	<b>1</b>	<b>11</b>	<b>18</b>	<b>18</b>	<b>36</b>	<b>9</b>
<b>Subtotal (Others)</b>	<b>129</b>	<b>121</b>	<b>43</b>	<b>13</b>	<b>48</b>	<b>61</b>	<b>42</b>
<b>Total</b>	<b>154</b>	<b>122</b>	<b>54</b>	<b>31</b>	<b>66</b>	<b>97</b>	<b>51</b>

\* Observer program includes shore-side samplers.

+ Recreational data not applicable.

could assist in developing overfishing criteria when information regarding the status of the stock is missing or intermittent. Assessment scientists and statisticians are needed to assist in reviewing the sampling design of proposed or existing fishery independent and fishery dependent sampling programs. This research effort would require a retrospective analysis of existing data to evaluate the efficiency of the current data collection program and to make recommendations for improvements in sampling design. Additional analytical staff could conduct research to better quantify and communicate the uncertainty in current assessments. Improved models will structure implementation of a more formal precautionary approach to harvest management. A final area of improvement is in the development of assessment models that fully utilize existing information on top down (predator/prey) influences on time trends in natural mortality, and bottom up on marine survival at early life stages in spatially explicit modes. AFSC is well positioned to advance this type of state-of-the-art stock assessment. The combination of a long history of data collection on the food habits of groundfish in the Eastern Bering Sea and Gulf of Alaska make the development of models that model top down forcing a realistic goal. Likewise, the long history of fisheries oceanographic process oriented research supported by the Fisheries Oceanography Coordinated Investigations provides the necessary knowledge of lower trophic level forcing required to implement a fully coupled model.

#### *Tier 2: Elevate stock assessments to new national standards*

Medium-term improvements in major data sources can lead to substantial improvements in assessment precision within about 10 years. These include major programs such as periodic resource assessment surveys, expanding and improving at-sea monitoring of total catch, collection of genetic stock structure data for more species, and evaluation of fish association with particular habitats. Beyond routine monitoring, research should be devoted to studies of factors that may influence survey standardization, and development of cost-effective survey technologies that are not susceptible to environmental influences on standardization.

Additional staff would be required to achieve a Tier 2 level of analysis for BSAI and GOA groundfish. Tier 2 envisions that assessments of core species would be upgraded at least Level 3 and would provide adequate baseline assessments for all managed species. Fishery dependent and fishery independent data collection are needed to achieve Tier 2. These staff members would be responsible for compiling and analyzing data for species currently managed as species groups (e.g. other flatfish, other rockfish and other species).

#### *GOA assessment needs to achieve Tier 2*

In the current implementation of the observer program, observers monitor catch and collect biological information on 70 of the 100 groundfish species in the Gulf of Alaska. Several minor species are classified into general categories. Skates are almost always recorded as “skate unidentified,” with very few exceptions between 1990-1998. In the Gulf of Alaska, at least 80% of the recorded sculpin catch by year is recorded as “sculpin unidentified,” with the remainder of the catch identified to the genus level. Only small amounts (<2%) of the sculpin catch each year were identified to species. Likewise, octopus and squid are generally not identified to species in the observer database. Octopus can only be recorded as “octopus unidentified,” or “pelagic octopus unidentified.” Eulachon and capelin are recorded to species more often than sculpins but in 1998, approximately 80% of their catch was recorded as “smelt unidentified.” Monitoring the catch of these minor species would require additional staff to train and implement an expanded observer program.

Groundfish populations are routinely monitored by fishery independent surveys. A longline survey is conducted annually for sablefish. A gulf-wide trawl survey of the shelf areas of the Gulf of Alaska has been conducted on a triennial basis since 1984. Current operating plans call for future surveys to occur on a biennial basis. An acoustic survey of a major spawning concentration of walleye pollock in Shelikof Strait is conducted on an annual basis. These surveys provide a calibrated abundance measure (Level 2 or above) for only 4 species (**Appendix 1**). These surveys provide an index of abundance for 83 species (**Appendix 1**). To achieve Tier 2 level analysis additional effort should be devoted to obtaining and analyzing the life history of characteristics of species captured in the longline or trawl surveys (e.g. regional differences in growth, maturity, and habitat association).

For species such as small soft-bottom roundfishes (sculpins, poachers, eelpouts, and skates) the existing time series of trawl survey data is inconsistent because of differing levels of species identification. Starting in 1999 this problem was nearly eliminated because all survey vessels had new species identification guides that included photos of all known species. Species identification has therefore been greatly increased with very little cost. An existing problem for these species in the GOA, however, is that they are likely to have very low catchability by the survey trawls and it is uncertain how well research vessel CPUE tracks stock size. Assessment of these species could be improved using auxiliary trawl experiments to measure escapement under the footrope.

Many species of rockfish are not well sampled because they occur in areas that are too rough to be sampled with our usual survey nets and, additionally, some species (e.g. Pacific Ocean perch, northern rockfish, and dusky rockfish) are extremely patchy and not likely to be well sampled in the present bottom trawl survey. Considerable work has been done in attempt to develop a rockfish specific survey, but the best approach has yet to be developed. To improve the survey assessment of rockfish we need more research on gear design and sampling techniques. Once the appropriate technique is developed, it will undoubtedly require a distinctly different survey design than is now used and could not be incorporated into the current normal survey operations. Additional work will be required to develop appropriate techniques for the semi-pelagic species.

Fishery independent collections of age, length frequency and size at maturity are obtained for the core species (about 20 species, mostly rockfish and slope species, split between GOA, AI, and EBS). Expanding the age collections to include the remaining species would require collecting otoliths for additional species on surveys and could be accomplished without a large increase in money or manpower. However, additional staff would be needed to conduct the age determinations. Obtaining size at maturity information would require a considerable increase in research cruises to collect species at a time that is close enough to spawning so that mature or recently spent fish are easily recognized. Most survey or research cruises at the AFSC are currently conducted in the summer, after most species have completed spawning. In addition, a sampling strategy must be worked out so that a sufficient number of small and immature fish are collected.

Acoustic-trawl surveys in Alaska conducted by the Resource Assessment and Conservation Ecology Division (RACE) focus on walleye pollock as a target species. All aspects of survey design (e.g. area, timing, sampling intensity, etc.) are devised to assess the distribution and abundance of pollock. Pollock is ideally suited for acoustic assessment due to its semi-demersal nature, widespread distribution, and tendency to form monospecific aggregations. During RACE acoustic-trawl surveys, other pelagic fish species are encountered in very low numbers. Existing acoustic data could provide some information on eulachon occurrence observed during the 1980-1998 winter-spring Shelikof Strait surveys. Expanding the current acoustic program to routinely monitor eulachon would require a significant effort, including both staff and vessel time. Additional trawling would be needed and extended tracklines may be necessary.

Application of an acoustic-trawl survey approach to other FMP species (e.g. rockfish, capelin, squid, etc.) has been successful under certain circumstances, but would require a substantial amount of work (e.g. literature reviews and feasibility studies) merely to make a good guess of the resources required. A significant amount of preliminary research would be necessary to simply estimate the staff and funding necessary to fund each project.

#### *Bering Sea / Aleutian Islands assessment needs to achieve Tier 2*

Bering Sea and Aleutian Island groundfish populations are routinely monitored by fishery independent surveys. A longline survey for sablefish is conducted in alternate years in either the Bering Sea or the Aleutian Islands. Groundfish trawl surveys of the Eastern Bering Sea shelf have been conducted on an annual basis since 1979. Groundfish trawl surveys are conducted on a triennial basis in the Aleutian Islands region. Current operating plans call for future surveys of the Aleutian Islands region on a biennial basis. Acoustic surveys of major spawning concentrations of walleye pollock near Bogoslof Island are conducted on an annual basis. An acoustic survey of walleye pollock on the Eastern Bering Sea shelf has been conducted on a triennial basis since 1979. These surveys provide a calibrated abundance measure (Level 2 or above) for 76 species (**Appendix 1**). These surveys provide an index of abundance (Level 1) for an additional 47 species (**Appendix 1**).

As in the case of the Gulf of Alaska, the existing time series of trawl survey data for species such as small soft-bottom roundfishes (sculpins, poachers, eelpouts, and skates) may provide inconsistent results because of differing levels of species identification. This problem has been addressed through the addition of new species identification guides which included photos of all known species. However, as in the GOA, it is likely that these species have very low catchability by the survey trawls in the Aleutian Islands region. Assessment of these species could be improved using auxiliary trawl experiments to measure escapement under the footrope.

Many species of rockfish are not well sampled by the Aleutian Island trawl survey because they occur in areas that are too rough to be sampled with our usual survey nets and, additionally, some species (e.g. Pacific Ocean perch and northern rockfish) are extremely patchy and not likely to be well sampled in the present bottom trawl surveys. Nevertheless, the current Aleutian Island trawl survey does provide an index of abundance for several rockfish species, and rockfish age data are collected during the surveys. Additional research is needed to design a calibrated survey for rockfish.

Staffing needs to expand fishery independent collections of age, length frequency and size at maturity were discussed in the section on GOA fishery independent surveys.

During Midwater Assessment and Conservation Engineering (MACE) acoustic-trawl surveys, other pelagic fish species are encountered in very low numbers. Existing acoustic data could provide some information on eulachon occurrence observed during the 1980-1998 winter-spring Bogoslof Island surveys. Expanding the current acoustic program to routinely monitor eulachon would require a significant effort - including both staff and vessel time. Additional trawling would be needed and extended tracklines may be necessary.

### *Tier 3: Next generation assessments*

A substantial increase in stock assessment staff would be required to achieve a Tier 3 level of analysis for BSAI and GOA groundfish. Tier 3 assessments would account for both biological and technological interactions and integration of biological and environmental data that may lead to more reliable long-range predictions. To accomplish this goal necessitates the implementation of fisheries oceanographic research programs for a broad spectrum of species. At the current time AFSC primarily supports fisheries oceanographic research on walleye pollock. Likewise, additional staff would be required to provide information on potential trophic interactions between species. Assessment scientists would be required to develop a broader spectrum of assessment modeling tools to address the complex interactions envisioned under Tier 3. In addition to the complex modeling activities envisioned for core species, additional stock assessment scientists would be required to conduct basic assessment functions for all species covered by the FMP.

## **E. Summary: National Resource Requirements**

Current FTEs and FTEs required to achieve the objectives of the three Tiers of assessment Excellence are summarized by Science Center, Tiers of Assessment Excellence, and activity in **Figure 15**. Similar but more detailed summaries are provided in **Tables 7** and **8**. **Table 7** sums the FTE requirements for Tiers 1, 2 and 3 by major activity for all five NMFS Science Centers combined. Almost three times as many additional staff are needed to collect, manage and process data, as compared to additional staff needed to conduct and communicate stock assessments, to evaluate alternative management strategies, and to conduct research

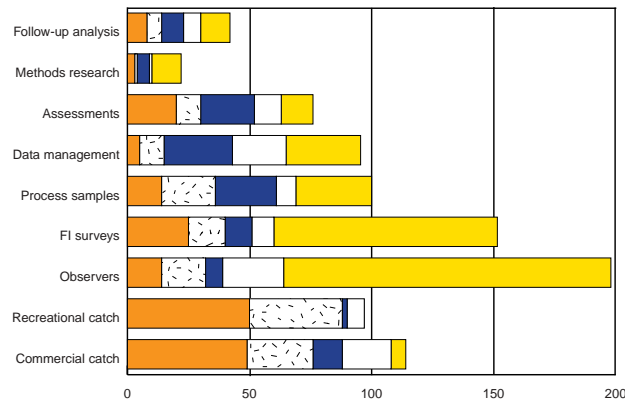
into assessment methods. By far the greatest overall need is for observers for Tier 2, particularly in the Southeast, Northwest and Alaska Science Centers. The second greatest overall need is for staff to participate in fishery-independent surveys (note, however, that this is contingent on the acquisition of adequate Fisheries Research Vessels, as outlined in the NOAA Fisheries Data Acquisition Plan, NMFS 1998c; **Appendix 3**).

**Table 8** summarizes the total FTEs requirements for Tiers 1, 2 and 3 for each Science Center and all Centers combined. In terms of current in-house staff, contract employees, and others who provide assessment data (e.g. state government biologists, and employees or contractors associated with various regional, national and international Commissions), the Alaska Center is the largest with 330 FTEs, the Northeast Center is second with 188, the Southeast Center is third with 147, the Southwest Center is fourth with 121, and the Northwest Center has 110. (These numbers apply to the baseline of January 2000, except where otherwise noted in **Tables 2-6**; in particular, the Northwest Center total includes 25 observers hired in FY2001). Considering the sum of Tier 1 and 2 requirements, the Alaska, Northeast, and Southeast Centers require additions of about 30-40% to existing staff, whereas the Southwest Center requires an addition of about 70%, and the Northwest Center an addition of about 80%. To calculate the approximate costs of new FTEs to satisfy Tiers 1, 2 and 3, a multiplying factor of \$150,000 per annum was used. This number takes into account salary and benefits, travel, training, equipment and individual Information Technology needs (although not the core systems needed for data management and communications); i.e. the multiplier covers everything except major infrastructure, particularly new workspace and buildings that may be required.

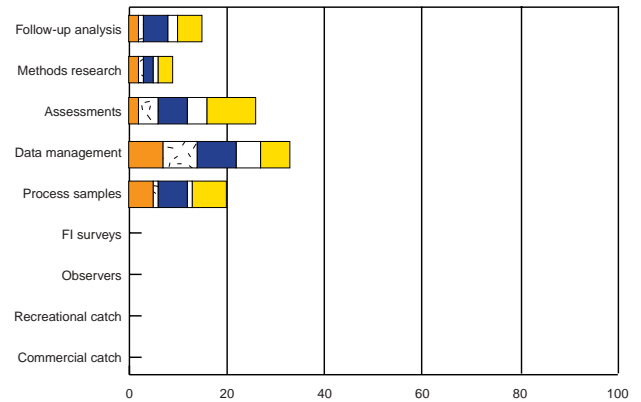
The numbers of additional staff indicated in **Tables 2-8** may seem staggering, but these numbers have been carefully thought through by the Task Force members. They simply represent the increasing demands being placed on NMFS to assess more stocks more frequently, and with greater accuracy, precision and timeliness; to incorporate associated non-target species and other ecosystem considerations into the analyses; and to evaluate a wider array of management options on increasingly finer temporal and spatial scales. In addition, as outlined in the Introduction, the FTE requirements detailed here are meant to complement other related NMFS plans such as the Data Acquisition Plan (NMFS 1998a; **Appendix 3**), which is primarily concerned with the costs of operating dedicated fishery research vessels and purchasing charter boat days at sea; the Stock Assessment Toolbox Plan (**Appendix 4**); the Center for Independent Experts Program (**Appendix 5**); the Pro-



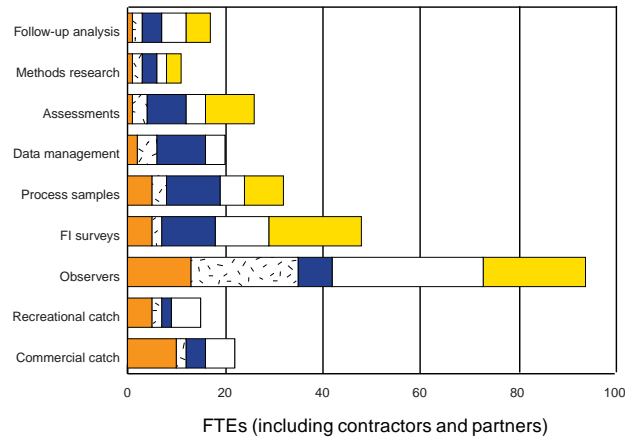
### Current Situation



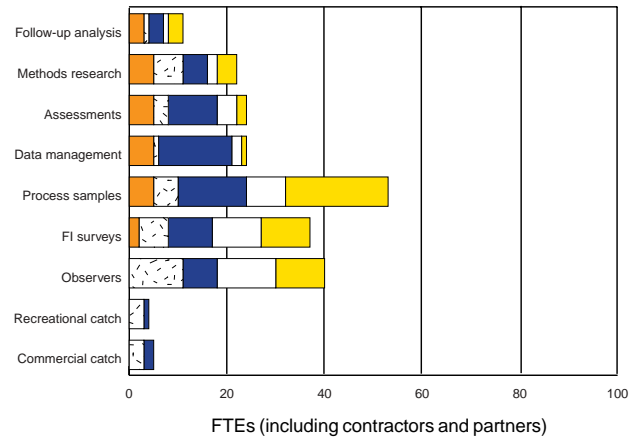
### Tier 1 Requirements



### Tier 2 Requirements



### Tier 3 Requirements



**Figure 15.**

Summary of FTE requirements by Science Center, Tiers of Assessment Excellence, and activity. FI=Fishery-independent.

posed Implementation of a Fishing Vessel Registration and Fisheries Information Management System (**Appendix 8**); the NMFS Bycatch Plan (**Appendix 9**); the National Observer Program (**Appendix 10**), the Social Sciences Plan (**Appendix 11**), the Advanced Technologies Working Group (**Appendix 12**), and relevant fisheries oceanography initiatives (e.g. **Appendix 13**). In order to develop a comprehensive ecosystem approach to fisheries stock assessments and management, and to estimate the actual costs of implementing ecosystem-based management (EBM), these and related plans, initiatives and activities should be merged into an umbrella plan.

## F. The Benefits of Implementing the Stock Assessment Improvement Plan

The benefits of implementing the Stock Assessment Improvement Plan are numerous and diverse. With adequate additional trained staff, existing databases can be mined for material to improve analyses for major target stocks and for currently overfished stocks, and to develop new analyses for stocks of currently unknown status. The benefits arising from Tier 1 alone will, however, be limited because the most important need is for new and expanded data collection programs. Ultimately, these will lead to greater numbers of stocks being assessed with higher frequency, and greater accuracy, precision and timeliness.

**Table 7.**

FTEs required to meet the three Tiers of Assessment Excellence by type of activity for all NMFS Science Centers combined. Numbers of FTEs in each category do not necessarily reflect the actual number of individuals involved in these activities, in that some individuals may divide their time between several activities. Estimated current FTEs include in-house staff, contractors such as observers, and "other," which includes state government biologists, and employees or contractors associated with various regional, national and international Commissions. Follow-up evaluations include the production of additional assessment outputs, evaluations of alternative management strategies, and participation in plan development teams. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>	<i>All Tiers</i>
	<i>In-house</i>	<i>Contract</i>	<i>Other</i>					
Commercial Catch & Biological Sampling	41	27	46		22	<b>22</b>	5	27
Recreational Catch & Biological Sampling	57	6	34		15	<b>15</b>	4	19
Observer Programs	34	160	4		94	<b>94</b>	40	134
Fishery-independent Surveys	94.5	18	39		48	<b>48</b>	37	85
Process Biological Samples (age, growth, maturity, etc.)	65	18	17	20	32	<b>52</b>	53	105
Data Management & Preprocessing of Data	58.5	12	25	33	20	<b>53</b>	24	77
Conduct Assessments	49	4	23+	26	26	<b>52</b>	24	76
Assessment Methods Research	15	2	5	9	11	<b>20</b>	22	42
Communication of Results & Follow-up Evaluations	32	2	8	15	17	<b>32</b>	11	43
<b>Subtotal (Assessment scientists)</b>	<b>96</b>	<b>8</b>	<b>36+</b>	<b>50</b>	<b>54</b>	<b>104</b>	<b>57</b>	<b>161</b>
<b>Subtotal (Others)</b>	<b>350</b>	<b>241</b>	<b>165</b>	<b>53</b>	<b>231</b>	<b>284</b>	<b>163</b>	<b>447</b>
<b>Total</b>	<b>446</b>	<b>249</b>	<b>201</b>	<b>103</b>	<b>285</b>	<b>388</b>	<b>220</b>	<b>608</b>

**Table 8.**

Total Full-Time Equivalent (FTEs) required to meet the three Tiers of Assessment Excellence for each Science Center and all Centers combined. Estimated current FTEs include in-house staff, contractors such as observers, and "other," which includes state government biologists, and employees or contractors associated with various regional, national and international commissions. Numbers should be cumulated across tiers.

<i>Activity</i>	<i>Current</i>			<i>Tier 1</i>	<i>Tier 2</i>	<i>Tier 1+2</i>	<i>Tier 3</i>	<i>All Tiers</i>
	<i>In-house</i>	<i>Contract</i>	<i>Other</i>					
NEFSC	123	49	16	18	43	<b>61</b>	25	86
SEFSC	71	30	46	14	42	<b>56</b>	39	95
SWFSC	80	15	26+	27	60	<b>87</b>	66	153
NWFSC	18	33	59	13	74	<b>87</b>	39	126
AFSC	154	122	54	31	66	<b>97</b>	51	148
<b>Summed FTEs</b>	<b>446</b>	<b>249</b>	<b>201</b>	<b>103</b>	<b>285</b>	<b>388</b>	<b>220</b>	<b>608</b>
<b>\$ \$ (FTE x \$150K)</b>				<b>\$15,450K</b>	<b>\$42,750K</b>	<b>\$58,200K</b>	<b>\$33,000K</b>	<b>\$91,200K</b>

Incorporation of ecosystem considerations into the analyses will facilitate analysis of trade-offs between harvesting target species and protecting non-target species such as marine mammals. The enhanced data collection and analysis activities proposed herein will also result in more accurate projections of future stock status under various alternative management strategies, and will enable evaluation of an increasingly wider array of management options on finer temporal and spatial scales, both of which will improve the basis for management decisions.

An improved knowledge base, improved ongoing data collection programs, and more comprehensive models should reduce the frequency of risk-prone management decisions, which have been common in many regions of the United States to date. This in turn will enable higher catches on average, at less risk to fisheries resources. The risk of non-target marine species becoming rare or extinct should also be considerably diminished, particularly in comparison to the current situation in which species could potentially be disappearing without us even being aware of it.

Overall, implementation of the Stock Assessment Improvement Plan will result in a greatly improved knowledge base for marine species, and a better basis for risk-averse man-

agement decisions which will result in fewer depleted or overfished stocks and greater stability and profitability in the fish harvesting sector. However, it should be noted that improved knowledge and enhanced stock assessment capability will not by themselves result in fewer overfished stocks and a more stable fishing industry; there must be a concomitant commitment to responsible fisheries management and fisheries policy development.

Another benefit of implementing the SAIP will be to improve relations between NMFS and other line offices within NOAA, other federal agencies, state agencies, academia, the commercial and recreational fishing industries, and environmental groups by promoting cooperative research and other types of partnerships. NMFS' own programs and those developed through such partnerships should also result in spin-offs in terms of monitoring information and research that can provide input into other programs; for example, risk and damage assessments. The resulting database of spatial and temporal distributions of marine species, associations between species, oceanographic variables, and habitat relationships will also be an invaluable source of raw material with which to develop and test hypotheses about population dynamics and ecosystem structure and function.

