

June 2004

PACIFIC
GROUND FISH

Continued Efforts
Needed to Improve
Reliability of Stock
Assessments



G A O

Accountability * Integrity * Reliability



Highlights of [GAO-04-606](#), a report to congressional requesters

Why GAO Did This Study

Because of concerns raised about the accuracy of National Marine Fisheries Service (NMFS) stock assessments, GAO reviewed the assessments for five species of Pacific groundfish: Pacific hake and four types of rockfish—bocaccio, canary, darkblotched, and yelloweye. Specifically, for these five species GAO (1) assessed the reliability of NMFS' stock assessments, (2) identified which relevant recommendations from NMFS' stock assessment improvement plan have been implemented and which have not, and (3) identified the costs associated with planned and ongoing improvements to groundfish stock assessments.

What GAO Recommends

GAO recommends that the Secretary of Commerce require the Director of NMFS to take actions to improve the reliability of stock assessments, such as continuing efforts to improve the quality and types of data used in groundfish assessments, establishing a standard approach that requires that data used in stock assessments be evaluated for reliability, and requiring stock assessment reports clearly present the uncertainties in the assessments.

NOAA generally agreed with the report's accuracy and agreed with the report's recommendations, but expressed concern that the report's conclusion could be misconstrued to infer that the assessments are unreliable for use in managing the west coast groundfish fishery.

www.gao.gov/cgi-bin/getrpt?GAO-04-606.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Anu K. Mittal at (202) 512-3841 or MittalA@gao.gov.

PACIFIC GROUND FISH

Continued Efforts Needed to Improve Reliability of Stock Assessments

What GAO Found

The reliability of the NMFS assessments is questionable for the five species GAO reviewed, although the assessments were based on the best information available at the time they were conducted. According to NMFS officials and a National Research Council report, to obtain reliable results each stock assessment should include at least one NMFS data source of sufficient scope and accuracy because such data are derived from unbiased, statistical designs. However, in the yelloweye assessment, no NMFS data were used, and in the darkblotched, canary, and bocaccio assessments, the NMFS data were limited because the NMFS' surveys were conducted in trawlable waters only. A 2003 NMFS report concluded that darkblotched groundfish are less abundant and bocaccio and canary are more abundant in untrawlable waters. Also for all five species, NMFS lacks a standard approach for ensuring the reliability of non-NMFS data used in stock assessments. Some assessors reviewed the quality of non-NMFS data; others did not. The assessors who reviewed the quality of the non-NMFS data found errors that made some of the data unusable or that could have impaired the reliability of certain stock assessments. Finally, for four species, the stock assessment reports were questionable because they did not present the uncertainty associated with the population estimates. For example, the canary stock assessment review panel recommended that standard estimates of uncertainty be included in the assessment report because without them it is difficult to determine their reliability.

NMFS has taken steps to implement some of the recommendations contained in the NMFS stock assessment improvement plan, but much remains to be done. NMFS has concentrated its efforts mostly on improving data quantity. For example, NMFS increased the frequency of groundfish stock assessments and extended the geographic ranges of the shelf and slope surveys to cover over 300 more miles along the southern California coast. However, because of staffing and funding limitations, NMFS has not yet implemented many of the recommendations aimed at obtaining more types of data and improving data quality. For example, NMFS has not collected enough ecosystem data, and the frequency and range of recruitment surveys (estimated production of new members of a fish population) are limited. Finally, because of other program priorities, NMFS has not implemented the recommendation to create a comprehensive plan that combines the improvement plan and its complementary plans.

NMFS records indicate at least \$8.9 million is needed to complete ongoing and planned stock assessment improvements—\$2.6 million that NMFS' Northwest Fisheries Science Center requested but did not receive in fiscal years 2001 to 2003, and \$6.3 million requested for fiscal years 2004 and 2005. It will cost about (1) \$7.7 million to improve the types of data used, such as more untrawlable water and recruitment surveys and (2) \$1.2 million to improve the quality of data used in stock assessments, such as enhanced calibration of vessel equipment and standardized trawl survey procedures. The actual cost of the remaining improvements may be even higher than the \$8.9 million estimated because the estimates primarily reflect the amount of money that agency officials believed could be realistically obtained, rather than what the improvements might cost.

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Abbreviations

NMFS National Marine Fisheries Service
NOAA National Oceanic and Atmospheric Administration

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United States General Accounting Office
Washington, D.C. 20548

June 4, 2004

The Honorable Gordon H. Smith
United States Senate

The Honorable Ron Wyden
United States Senate

Pacific groundfish, 82 species of bottom-dwelling fish, such as several species of rockfish and sole, have contributed to the economies of fishing communities in California, Oregon, and Washington, generating over \$220 million in income in 2001. However, some populations of Pacific groundfish have declined sharply because of natural conditions, such as climate, as well as man-made conditions, such as overfishing. In an effort to achieve sustainable populations, the National Marine Fisheries Service (NMFS) significantly reduced the allowable harvest for nine species of Pacific groundfish. NMFS made this decision based on its stock assessments—which include estimates of species' total biomass (weight of the total population)—and recommendations from the Pacific Fishery Management Council, one of eight councils responsible for managing fisheries in federal waters.

NMFS generally uses internal scientists or contracts with outside experts to conduct stock assessments. These assessors use multiple types of data, including data from external sources, such as state-collected data on the poundage and species of fish brought ashore by commercial and recreational fishermen. NMFS' Northwest Fisheries Science Center (Northwest Center), which coordinates Pacific groundfish stock assessments, also collects its own data through fish population surveys, particularly two key surveys: (1) the shelf and slope bottom trawl survey, in which a trawl net is dragged along the ocean floor, and the resulting catch is sorted, counted, and biologically examined (e.g., age and sex) and (2) the acoustic survey, in which sound waves are used to measure density of schools of groundfish in mid-level waters; bottom trawls are not feasible in these waters. Fish survey and other data are entered into computerized mathematical models (stock assessment models), which estimate the total biomass for the fish species being assessed. However, concerns have been raised about the accuracy of stock assessments and therefore whether they can be relied upon to specify the amount of fish that can be harvested to ensure a sustainable population.

In 1999, NMFS commissioned a national task force to review the stock assessment process across the agency. Task force members were from NMFS headquarters and five of the six NMFS science centers, including the Northwest Center. In the October 2001 Marine Fisheries Stock Assessment Improvement Plan,¹ the task force identified a lack of adequate data as the greatest impediment to producing reliable stock assessments and recommended actions to improve the quantity, quality, and types of data used in the models that estimate biomass. The task force also identified a need to better communicate and quantify uncertainties in these models.

In this context, you requested that we review NMFS' stock assessments for five species of Pacific groundfish: Pacific hake as well as four types of rockfish—bocaccio, canary, darkblotched, and yelloweye. Specifically, for these five species you asked us to (1) assess the reliability of NMFS' stock assessments, (2) identify which relevant recommendations from the stock assessment improvement plan have been implemented and which have not, and (3) identify the estimated costs associated with planned and ongoing improvements to groundfish stock assessments.

To address these issues, we reviewed key laws and stock assessment studies (2002 and 2004 studies for Pacific hake, 2002 and 2003 studies for bocaccio, 2002 study for canary, 2000 and 2003 studies for darkblotched, and 2001 and 2002 studies for yelloweye), along with the types of fish population surveys used and the controls over stock assessment data. We spoke with officials from NMFS, the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the California Department of Fish and Game, the Pacific Fishery Management Council, the Pacific States Marine Fisheries Commission, environmental groups, and industry associations, as well as fishermen and academics. We also reviewed NMFS' budget documents to develop cost estimates. We did not simulate NMFS' stock assessment models or evaluate the mathematical and statistical methodologies used in the models. We conducted our review from May 2003 through April 2004 in accordance with generally accepted government auditing standards. See appendix I for additional details on our scope and methodology.

¹*Marine Fisheries Stock Assessment Improvement Plan*, U.S. Department of Commerce, NOAA Tech. Memo. NMFS-F/SPO-56, 69, 2001.

Results in Brief

For a variety of reasons, the reliability of the NMFS assessments is questionable for the five species we reviewed, although the assessments were based on the best information available at the time they were conducted. First, according to NMFS officials and a 1998 National Research Council report, to obtain reliable results, each stock assessment should include at least one source of NMFS-collected data of sufficient scope and accuracy because such data are derived from unbiased, statistical, and scientific designs. However, the four rockfish assessments did not meet this standard, although the assessment for Pacific hake did. NMFS did not use any of its own data in the yelloweye assessment, and the NMFS data used in the bocaccio, canary, and darkblotched assessments were limited because NMFS conducted its surveys in trawlable waters only; these fish also inhabit both trawlable and untrawlable waters. In the absence of data from rocky, untrawlable waters, the assessors estimated overall biomass using the NMFS data collected from the trawlable areas. However, in 2003, NMFS found that darkblotched are less abundant and bocaccio and canary are more abundant in untrawlable waters. As a result, some rockfish populations may be overstated, while others may be understated. Second, for all the species, NMFS lacks a standard approach for ensuring the reliability of non-NMFS data used in the stock assessments. As a result, some assessors reviewed the quality of these data while others did not. The assessors who reviewed the quality of the non-NMFS data found errors that they believed made the data unusable or impaired the reliability of the stock assessment. Finally, the reliability of four of the stock assessment reports—bocaccio, canary, darkblotched, and yelloweye—is questionable because they did not present the uncertainty associated with the population estimates. The National Research Council, NMFS, and GAO agree that estimates of uncertainty should be included in stock assessment reports because without them it is difficult to determine their reliability.

NMFS has taken steps to implement the NMFS stock assessment improvement plan recommendations to improve stock assessments, but much remains to be done to enhance their reliability. While the task force considered the lack of adequate data—in quantity, quality, and type—as the greatest impediment to accurate stock assessments, the Northwest Center has concentrated most of its efforts on improving data quantity. For example, starting in 2003, the Northwest Center extended the geographic ranges of the shelf and slope surveys, expanding them to cover over 300 additional miles along the southern California coast. It also increased the frequency of the groundfish shelf and slope survey from triennially to annually and the frequency of the Pacific hake acoustic survey from

triennially to biennially. However, NMFS has not yet fully implemented many of the recommendations aimed at obtaining more types of data and improving data quality. For example, although Northwest Center officials recognize that recruitment surveys (estimated production of new members of a fish population) should be conducted biannually along the entire coast, these surveys are currently conducted only annually and only in selected regions. While Northwest Center officials also recognize that actions, such as calibrating vessel equipment to ensure comparable survey data, are needed to improve data quality, these actions have not yet been fully implemented. Finally, NMFS has not implemented the recommendation to create a comprehensive plan that combines the improvement plan and related plans to develop integrated program initiatives. Although NMFS officials recognize a need for such a plan, other priorities have precluded them from developing it.

According to NMFS funding and budget documents, NMFS needs at least \$8.9 million to complete ongoing and planned improvements to its stock assessments of Pacific groundfish—\$2.6 million that the Northwest Center had requested but did not receive in fiscal years 2001 through 2003, and \$6.3 million requested for fiscal years 2004 and 2005. Specifically, according to these records, the Northwest Center has the following funding needs:

- \$7.7 million to improve the types of data used, including \$2.4 million for surveys of untrawlable waters, \$2.1 million to expand acoustic and recruitment surveys, and \$3.2 million to collect ecosystem data and
- \$1.2 million to improve the quality of data used in stock assessments, including \$600,000 to enhance the calibration of vessel equipment, \$525,000 to develop and implement methods to more accurately distinguish among groundfish species, and \$75,000 to standardize trawl survey procedures.

The actual cost of implementing improvements to Pacific groundfish stock assessments may be even higher than the \$8.9 million estimated because the Northwest Center's budget requests primarily reflect the amount of money the Center believed it could realistically obtain, rather than what the improvements would cost, according to NMFS officials.

Background

The Magnuson-Stevens Fisheries Conservation and Management Act granted responsibility for managing marine resources to the Secretary of Commerce.² The Secretary delegated this responsibility to NMFS, which is part of Commerce's National Oceanic and Atmospheric Administration (NOAA). The act also established eight regional fishery management councils, each responsible for making recommendations to the Secretary of Commerce about managing fisheries in federal waters. The eight fishery management councils—consisting of fishing industry participants, state and federal fishery managers, and other interested parties—and their areas of responsibility include the following:

- Caribbean Council, covering waters off the U.S. Virgin Islands and the Commonwealth of Puerto Rico;
- Gulf of Mexico Council, covering waters off Texas, Louisiana, Mississippi, Alabama, and the west coast of Florida;
- Mid-Atlantic Council, covering waters off New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina;
- New England Council, covering waters off Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut;
- North Pacific Council, covering waters off Alaska;
- Pacific Council, covering waters off California, Oregon, and Washington;
- South Atlantic Council, covering waters off North Carolina, South Carolina, Georgia, and the east coast of Florida; and
- Western Pacific Council, covering waters off Hawaii, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and uninhabited U.S. territories in the Western Pacific.

In addition to these eight councils, NMFS has six regional science centers, which are responsible for generating the scientific information necessary for the conservation, management, and use of each region's marine

²Pub. L. No. 94-265, 90 Stat. 331 (codified as amended at 16 U.S.C. §§ 1801-1883).

resources. The six fishery science centers and their areas of responsibility are as follows:

- Alaska Center, covering the coastal oceans off Alaska and parts of the west coast of the United States;
- Northeast Center, covering waters along the Northeast Continental Shelf from the Gulf of Maine to Cape Hatteras, North Carolina;
- Northwest Center, covering the northeast Pacific Ocean, primarily waters off the coasts of California, Oregon, Washington, and British Columbia;³
- Pacific Islands Center, covering the central and western Pacific Ocean;
- Southwest Center, primarily covering waters off the coast of California and areas throughout the Pacific and Antarctic Oceans;⁴ and
- Southeast Center, covering waters along the continental southeastern United States as well as Puerto Rico and the U.S. Virgin Islands.

The Magnuson-Stevens Act, as amended by the Sustainable Fisheries Act,⁵ also established national standards for fishery conservation and management. These standards deal with preventing overfishing, using scientific information, using fishery resources efficiently, minimizing bycatch,⁶ and minimizing administrative costs. The regional councils use these standards to develop appropriate plans for conserving and managing fisheries under their jurisdiction, including measures to prevent overfishing and to rebuild overfished stocks as well as measures to protect, restore, and promote the long-term health and stability of the fishery.

³In addition, the Northwest Center and the Southwest Center share some responsibilities in freshwater rivers and streams in Idaho, Oregon, Montana, and Washington.

⁴Ibid.

⁵Pub. L. No. 104-297, 110 Stat. 3559 (1996).

⁶Under the Magnuson-Stevens Act, “bycatch” means fish that are harvested in a fishery, but which are not sold or kept for personal use. Bycatch includes fish discarded for regulatory or economic reasons.

In 1982, the Pacific Fishery Management Council (Pacific Council) released its initial Fishery Management Plan for groundfish. The Pacific Council's goal is to have long-range plans for managing groundfish fisheries that will promote a stable planning environment for the seafood industry, including marine recreation interests, and will maintain the health of the resource and environment. To help achieve these goals, stock assessments are conducted on groundfish species to estimate fish populations. Since 1995, the Northwest Center has had lead responsibility for conducting stock assessments on Pacific groundfish. The Northwest Center receives assistance from other NMFS science centers, such as the Southwest Center, which conducted the bocaccio assessment.

Stock assessments are the biological evaluation of the status of fish stocks. Stock assessments provide official estimates in key areas, such as the size of the stock population, the size of the spawning population, the amount of fish that have died (fish mortality), and the estimated number of fish at a particular young age (recruitment). Stock assessments form the scientific basis used by regional councils to determine biologically sustainable harvests and guide the monitoring and rebuilding of overfished and threatened stocks. For example, regional councils use stock assessments and other indicators of biological productivity to recommend to NMFS a maximum, or total allowable catch, in a particular fishery—typically for a year. Stock assessments are a key tool for managing fisheries. Without stock assessments, fishery managers would have limited information about the status of fisheries in making decisions about setting harvest levels and developing plans to rebuild overfished stocks.

For each species, the assessor reviews previous stock assessments, gathers available data about the species being assessed, runs the data through computer-generated models, and estimates the species' total biomass. Stock assessors use NMFS-collected data, such as stock surveys conducted on NOAA vessels or contracted commercial fishing vessels, as well as data collected by non-NMFS sources, such as commercial and recreational catch data collected by state agencies. The following six key types of data are collected:

- *Stock abundance*—surveys of how many fish constitute a stock's total size or weight.
- *Commercial and recreational fisheries data*—the amount and composition of fish caught from a particular stock, whether caught intentionally by commercial and recreational fishermen or

unintentionally caught and discarded. Data sources include fishing logbooks, dockside samples, and onboard observations, among others.

- *Life history*—biological data, such as the age and sex composition of the stock, age at first maturity, fertility, average lifespan, and natural mortality.
- *Ecosystem relationships*—data on the relationship between a fish stock and its physical environment, as well the relationship of a fish stock to other species.
- *Recruitment research*—data on the abundance of juvenile and larval fish (fish at their earliest stage), which helps scientists forecast the size of a particular stock in the future.
- *Synoptic oceanographic sampling*—data on the ocean ecosystem, such as water temperature or salinity, plankton composition, or ocean currents.

For each stock assessment, a review panel, consisting of NMFS scientists and outside experts, independently reviews the methodology of the assessment and works with the assessor to ensure their comments are adequately addressed.

Through 2003, 24 of the 82 species of Pacific groundfish have had a full quantitative stock assessment. Relying on these assessments, NMFS has declared that nine species of Pacific groundfish are overfished, including the five species of Pacific groundfish we reviewed in this report—Pacific hake as well as bocaccio rockfish, canary rockfish, darkblotched rockfish, and yelloweye rockfish. Rockfish are long-lived, late-maturing and slow-growing species, making them particularly susceptible to overfishing. More specifically:

Pacific hake, also called Pacific whiting, is generally found off the west coast of North America. It is one of many species of hake distributed in the Atlantic and Pacific oceans. Fishing of Pacific hake primarily takes place off the coasts of northern California, Oregon, Washington, and British Columbia. Fishermen use mid-water trawls and generally fish over the ocean bottom at depths of 100 to 500 meters. Pacific hake was declared overfished in 2002 because the 2002 stock assessment estimated Pacific hake biomass at 700,000 metric tons. By 2004, the biomass was estimated at between 2.7 and 4.2 million metric tons, and Pacific hake is no longer considered overfished. Figure 1 shows a picture of a Pacific hake.

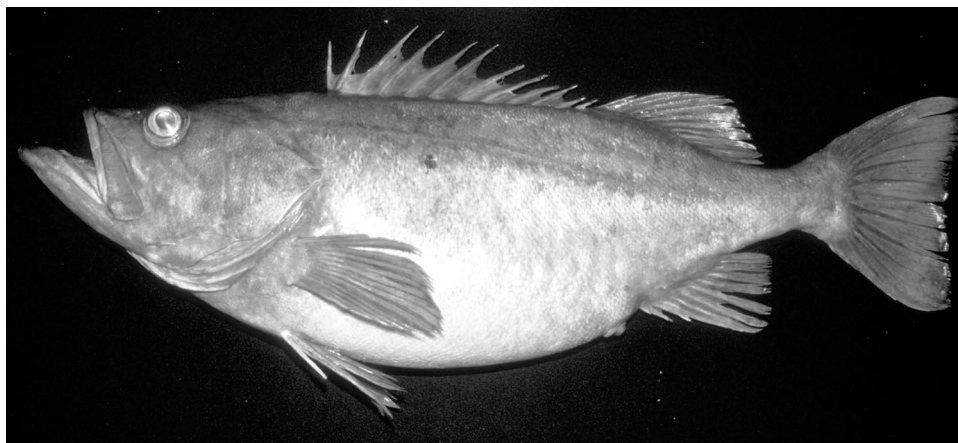
Figure 1: Photograph of a Pacific Hake



Source: Guy Fleischer, Northwest Fisheries Science Center, NMFS.

Bocaccio rockfish generally inhabit waters off the coast of northern Baja, Mexico to Alaska. Bocaccio, commonly sold at market as “red snapper,” are commercially fished using trawls, hook-and-line and gillnets. Adult bocaccio commonly live over rocky areas or open areas of the ocean’s floor to about 320 meters. Bocaccio were formally declared to be “overfished” in 1999. The 2003 stock assessment estimated the bocaccio biomass at 7,133 metric tons. Figure 2 shows a picture of a bocaccio rockfish.

Figure 2: Photograph of a Bocaccio Rockfish



Source: Robert Lauth, Alaska Fisheries Science Center, NMFS.

Canary rockfish inhabit the northeastern Pacific Ocean, from northern Baja, Mexico to the western Gulf of Alaska. Adult canary rockfish are primarily found along the continental shelf, from 46 to 457 meters deep. Canary rockfish are harvested commercially using trawl nets and hook-and-line and are also considered an important species for recreational fishermen. NMFS declared canary rockfish as overfished in 2000. The 2002 stock assessment estimated the canary rockfish biomass at 6,197 metric tons. Figure 3 shows a picture of a canary rockfish.

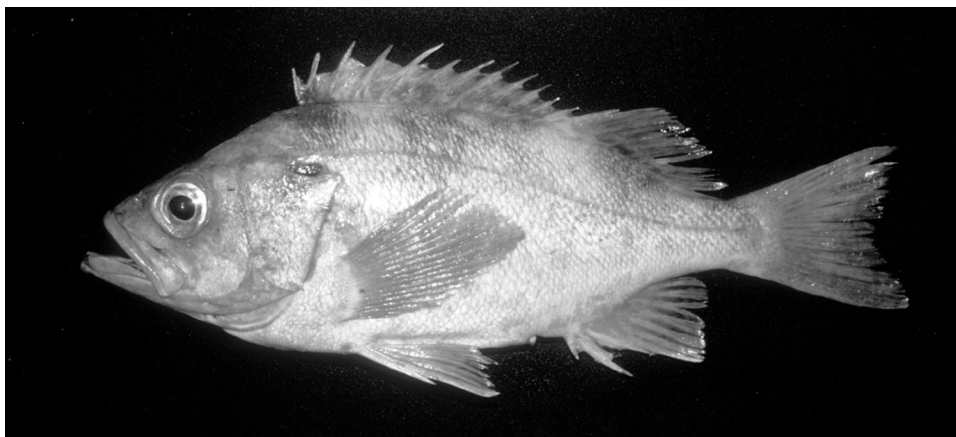
Figure 3: Photograph of a Canary Rockfish



Source: Robert Lauth, Alaska Fisheries Science Center, NMFS.

Darkblotched rockfish are found in the waters from Santa Catalina Island, California to the Bering Sea on soft bottom areas at about 29 to 549 meters deep. Commercial fishery concentrations are located off the coasts of California and Oregon. Darkblotched rockfish are caught primarily by commercial trawls and contribute to both commercial and recreational fishing. NMFS determined that darkblotched rockfish was overfished in 2000, when the last full stock assessment was conducted; it was updated in 2003. This update estimated the darkblotched rockfish biomass at 7,266 metric tons in 2001.⁷ Figure 4 shows a picture of a darkblotched rockfish.

Figure 4: Photograph of a Darkblotched Rockfish



Source: Robert Lauth, Alaska Fisheries Science Center, NMFS.

⁷The 2003 darkblotched update was not a full stock assessment, but rather updated the 2000 darkblotched stock assessment by adding some additional data in order to estimate new biomass figures. The most recent estimate from this update is for 2001.

Yelloweye rockfish almost exclusively inhabit rocky areas from northern Baja, Mexico to the Aleutian Islands, Alaska. Yelloweye rockfish, found in depths ranging from 15 to 550 meters, are caught using both trawl nets and line gear and are highly prized by both commercial and recreational fishermen. Stock assessments for yelloweye rockfish were first conducted in 2001, and NMFS determined that the species was overfished in 2002. The 2002 stock assessment estimated the yelloweye biomass at 2,325 metric tons in 2001.⁸ Figure 5 shows a picture of a yelloweye rockfish.

Figure 5: Photograph of a Yelloweye Rockfish



Source: Robert Lauth, Alaska Fisheries Science Center, NMFS.

Reliability of NMFS' Pacific Groundfish Stock Assessments Is Questionable

The reliability of NMFS' stock assessments is questionable for the Pacific hake and four rockfish species we reviewed, although they were based on the best information available at the time the assessments were conducted. The reliability of the stock assessments we reviewed is questionable because (1) four of the assessments did not have at least one NMFS-collected data source of sufficient scope and accuracy; (2) NMFS lacked a standard process for assessing the reliability of non-NMFS data used in all five assessments; and (3) for four of the assessments, the stock

⁸The most recent estimate of biomass for yelloweye from this stock assessment is for 2001.

assessment reports did not adequately identify the uncertainty of the biomass estimates. (See table 1.) To address these limitations, the Northwest Center plans to increase the scope and accuracy of its collected data, as additional funds become available; is implementing changes that will help ensure the reliability of non-NMFS data; and plans to update the stock assessment model to provide uncertainty ranges for the 2005 stock assessments.

Table 1: Stock Assessment Reliability Issues for Five Pacific Groundfish Species

Species	NMFS-collected data available?	Standard data reliability testing conducted by NMFS?	Uncertainty ranges for biomass estimates provided?
Pacific hake	Yes	No	Yes
Bocaccio	Limited ^a	No	No
Canary	Limited ^a	No	No
Darkblotched	Limited ^a	No	No
Yelloweye	No	No	No

Source: GAO analysis of information provided by NMFS.

^aNMFS-collected data are available for only the trawlable portion of the species' habitat.

Absence of NMFS Survey Data Adversely Affects the Assessments' Reliability

Stock assessors use a variety of data, including NMFS data and non-NMFS data, in developing their assessments.⁹ Two key pieces of NMFS survey data are the shelf and slope bottom trawl survey and the acoustic survey. Other NMFS data that assessors sometimes use include larval surveys (data for fish in their earliest stage) and recruitment surveys. The non-NMFS data assessors use include commercial catch data and recreational catch data.

A 2002 National Research Council report found that the inclusion of NMFS survey data was the best option for a reliable estimate of abundance because such surveys use an unbiased statistical design, control sampling locations, and provide for quality assurance.¹⁰ According to Northwest

⁹NMFS generally refers to its data as fishery-independent data and to non-NMFS data as fishery-dependent data.

¹⁰*Science and Its Role in the National Marine Fisheries Service*, National Research Council, National Academy Press, July 2002.

Center officials, to obtain reliable results, each stock assessment should include at least one source of NMFS-collected data of sufficient scope and accuracy because such surveys are unbiased and scientifically designed.

Northwest Center officials raised concerns about basing assessments solely on non-NMFS data such as commercial and recreational catch data. Catch data do not provide the species' relative or absolute biomass, according to NMFS officials. For example, catch data alone is insufficient because

- fishermen are not randomly sampling the ocean but are fishing areas that they are allowed to fish and they believe have the most fish;
- fishing restrictions, such as a total allowable catch, can limit the amount of fish being caught; and
- catch data have often been inaccurate for a variety of reasons, such as imprecise accounting for dead fish tossed back into the ocean.

Although the assessors used several different data sources, four of the five assessments did not use NMFS survey data or the NMFS data used covered only a portion of the species' habitats. In the yelloweye assessment, no NMFS survey data were available because yelloweye live almost exclusively in the rocky habitat that NMFS trawl surveys cannot cover. As a result, the yelloweye assessment was based solely on non-NMFS data. Similarly, the NMFS survey data used in the bocaccio, canary, and darkblotched assessments were limited in scope because the surveys were conducted only in trawlable waters. Bocaccio, canary, and darkblotched live in both the trawlable and untrawlable habitats. Using data from trawl surveys conducted from 1977 through 1998, NMFS reported in 2003 that 77 percent of the survey area was trawlable and 23 percent was untrawlable.¹¹ Lacking data on species in the 23 percent of the ocean floor that is untrawlable, the assessors estimated the overall biomass using the NMFS data collected from the trawlable areas. However, the abundance in the trawlable area is not representative of the abundance in the untrawlable area. The 2003 NMFS report also found that darkblotched groundfish are less abundant in untrawlable waters, while canary and bocaccio species are more abundant in untrawlable waters. As a result, some rockfish

¹¹Zimmermann, *Calculations of Untrawlable Areas within the Boundaries of a Bottom Trawl Survey*, NRC Research Press, July 2003.

populations may be understated while others may be overstated. According to stock assessors, relying solely on survey data from trawlable waters increases the uncertainty of stock assessments.

In contrast, the fifth groundfish species, Pacific hake, lives primarily in mid-water habitat; and so the concerns about the lack of NMFS data in rocky, untrawlable habitats are not applicable.

NMFS Lacks a Standard Process for Ensuring the Reliability of Non-NMFS Data Used in the Stock Assessments

NMFS does not have a standard process for evaluating whether the non-NMFS data used in its stock assessments are reliable. We believe that certain internal control activities, such as a standard process for ensuring data reliability, can help ensure that information used to make management decisions is complete and accurate.¹² Lacking a standard process, some assessors reviewed the quality of the raw non-NMFS data, while others did not. Assessors who reviewed for data quality found mistakes that they believed made some of the data unusable or that could have impaired the accuracy of the stock assessments. For example, the assessor for the 2002 yelloweye stock assessment found numerous errors in the recreational catch data, such as attributing the catch from an entire fishing vessel to a single fisherman, and thus did not use the data because doing so could have resulted in overestimating the biomass. According to another stock assessor, commercial catch data frequently have inconsistencies. Specifically, the assessor said California, Oregon, and Washington require fishermen to enter catch and location information into logbooks, but logbooks are often incomplete and inaccurate. While the stock assessment review panels evaluated the assessments, the panels did not evaluate the quality of the raw data used in the assessments.

According to a Northwest Center official, several assessors have raised concerns about data quality and accessibility in feedback meetings. In response to these concerns, the Northwest Center official has recently begun assigning data stewards to each data set used in its assessments. Data stewards are responsible for helping assessors compile relevant data and for conducting quality assurance and quality control checks on the data. The Northwest Center plans to conduct a data quality workshop in July 2004 to formally establish the roles and responsibilities of the data stewards, with the intent of standardizing the data evaluation process.

¹²U.S. General Accounting Office, *Standards for Internal Control in the Federal Government*, GAO/AIMD-00-21.3.1, (Washington, D.C.: November 1999).

Stock Assessments for Four Species Did Not Provide Uncertainty Estimates

In 1998, the National Research Council recommended that NMFS include realistic measures of uncertainty in its stock assessments.¹³ NMFS' 2001 stock assessment improvement plan also recognized the need to better quantify and communicate the uncertainty in assessments. In a review of the 2002 canary assessment, the stock assessment review panel recommended that standard estimates of uncertainty be included in future assessments because it is difficult to determine the reliability of the stock assessment without them.¹⁴ Similarly, we believe that estimates based on samples should have a range of uncertainty to show the amount of variability in the estimates.¹⁵ However, the bocaccio, canary, darkblotched, and yelloweye assessments did not present a measure of uncertainty associated with the biomass estimates.

Without uncertainty ranges, it is difficult for regional councils and NMFS to know how much confidence they can have in relying on the estimates for determining stock abundance and hence for setting allowable harvests of the fish. For example, lacking uncertainty ranges, the 2002 bocaccio stock assessment estimated a bocaccio biomass of 2,914 metric tons in 2002. The 2003 assessment of bocaccio biomass, however, estimated 6,506 metric tons in 2002—more than doubling the previous estimate because of additional and updated data. With such wide variations, it is important to provide uncertainty ranges, otherwise management may make inappropriate decisions.

While assessors told us that their stock assessments included some information about differences in estimated biomass when using different data sources (sensitivity analyses), the mathematical model that NMFS uses to estimate biomass (Stock Synthesis model) does not calculate uncertainty ranges. NMFS officials told us that NMFS is updating the model so that it can compute uncertainty ranges; NMFS expects to use the updated model for all 2005 stock assessments. The Pacific hake assessor used a mathematical model (AD Model Builder) that could compute

¹³*Improving Fish Stock Assessments*, National Research Council, National Academy Press, 1998.

¹⁴*Canary Rockfish STAR Panel Meeting Report*, Northwest Fisheries Science Center, May 7, 2002.

¹⁵U.S. General Accounting Office, *Quantitative Data Analysis: An Introduction*, GAO/PEMD-10.1.11, (Washington, D.C.: May 1992).

uncertainty ranges and included these ranges in the Pacific hake assessment report.

Some Recommended Stock Improvements Have Been Implemented, but Much Remains to be Done

NMFS has taken some steps recommended in the Marine Fisheries Stock Assessment Improvement Plan to improve the quantity, quality, and type of data used in Pacific groundfish stock assessments, but much remains to be done to make the assessments more reliable. The Northwest Center has concentrated most of its efforts on implementing recommendations aimed at obtaining more data. Recommendations aimed at increasing the types of data and improving their quality have not yet been fully implemented for a variety of reasons, such as staffing and funding limitations. In addition, other program priorities have precluded NMFS from implementing the recommendation to create a comprehensive plan that incorporates the improvement plan and related plans so that it can develop integrated program initiatives to improve stock assessments.

The Northwest Center Has Taken Some Steps Recommended for Improving Stock Assessments

The October 2001 stock assessment improvement plan identified three scenarios (tiers) to consider when analyzing the resources needed to improve stock assessments. The three tiers of assessment improvements are as follows:

- *Tier 1*—improve stock assessments using existing data without initiating new data collection programs.
- *Tier 2*—conduct baseline monitoring of species, which in most cases requires sampling the species at least every 1 to 3 years, and preferably at least every 1 to 2 years.
- *Tier 3*—implement “next generation” stock assessments by explicitly incorporating ecosystem considerations, such as multispecies interactions and environmental effects in assessments.

The improvement plan also made a number of recommendations to improve stock assessments. The recommendations fall into the following four categories:

- *Data collection*—pursue new initiatives to expand data collection efforts that at a minimum bring stock assessment science to Tier 2. In addition, continue to develop partnerships and cooperative research

programs with other entities, such as state agencies, commercial and recreational fishing organizations, and individuals to improve the quantity, quality, and type of data collected.

- *Communication*—educate constituents about NMFS' strategies for improving stock assessments.
- *Training*—implement comprehensive training and staff development programs for NMFS' analytical and quantitative staff, and augment existing programs that support graduate students interested in stock assessment science.
- *Planning*—develop integrated program initiatives by preparing a comprehensive plan that combines the improvement plan with its complementary plans.

Improvement in the quantity of data collected for use in stocks assessments is a key component to achieving Tier 2 status. The improvement plan states that as the quantity of the data increases, the assessments become more reliable because the data cover a longer period of time, producing better population trend information. Northwest Center officials said that the quality of the data improves with more frequent surveys and more randomly selected survey locations that, over the long term, provide a better understanding of the variability inherent in the population distribution and abundance. A better sense of trends and variability allow for improved short-term predictions of the status of the species.

The Northwest Center has concentrated most of its efforts on implementing improvements in data quantity, such as more frequent acoustic, and shelf and slope bottom trawl surveys. The following illustrate some of the actions the Northwest Center took in 2003 to improve data quantity:¹⁶

- Increased the frequency of the Pacific hake acoustic survey from triennially to biennially. Beginning in 2003, the survey was restructured into a single, integrated survey with Northwest Center and Canadian officials jointly planning all survey elements. Officials from the

¹⁶The Southwest Center also took some independent and joint actions with the Northwest Center to improve data quantity.

Northwest Center and Canada now jointly conduct all of the acoustic surveys.

- Increased the frequency of the groundfish shelf and slope bottom trawl survey from triennially to annually, leveraging available resources by cooperatively working with the fishing industry. Specifically, contracting with private commercial fishing vessels to conduct the surveys. According to Northwest Center officials, working collaboratively with the fishing industry has afforded fishermen the opportunity to become stakeholders in the data collection process.
- Extended the geographic range of the groundfish shelf and slope bottom trawl survey. The surveys are now coastwide from Cape Flattery, Washington to the Mexican border, adding over 300 more miles along the southern California coast. Previous surveys ended at Morro Bay, California.

Efforts continue to communicate the strategies needed to improve stock assessments and to augment existing programs aimed at developing future stock assessment scientists. For example, through the Pacific Fishery Management Council, Northwest Center staff meet with their constituents, such as representatives from state agencies and the fishing industry, to discuss groundfish management issues. In addition, the Northwest Center organized a series of public meetings to discuss new initiatives that affect the stock assessment program. For example, the Northwest Center held public meetings in several communities along the Pacific coast to discuss implementation of the Observer Program—a program designed to collect information about discarded fish for the non-hake west coast groundfish fleets.¹⁷

Finally, the Northwest Center now participates in NMFS' National Sea Grant program to augment a Northwest Center-supported graduate study program at the University of Washington that trains stock assessment scientists. The Sea Grant program provides fellowships for students interested in marine research, such as stock assessment methodology and marine resource economics. The Northwest Center plans to employ two Sea Grant students during the summer of 2004.

¹⁷Pacific hake has a separate observer program. Discards are the amount of fish unintentionally caught and not retained on the fishing vessel. Discard information is collected for use in assessing the mortality for a number of groundfish species.

Further Actions Are Needed to Improve Stock Assessments

While the Northwest Center has implemented some recommendations aimed at improving stock assessments, it has not yet fully implemented many others. These recommendations include collecting additional types of data, such as ecosystem and recruitment information; improving data quality, such as calibrating survey vessel equipment; and increasing training opportunities for Northwest Center staff. Also, NMFS has not acted on the task force recommendation to combine the improvement plan and its complimentary plans into a comprehensive plan that provides integrated program initiatives.

According to the improvement plan, additional types of data will allow NMFS to further test and validate model assumptions, thereby increasing the reliability of the stock assessments. The improvement plan further states that information derived from ecosystem research and recruitment surveys is essential if assessments are to meet the national standards of “next generation” assessments or Tier 3 status. According to Northwest Center officials, ecosystem information and coastwide recruitment surveys are two of the most critical data sets needed to ensure continuous improvement of groundfish stock assessments. The Northwest Center conducts ecosystem research as part of its Science for Ecosystem-based Management Initiative. Understanding the complex ecological relationships between fish and the environment within which they exist provides a better understanding of the effects of the ecosystem on the groundfish fisheries and the scientific knowledge needed to make informed ecosystem-based management decisions. Although research is ongoing to develop ecosystem information, only a limited amount of the data is collected and used in stock assessments. For example, ecosystem data are collected during shelf and slope bottom trawl surveys as time and resources allow. However, this information is not widely incorporated into stock assessments. For the five species we reviewed, only the bocaccio assessment used ecosystem data—information on the temperature of the ocean’s surface.

According to Northwest Center officials, the collection of ecosystem data is limited because the relatively small size of the commercial vessels used in the shelf and slope bottom trawl surveys cannot support the number of researchers needed to effectively conduct comprehensive ecosystem research and collection activities. Furthermore, the implementation of comprehensive ecosystem research and data collection programs is contingent upon the funding of a dedicated research vessel for west coast surveys. Northwest Center officials said they are to receive a dedicated

research vessel sometime during calendar years 2008 or 2009, at the earliest.

Better recruitment information for Pacific groundfish is also needed because such information provides an early predictor of fish abundance, especially for species such as hake, where there is a great variation in recruitment. Northwest Center officials said that current recruitment surveys are limited because existing funds support only yearly surveys in selected areas. To achieve the best early predictions of stock status, these officials said, recruitment surveys should be coastwide and conducted twice a year. According to Northwest Center officials, 13 full-time staff are needed to expand these and other high-priority data collection efforts, such as surveys in untrawlable habitat and expanded acoustic surveys.

The lack of quality data was identified in the improvement plan as an impediment to producing reliable stock assessments. For example, when equipment on different survey vessels are not calibrated, the data are not comparable, and trends may not be accurately determined. The Northwest Center is continuing its efforts to calibrate survey vessel equipment.

The improvement plan also recommended that NMFS provide additional training to ensure that qualified NMFS staff are available now and in the future to conduct stock assessments and related activities. For example, the plan recommended the development of a comprehensive training program and more professional developmental opportunities for NMFS' scientific staff. Northwest Center officials said they try to meet the training and professional development needs of their scientific staff. However, to date they have focused on developing external training programs, such as the University of Washington graduate program, to develop stock assessment scientists for the future and have yet to develop a comprehensive training program for in-house stock assessment scientists.

Finally, the improvement plan recommended that NMFS prepare a comprehensive plan that combines the improvement plan with other complementary plans, such as the NOAA Fisheries Data Acquisition Plan and the NMFS Social Sciences Plan. A comprehensive plan would allow NMFS to better integrate and coordinate program initiatives for improving stock assessments. For example, the acquisition plan—the key complementary plan to the improvement plan—identifies the need for fishery research vessels to satisfy NMFS' data collection needs. Although the improvement plan includes the number of staff that would participate in data collection surveys, it does not contain the capital and operating

costs of the research vessels. Similarly, the staffing requirements for augmenting the social sciences capabilities of NMFS to conduct economic analyses is represented in the sciences plan and not in the stock improvement plan. A NMFS official said that other program priorities, such as conducting more stock assessments and improving data collection activities, have precluded them from developing a comprehensive plan.

Remaining Improvements Estimated to Cost at Least \$8.9 Million

According to NMFS funding and budget requests, the Northwest Center needs at least \$8.9 million to complete ongoing and planned improvements to the stock assessments for Pacific groundfish. However, the actual cost of implementing remaining improvements to Pacific groundfish stock assessments may be even higher because the Northwest Center's budget requests primarily reflect the amount of money the Center believed it could realistically obtain, rather than the actual cost of the improvements.

Remaining Improvements Are Estimated to Cost at Least \$8.9 Million, but Estimate Is Likely Understated

According to NMFS, the Northwest Center needs at least \$8.9 million to complete ongoing and planned improvements for Pacific groundfish stock assessments: \$2.6 million that NMFS' Northwest Center requested but did not receive between fiscal years 2001 to 2003 and \$6.3 million the Center requested for fiscal years 2004 and 2005. Specifically, as shown in table 2, the Northwest Center records have identified the following funding needs

- \$7.7 million to improve the types of data used, including \$2.4 million for surveys of untrawlable waters, \$2.1 million to expand acoustic and recruitment surveys, and \$3.2 million to collect ecosystem data; and
- \$1.2 million to improve the quality of data used in stock assessments, including \$600,000 to enhance the calibration of vessel equipment; \$525,000 to develop and implement methods to collect information on stock identification, structure, and movement; and \$75,000 to standardize trawl survey procedures.

Table 2: Pacific Groundfish Stock Assessment Improvement Funds Requested and Received by Data Type and Quality, Fiscal Years 2001-2005

Dollars in millions

Category	Requested	Funded	Unfunded requests
Types of data used			
Surveys for untrawlable waters			
Nearshore surveys (2003)	\$1.10	\$.50	\$.60
Untrawlable habitat surveys ^a (2003)	.30	.20	.10
Longline groundfish fishing tag surveys ^a (2003)	.40	0	.40
Augment trawl survey in nearshore (2004)	.51	N/A	.51
Fixed-gear survey (2004)	.78	N/A	.78
Subtotal			2.4
Expand acoustic and recruitment surveys			
Recruitment surveys (2003)	.40	.20	.20
Acoustic studies of Southern California bight rockfish ^a (2003)	.20	0	.20
Coastwide augmentation of recruitment survey by Southwest Fisheries Science Center (2004)	.45	N/A	.45
Acoustic surveys in inaccessible habitat (2005)	1.25	N/A	1.25
Subtotal			2.1
Ecosystem data			
Coastwide observing system (2003)	.80	.60	.20
West coast observing system ^{a,b} (2003)	.46	.20	.26
Habitat-specific resource surveys and fishing gear impacts (2004)	1.45	N/A	1.45
Ecosystem studies of ocean productivity and climate impacts (2004)	1.28	N/A	1.28
Subtotal			3.2
Total			7.7
Quality of data used			
Fishing survey vessel calibration (2003)	.60	0	.60
Trawl standardization (2003)	.45	.38	.08
Stock identification, structure, and movement (2004)	.53	N/A	.53
Total			1.2
Other			
Stock assessment training and coordination (2003)	.35	.15	.20
Stock assessment training ^{a,b} (2003)	.30	.50	-.20
Stock assessment training (2003)	.29	.29	0
Stock assessment training (2002)	.29	.29	0
Stock assessment training (2001)	.29	.29	0

(Continued From Previous Page)

Dollars in millions

Category	Requested	Funded	Unfunded requests
Total			0
Total unfunded requests			8.9

Source: GAO analysis of NMFS data.

Notes: These figures exclude the cost of constructing a new fishing research vessel, which is currently designated to be home ported at and used primarily by the Northwest Center for surveys of fish species, such as Pacific groundfish. This vessel has not yet been funded and construction has not yet begun.

The amounts requested by the Northwest Center in fiscal years 2004 and 2005 are preliminary budget requests.

^aIncludes funding for the Southwest Fisheries Science Center assistance to the Northwest Center's Pacific groundfish stock assessment improvement program.

^bRepresents requests and funding for all marine species—not Pacific groundfish alone. NMFS was unable to identify what portion of these funds went solely to groundfish.

The Northwest Center did not receive its full funding request, in part, because NMFS did not receive all the funding it had requested. Between fiscal years 2001 and 2003, NMFS received \$20.6 million (80 percent of its request) in additional funding to implement improvements for all marine stock assessments. NMFS allocated \$3.6 million (58 percent of funds the Northwest Center requested) to the Northwest Center for improving Pacific groundfish stock assessments, resulting in a \$2.6 million shortfall in the Center's request. This shortfall occurred in part because of NMFS' need to balance the requests of its six science centers against its program priorities and the available funds.¹⁸ According to NMFS officials, their goal is to achieve parity among the science centers in terms of their capability to conduct scientific work, such as stock assessments.

Estimated Costs May Understate Actual Cost of Remaining Improvements

The \$8.9 million needed to implement remaining recommended improvements is probably understated because the Northwest Center's budget requests primarily reflect the amount of money the Center officials believed they could realistically obtain, rather than the amount the improvements would actually cost, according to NMFS officials. The Northwest Center's budget requests for fiscal years 2004 and 2005 are preliminary requests submitted before the Northwest Center received its

¹⁸The sixth science center, the Pacific Islands Fisheries Science Center, opened in 2003.

fiscal year 2003 funding.¹⁹ Consequently, the Northwest Center will likely submit revised budget requests for fiscal years 2004 and 2005 that account for both its unfunded needs from fiscal years 2001 through 2003 and items that were unexpectedly funded in fiscal year 2003. Moreover, the fiscal year 2004 and 2005 preliminary budget requests do not incorporate any unanticipated problems or data gaps that have developed since the Northwest Center submitted its preliminary requests.

According to NMFS officials, NMFS' science centers, including the Northwest Center, primarily make and justify their funding requests in response to how much money Congress appropriates. After Congress passes NMFS' budget, NMFS asks its science centers to reassess and detail how much new money each needs to implement science center programs, such as marine stock assessment improvements. According to NMFS officials, it is unrealistic for a science center to request more funds than are available in its appropriation, even if it needs more. While NMFS' Northwest Center requested \$6.2 million to implement improvements to Pacific groundfish stock assessments between fiscal years 2001 and 2003, NMFS' 2001 West Coast Groundfish Research Plan estimated that almost twice as much money would be needed—approximately \$11.7 million in new funding—to implement top-priority improvements to Pacific groundfish stock assessments.

NMFS is now updating its plan and cost estimates for improving Pacific groundfish stock assessments. Using key findings from its December 2003 review of the groundfish program, the Northwest Center plans to update its groundfish research plan, last published in 2001. According to NMFS, the updated groundfish research plan should be completed in late 2004 and is designed to (1) provide a comprehensive framework for Pacific groundfish, (2) identify some of the greatest information gaps, and (3) provide guidance for setting priorities on work to fill these gaps. In addition, the updated plan will estimate how much such improvements will cost.

Conclusions

Stock assessments are the key to effectively managing fisheries. They provide estimates of the species population, which NMFS uses to set

¹⁹In light of the delayed congressional appropriation of fiscal year 2004 funds, NMFS has not yet determined the precise amount of money available to its science centers. As a result, as of April 2004, NMFS had not yet asked the Northwest Center to update its preliminary requests for fiscal year 2004 funds.

harvest limits that allow for sustainability and/or recovery of the species. While stock assessment results often change from assessment report to assessment report, the more types of information used in the assessments, such as recruitment surveys and ecosystem studies, and the greater the accuracy and quality of the data, such as scientifically designed and collected data, the more reliable the assessment results. However, the Pacific groundfish assessments we reviewed did not (1) use scientifically designed and collected NMFS data of sufficient scope and accuracy, such as survey data on the abundance of groundfish residing in rocky, untrawlable habitats; (2) subject the non-NMFS data used to a standard process for assessing its reliability; and/or (3) identify the uncertainties of the assessments total biomass estimates. As a result, the reliability of the five assessments is questionable. Without reliable assessments, fishery managers may reach erroneous conclusions and take actions that could adversely affect the fishing industry economically or adversely affect the recovery and sustainability of the fishery resources. Moreover, without a comprehensive, integrated improvement plan, funding requests and planned actions to improve the stock assessments may not be coordinated, jeopardizing successful and timely implementation of assessment improvements.

Recommendations for Executive Action

To improve the reliability of Pacific groundfish stock assessments, we recommend that the Secretary of Commerce require the Director of National Marine Fisheries Service to take the following four actions:

- Continue efforts to collect more types of data, such as data obtained from surveys in rocky, untrawlable waters, recruitment surveys, and ecosystem studies, for groundfish assessments where reliable data are now lacking.
- Establish a standard approach that requires that non-NMFS data used in stock assessments be evaluated for its reliability, and continue efforts to implement the task force's recommendations to improve data quality.
- Require that stock assessment reports clearly present the uncertainties in the assessments, such as the margin of error associated with species biomass estimates.
- Develop a comprehensive plan that integrates the NMFS stock assessment improvement plan with other NMFS plans to ensure that

stock assessment improvement actions and budget requests are coordinated.

Agency Comments and Our Evaluation

We provided the Department of Commerce with a draft of this report for review and comment. We received a written response from the Under Secretary of Commerce for Oceans and Atmosphere that included comments from the National Oceanic and Atmospheric Administration (NOAA). NOAA generally agreed with the report's accuracy and concurred with the reports recommendations. However, NOAA said it was concerned about the report's conclusion—that the reliability of stock assessments is questionable for the five species reviewed—because it could be misconstrued to infer that the assessments are unreliable for use in managing the west coast groundfish fishery. In this regard, NOAA provided additional comments to show the usefulness of the assessments, even if some of the input data used in the assessments contained errors. We stand by our conclusions that the five stock assessments we reviewed were questionable because the input data were insufficient and/or potentially inaccurate and that four of the assessment reports did not present the uncertainties associated with the biomass estimates. Nonetheless, we added language to the report to address NOAA's concern. Specifically, we expanded upon the fact that NMFS used the best information available at the time the stock assessments were conducted by adding information on the importance of the assessments to effectively manage the fisheries. Without these stock assessments, NMFS and fishery managers would have very limited information on which to base fishery management decisions.

NOAA agreed with the report recommendation to continue collecting more types of data for groundfish assessments where reliable data are now lacking. NOAA said that the reliability of stock assessments will be improved if NMFS survey efforts are expanded and additional NMFS fishery data are collected. NOAA said NMFS places a priority on these improvements and will continue efforts to address this and other recommendations to improve the collection of fishery data as funding becomes available.

NOAA also agreed with the report recommendation to establish a standard approach to evaluate the reliability of non-NMFS data used in stock assessments and continue efforts to improve data quality. NMFS said, through its west coast fishery science centers, it participates on interagency data committees, to develop quality assurance protocols and to assess the quality of non-NMFS data. NOAA agreed that it is important to

ensure that these interagency data committees continue to highlight the need for standardized quality control procedures for the collection of data.

NOAA agreed with the report recommendation to clearly present the uncertainties in the stock assessments. NOAA said that quantifying uncertainty of stock assessments is important to sound decision-making by providing more information about the assessment, although this quantification does not reduce the uncertainty in the assessment itself. While the methods used and the completeness of the uncertainty characterization varied from assessment to assessment, NOAA said it is desirable to have both a quantitative analysis of model uncertainty and an evaluation of the consequences of alternative model scenario.

Finally, NOAA agreed with the report recommendation to develop a comprehensive plan that integrates the stock assessment plan with other NMFS plans to ensure that improvement actions and budget initiatives are coordinated. NOAA said that while much remains to be done, long-term planning efforts and coordination among field and headquarters are ongoing, and NOAA is committed to these actions.

NOAA's comments and our detailed responses are presented in appendix II of this report. NOAA also provided technical comments that we incorporated in this report as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 7 days from the report date. At that time, we will send copies of this report to the Secretary of Commerce and the Director of the National Marine Fisheries Service. We will also provide copies to others upon request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions about this report, please call me at (202) 512-3841 or Keith Oleson at (415) 904-2218. Key contributions to this report are listed in appendix III.

A handwritten signature in black ink that reads "Anu K. Mittal". The signature is written in a cursive style with a large initial 'A' and 'M'.

Anu K. Mittal
Director, Natural Resources
and Environment

Objectives, Scope, and Methodology

We reviewed National Marine Fisheries Service (NMFS) stock assessments for five species of Pacific groundfish: Pacific hake (Pacific whiting) as well as four types of rockfish—bocaccio, canary, darkblotched, and yelloweye. Specifically, for these five species you asked us to (1) assess the reliability of NMFS' stock assessments, (2) identify which relevant recommendations from the stock assessment improvement plan have been implemented and which have not, and (3) identify the estimated costs associated with planned and ongoing improvements to groundfish stock assessments. We did not review the stock assessments of any of the other west coast Pacific groundfish species, thus the information contained in this report pertains to the five species we reviewed unless stated otherwise.

For all three objectives, we reviewed key laws and agency reports and interviewed officials from NMFS, including officials from the Northwest Fisheries Science Center, which has lead responsibility for conducting Pacific groundfish stock assessments with assistance from other west coast science centers.

To assess the reliability of the Pacific hake, bocaccio, canary, darkblotched, and yelloweye stock assessments, we examined methodological and administrative documents developed by NMFS and others to support the groundfish data collection, maintenance, and assessment process. We reviewed the controls over stock assessment data, the types of fish population surveys used, and recent Pacific groundfish stock assessment studies (2002 and 2004 studies for Pacific hake, 2002 and 2003 studies for bocaccio, 2002 study for canary, 2000 and 2003 studies for darkblotched, and 2001 and 2002 studies for yelloweye). We examined whether and to what extent NMFS has processes and procedures in place to ensure the reliability of data used in the Pacific groundfish stock assessments. We reviewed the stock assessment reports and determined whether they articulated the level of uncertainty in the assessment model estimates. We interviewed an array of government officials and fisheries experts, including the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the California Department of Fish and Game, the Pacific Fishery Management Council, the Pacific States Marine Fisheries Commission, environmental groups, and industry associations, as well as fishermen and academics. We did not simulate NMFS' stock assessment models nor evaluate the mathematical and statistical methodologies used in the models for Pacific hake, bocaccio, canary, darkblotched, and yelloweye.

To identify the relevant recommendations to improve stock assessments that NMFS has implemented and has not implemented, we reviewed agency reports on marine fisheries stock assessments, strategic planning, and data collection. We also interviewed officials from the Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the California Department of Fish and Game, the Pacific Fishery Management Council, and the Pacific States Marine Fisheries Commission as well as environmental groups, industry associations, fishermen, and academics.

To determine the estimated costs associated with NMFS' planned and ongoing improvements to Pacific groundfish stock assessments, we reviewed relevant budget requests and funding documents for fiscal years 2001 through 2005 and interviewed National Oceanic and Atmospheric Administration officials. We did not evaluate the accuracy of NMFS' budget requests for specific project items but rather used the amounts NMFS requested for these project items to estimate the total additional costs of implementing the planned and ongoing improvements to Pacific groundfish stock assessments.

We conducted our review from May 2003 through April 2004 in accordance with generally accepted government auditing standards.

Comments From the Department of Commerce

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary of Commerce
for Oceans and Atmosphere
Washington, D.C. 20230

MAY 19 2004


Ms. Anu K. Mittal
Director, Natural Resources
and Environment
United States General Accounting Office
441 G Street, NW
Washington, D.C. 20548

Dear Ms. Mittal:


Thank you for the opportunity to review and comment on the General Accounting Office's draft report entitled "Pacific Groundfish: Continued Efforts Needed to Improve Reliability of Stock Assessments," GAO-04-606. Enclosed is the National Oceanic and Atmospheric Administration's comments on the draft report.

These comments were prepared in accordance with the Office of Management and Budget Circular A-50.

Sincerely,


Conrad C. Lautenbacher, Jr.
Vice Admiral, U.S. Navy (Ret.)
Under Secretary of Commerce for
Oceans and Atmosphere

Enclosure

 Printed on Recycled Paper

THE ADMINISTRATOR



**Appendix II
Comments From the Department of
Commerce**

Page numbers in the draft report may differ from those in this report.

**NOAA Comments on the Draft GAO Report Entitled
“Pacific Groundfish: Continued Efforts Needed to
Improve Reliability of Stock Assessments”
(GAO-04-606/June 2004)**

Comment on the Scope of the Report

See comment 1.

The report title implies the scope of this report is Pacific Coast wide, but the focus is heavily weighted to survey and assess activities of the Northwest Fisheries Science Center (NWFS). The report uses the acronyms NMFS and NWFS interchangeably. Inclusion of information from the Southwest and the Alaska Fisheries Science Centers is highly inconsistent. Insufficient information was included to fully portray the scope, strengths and weaknesses of their past and present contributions to Pacific Coast groundfish work. However, inclusion of bocaccio in the set of GAO-reviewed stocks and references to SWFSC and AFSC work were frequent enough to preclude casting the report as exclusively pertaining to the NWFS. We recommend the report be characterized as “A review of the NWFS’s groundfish program including aspects of West Coast groundfish research conducted by other West Coast Science Centers.” This is more accurate than referring to it either as a review of the NWFS or NOAA Fisheries’ West Coast Groundfish program. It is more than the former, but less than the latter. This scope should be made clear in the introduction of the report.

Recommended Changes for Factual Information

See comment 2.

GAO Highlights, par. 1, line 9: Replace 2002 with 2003.

See comment 3.

GAO Highlights, par. 1, lines 14-16: Change to read “The assessors who reviewed the quality of the non-NMFS data found errors that made “some of” the data unusable or impaired the reliability of “certain” stock assessments.” See our response to GAO recommendation 2. Also, this statement does not pertain to the hake assessment.

See comment 4.

GAO Highlights, par. 2, line 10: This statement is not correct. NMFS has increased a limited number of recruitment surveys and work on untrawlable habitat.

See comment 5.

Page 1, par. 2: NMFS also uses assessments conducted by independent scientists in state resource agencies.

See comment 6.

Page 1, par. 2, line 4: Should read, “Northwest Fisheries Science Center,” as statement is not correct for NMFS generally.

See comment 7.

Page 1, par. 2, line 5: ...(1) the shelf and slope [insert “bottom”] trawl survey...

See comment 8.

Page 2, par.1, line 1: Delete “In response,” replace with “In 1999,” ...review the stock assessment process “across the agency.”

See comment 9.

Page 2, par.1, line 4: ...for conducting “some of the” Pacific ...

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See comment 10.

Page 2, par. 1, line 5: Add citation for October 2001 Marine Fisheries Stock Assessment Improvement Plan NMFS. 2001. Marine Fisheries Stock Assessment Improvement Plan. Report of the National Marine Fisheries Service National Task Force for Improving Fish Stock Assessments, Second Ed. (Rev.). U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-F/SPO-56, 69 p., 25 appendices.

See comment 2.

Page 2, par. 3, line 2: The publication date for the canary assessment was 2002.

See comment 11.

Page 3, par. 1, line 4: Add "1998" National Research Report*, and footnote citation: "*NRC 1998. Improving Fish Stock Assessments. National Research Council. National Academy Press. Washington, D.C. 177 p."

See comment 12.

Page 3, par. 1, lines 7-11: These statements are incorrect because NMFS had and used fishery-independent data for all but the yelloweye rockfish assessment. Revision to this page should be made in line with the general comments we have made regarding use of surveys in assessments.

See comment 2.

Page 3, par. 1, line 13: Replace 2002 with 2003.

See comment 6.

Page 4, par. 2: There is no clarification of budget needs as NMFS-wide versus NWFSC-specific.

See comment 13.

Page 6, par. 2, bullets 3 and 5, and footnote 2: The NWFSC and SWFSC have joint responsibility for salmon fishery and ESA responsibility in freshwater rivers and streams in Washington...etc. and California.

See comment 14.

Page 8, bullet 1: Stock abundance...stock's total "size or weight." Delete "population."

See comment 15.

Page 8, bullet 5: Recruitment research...abundance of juvenile "and larval" fish...

See comment 16.

Page 8, paragraph after bullets: The last phrase in the sentence is not correct. It should read, "For each stock assessment, a review panel, consisting of NMFS scientists and outside experts, independently reviews the methodology of the assessment and works with the assessor to ensure their comments are adequately addressed."

See comment 17.

Page 8, last par., line 3: Seven species of rockfish have been declared overfished. The other three are cowcod, widow rockfish, and Pacific Ocean perch.

See comment 18.

Page 9, bullet 1, line 2: Replace "11 other species of hake" with "15 species of the genus *Merluccius* (hakes)*" [could include a new reference footnote - *Source: www.fishbase.org"]

See comment 19.

Page 12, line 14; also page 14, full par. 1: Our general comments describe how the data situation for these species is not nearly as limited as described here. Certainly bocaccio has more fishery-independent data than acknowledged here. Obtaining data from untrawlable habitat will improve the precision of the canary, bocaccio and darkblotched assessments and, perhaps more importantly, it will enable assessments for other rockfish that occur primarily on these habitats.

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See comment 19.

Page 13, Table 1 and par. 1: Bocaccio clearly rates a “yes” for NMFS-collected data. The CalCOFI larval abundance data has been collected on a rigorous scientific basis by NMFS (SWFSC) for over 50 years. In addition, our general comments clarify the degree to which the survey data are not critically limited for darkblotched and canary rockfish.

See comment 20.

Page 13, Table 1: Highly standardized protocols are used for collecting the fishery-dependent data, including the non-NMFS data for rockfish. Our general comments show at least hake should be rated as a “yes” in this category.

See comment 7.

Page 13, par. 1, line 3: ...slope [insert “bottom trawl”] survey...

See comment 21.

Page 13, par. 1, lines 4-5: The comma in the phrase “include, larval” should probably be deleted. The phrase “The non-NMFS data assessors use include....” is slightly awkward. Could it be replaced with “Assessors use non-NMFS data such as...”?

See comment 2.

Page 14, full par. 1, line 10: Replace 2002 with 2003.

See comment 22.

Page 15, par. 1, line 1: Replace “lives in a different habitat than the other four species,” with “live primarily in mid-water, above the sea floor, and so...”

See comment 23.

Page 15, footnote 9: Reposition on page 14; replace citation as follows: Zimmerman, M. 2003. Calculation of untrawlable areas within the boundaries of a bottom trawl survey. Can. J. Fish. Aquat. Sci. 60:657-669.

See comment 24.

Page 16, full par. 1, line 2: Introduces the NMFS 2001 Stock Assessment Improvement Plan in the document text. It would be helpful to also introduce the acronym “Marine Fisheries SAIP” and then use in the following pages. There are many references after this point using the phrase “improvement plan” and it seems likely all of these refer to the SAIP, but there also is the West Coast Groundfish Research Plan.

See comment 25.

Page 16, full par. 2, line 2: Replace “health” with “stock abundance.”

See comment 26.

Page 16, footnote 10: Reposition on page 15.

See comment 27.

Page 17, last par., line 3: ...tiers of assessment [insert “improvements”] are as...

See comments 7 and 21.

Page 19, par. 1, line 2: ...frequent acoustic [insert “,”] and shelf and slope [insert “bottom trawl”] surveys.

See comment 28.

Page 19, par. 1: While this list of actions may accurately reflect what the NWFS did to improve data quantity, it is not a comprehensive list of all that has been done to improve data quantity coast wide, and especially omits projects initiated by the SWFSC, some joint with the NWFS.

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See comment 29.

Page 21, par. 1: While this may represent the NWFSC's ecosystem science programs, it is not an accurate portrayal of the coast wide program. For example, in the SWFSC, both the CalCOFI survey and the pelagic juvenile rockfish survey collect comprehensive environmental/ecosystem data, and the SWFSC's Pacific Fisheries Environmental Laboratory is wholly devoted to the conduct of environmental research in a fisheries context.

See comment 30.

Page 21, par. 2, line 5: Replace "is" with "are."

See comment 31.

Page 21, par. 2, line 6: Substitute ...dedicated research vessel for West Coast surveys.

See comment 32.

Page 24, Table 2: Footnote b only refers to requests and funding for the SWFSC. The NWFSC separated groundfish funding from non-groundfish funding.

See comment 6.

Page 26, last sentence of first full paragraph: This is somewhat misleading. The groundfish research plan was developed with all the NMFS Centers as a coastwide plan. So the term "its" in this sentence is misleading. In the next paragraph, the coast wide research plan will be updated (not just the NWFSC plan).

See comment 33.

Page 26, par. 4, line 3: Suggest replacing "survivability" with "sustainability."

See comment 19.

Page 27, par. 1, line 4: (1)... etc. See comment for page 12 above.

See comment 34.

Page 27, par. 1, line 11: "...survivability of the fishery ["resources"? or "industry" ?]

General Comments

Reliability of Assessments

See comment 35.

The GAO report states, "The reliability of NMFS stock assessments is questionable for the Pacific hake and four rockfish species we reviewed, although the assessments were based on the best information available at the time they were conducted." This statement does not adequately convey the different degrees of precision associated with each of these assessments and could easily be misconstrued to mean all these assessments are an unreliable basis for management of the West Coast groundfish fishery. NOAA doubts GAO intended such an extreme conclusion from their findings, and NOAA would like to take this opportunity to provide additional information regarding these assessments: namely, that all have passed a scientific review and all are serving as the basis for formal status determination and management of these stocks. Our response to GAO recommendation 2 demonstrates quality assurance for non-NMFS data is not absent; thus, the assessments are not unreliable due to use of these data. Our response to GAO recommendation 3 indicates precision is quantified to the extent feasible today, is on par with state-of-the-science assessments elsewhere, and is rapidly improving. NOAA acknowledges quantifying precision of these assessment results would provide more information about the assessment, and expanded and improved data would improve the certainty of the assessment results and forecasts. Nevertheless, there is no reason to believe these assessments are inadequate for guiding this fishery. In addition to NOAA's responses to GAO recommendations 2 and 3, NOAA provides the following information with regard to the reliability of these stock assessments:

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Surveys as Stock Trend Indicators

Stock assessments require data on the relative trend in stock abundance and on the removals (catch). Both are needed in order to produce the target assessment results. Although catch data alone are not a substitute for survey trend data, in some circumstances with fishery effort information, the catch per unit of fishing effort can be standardized to provide an index of the trend in stock abundance. The National Research Council's report on "Improving Fish Stock Assessments" and NOAA's own studies indicate stock assessments should include a standardized, scientifically-designed survey of fish abundance so that changes observed in the survey confidently reflect true changes in the stock's abundance and not some confounding factor. These conditions are better met with the controlled conditions of a fishery-independent survey than with fishery catch per effort.

NMFS and Non-NMFS Data

The GAO report categorized the five reviewed assessments according to the availability of NMFS-collected survey data, often abbreviated to just "NMFS data." While NMFS collects nearly all the fishery-independent survey data for West Coast groundfish and the states collect much of the fishery-dependent data on catch and fishing effort, it is more pertinent to focus on the degree of standardization of the survey data than on the source. NMFS is firmly committed to providing such surveys on a long-term basis, but useful surveys can be conducted by non-NMFS organizations. The desire for standardized, fishery-independent surveys should not be equated with a concern about basing an assessment on non-NMFS data. Also, less precise assessments can be conducted with only non-NMFS fishery-dependent data as long as there is adequate standardization and quality assurance.

Assessments

The Pacific hake assessment is one of the most data-rich and sophisticated assessments in the nation. It is based upon a highly calibrated acoustic survey of hake abundance and a very complete system for monitoring the hake catch. Even if the portion of the hake catch data provided by the states had some major shortcomings (which is unlikely), this would have little impact on the overall assessment's precision and certainly would not make it unreliable. More frequent Pacific hake acoustic surveys and a more geographically extensive recruitment survey will improve the timeliness and precision of short-term forecasts, but the overall assessment of the status of the stock certainly is highly reliable according to all scientific reviews.

The bocaccio, canary, and darkblotched rockfish assessments all obtain adequate abundance trend information from the NMFS bottom trawl surveys because these species commonly occur in these surveys. The bocaccio assessment includes several other fishery-independent sources of abundance trends, particularly the NMFS-SWFSC juvenile rockfish survey providing an index of recruitment, and the SWFSC led CalCOFI survey provides a larval index of spawning biomass. The fact that the bottom trawl survey cannot access the roughest habitat does not invalidate its usefulness as an index of relative changes in the overall abundance of these three stocks, even if the density of fish in untrawlable habitat is typically different than the density on trawlable habitat assuming a random or consistent bias. New surveys, some based on new technology, providing information from untrawlable habitat will allow more direct evaluation of the total

See comment 36.

See comment 37.

See comment 38.

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stock and calibration of the bias assumptions, but the current fishery-independent survey data are likely to be sufficiently complete to determine these stocks have declined substantially into an overfished state. With improved and more frequent surveys and more timely assessments using these surveys, recovery of these stocks and possible declines in other stocks will be more accurate and precise and detected sooner.

See comment 39.

The yelloweye rockfish assessment cannot obtain relevant information from the NMFS bottom trawl survey because this species primarily occurs on rough habitat; instead, the yelloweye assessment relies upon the trend observed in recreational fishery catch per unit effort. Certainly fishery catch per effort is less standardized a data source than the NMFS bottom trawl survey so this is logically the least precise of the assessments reviewed by GAO, but use of fishery catch per effort is a standard practice for many important assessments where fishery-independent surveys are impractical (such as highly migratory tunas). The yelloweye assessment contains a caveat regarding uncertainty in the calibration of the fishery catch per effort and it acknowledges the new effort to collect new kinds of survey data from the untrawlable habitat. The yelloweye assessment represents a rational use of available fishery-dependent data until sufficient new fishery-independent data become available.

See comment 40.

On page 16, the GAO report references the doubling of estimated bocaccio biomass when the assessment was redone in 2003 and reiterates GAO's call for uncertainty ranges. Note, most of the doubling was due to factors (a new abundance index and a change in the level of natural mortality used in the assessment model) that would not be addressed in a standard statistical analysis of uncertainty.

NOAA Response to GAO Recommendations

Recommendation 1: "Continue efforts to collect more types of data, such as data obtained from surveys in rocky, untrawlable waters, recruitment surveys, and ecosystem studies, for groundfish assessments where reliable data are now lacking."

NOAA Response: NOAA agrees with this recommendation. The reliability of stock assessments will be improved if NMFS survey efforts are expanded and additional fishery-independent data are collected. NMFS places a priority on these improvements and through the Expand Stock Assessment – Improve Data Collection budget line has already started new budget initiatives and programmatic expansions in this area. The agency will continue to address the recommendations of the Marine Fisheries Stock Assessment Improvement Plan (and others) as funding becomes available.

Recommendation 2: "Establish a standard approach that requires that non-NMFS data used in stock assessments be evaluated for its reliability, and continue efforts to implement the task force's recommendations to improve data quality."

NOAA Response: NOAA agrees with this recommendation. NMFS, through the West Coast Fisheries Science Centers, participates on the interagency data committees for the Pacific States Marine Fisheries Commission's Pacific Fisheries Information Network (PacFIN) for commercial West Coast fishery data, and the Recreational Fisheries Information Network (RecFIN), to

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develop quality assurance protocols and to assess the quality of fishery-dependent data. Quality assurance protocols were last outlined and specified in a NOAA Technical Memorandum (Commercial Fisheries Data Collection Procedures for the U.S. Pacific Coast Groundfish, 1997, Sampson and Crone (eds)).

Each assessment relies upon these procedures and protocols to produce sound fishery-dependent data with good quality assurance. In cases where novel applications of these data are attempted, the assessment scientists will be more involved in preparation of the raw data and may find the data are inadequate for the new application, such as catch per unit effort for a particular fishery sector. Rejection of certain data for such a new purpose does not invalidate the entire fishery monitoring program. Therefore, NOAA agrees it is important to assure the terms of reference of these interagency data committees continue to highlight the need for standardized quality control procedures for the collection of the data. NMFS membership on the PacFIN and RecFIN committees assures such protocols are monitored and implemented.

Recommendation 3: “Require that stock assessment reports clearly present the uncertainties in the assessments, such as the margin of error associated with population estimates.”

NOAA Response: NOAA agrees with this recommendation. Quantifying uncertainty of assessments is important for sound decision-making by providing more information about the assessment, although this quantification does not reduce the uncertainty in the assessment itself. Currently, the Scientific and Statistical Committee of the Pacific Fishery Management Council has terms of reference for stock assessments including requiring that the uncertainty be characterized. However, the methods used and the completeness of the uncertainty characterization has varied from assessment to assessment. It is desirable to have both a quantitative analysis of model uncertainty due to statistical goodness-of-fit within a selected model scenario, and an evaluation of the consequences of alternative model scenarios to investigate potential biases. Doing both for complex fishery stock assessment models is technically challenging and the West Coast groundfish assessments are near the state-of-the-science. The GAO report focused on the statistical goodness-of-fit, which was available for the Pacific hake assessment, but this cannot be done routinely with the older generation models necessary for the types of data available for the four rockfish assessments reviewed by GAO. NMFS has only been able to work slowly on new model development at its current level of funding, but in 2004, it will roll out and review a next generation model suitable for rockfish assessments that will be capable of producing the desired uncertainty calculations. In addition, NMFS’ cooperative research with the University of Washington is exploring methods to quantitatively combine uncertainty analyses across multiple model scenarios, thus achieving a new level of overall uncertainty characterization. NMFS will assist in developing new terms of reference more clearly outlining the requirement for uncertainty characterization and giving clear guidance on the methods to be used to calculate and report this uncertainty.

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Recommendation 4: “Develop a comprehensive plan that integrates the NMFS stock assessment improvement plan with other NMFS plans to ensure that stock assessment improvement actions and budget requests are coordinated.”

NOAA Response: NOAA agrees with this recommendation. The NMFS Office of Science and Technology, together with all six regional Fisheries Science Centers, is responsible for developing budget initiatives for major program areas focusing on improving the scientific basis for fishery management. Long-term program development and field-headquarters’ coordination activities are continuing for the following: Expand Stock Assessments-Improve Data Collections, Fisheries Statistics (National Fisheries Information System), Economics and Social Sciences Research, Fisheries Observers, Fishery Oceanography, National Cooperative Research, and new NOAA Fishery Survey Vessel fleet construction. These multi-year program activities have been favorably reviewed by our external partners, constituents, and the Congress. Initial new funding has been received, but much remains to be done. NOAA is committed to continuing on this course.

The following are GAO comments on NOAA's letter dated May 13, 2004.

GAO Comments

1. We added clarifying language to the scope and methodology section of the report to clearly identify the species and activities covered by the review.
2. We revised the report to show the publication date.
3. We revised the report accordingly.
4. We revised the report to clearly show that NMFS has not collected enough ecosystem data and that the frequency and range of recruitment surveys are limited. The statement does not address untrawlable habitat.
5. We revised the report to clarify that NMFS "generally uses" NMFS's staff or contracts with outside experts.
6. We revised the report to more clearly differentiate between NMFS as a whole and NMFS' Northwest Center in particular. We made similar revisions, as appropriate, throughout the report.
7. We revised the report to specify "bottom" trawl survey. We made similar changes, as appropriate, throughout the report.
8. We revised the report to include the year and scope of the task force review.
9. We revised the report to indicate that the Northwest Center is responsible for coordinating groundfish stock assessments.
10. We revised the report to include the citation.
11. We revised the report to include the date and citation of the National Research Council report.
12. The NMFS data used in the bocaccio, canary, and darkblotched assessments were limited because NMFS conducted its surveys in trawlable waters only. NMFS data were not available for untrawlable waters, which these species also inhabit. For this reason, we did not revise the report.

13. We revised the report to clarify the shared responsibilities of the Northwest and Southwest Centers.
14. We revised the report to include NOAA's recommended definition of stock abundance.
15. We revised the report to include larval fish.
16. We revised the report to clarify the role of the review panel.
17. We revised the report to more explicitly distinguish the five species related to our report from other overfished Pacific groundfish.
18. We revised the report to more clearly describe the distribution of Pacific hake.
19. Bocaccio survey data for untrawlable habitats, as stated in comment 12, was unavailable. For this reason, we did not change the report.
20. NOAA commented that highly standardized protocols are used for collecting non-NMFS data (fishery dependent data) for rockfish. We found that although NMFS does have collection and quality assurance procedures for state-collected non-NMFS data, NMFS does not check or have a standard process to verify that these data have been reviewed for reliability. As discussed in our report, some assessors chose to review the raw data, while others did not. Assessors who voluntarily reviewed raw non-NMFS data found mistakes that either made some of the data unusable or could have impaired the accuracy of the stock assessments. For these reasons, we did not change the report.
21. We revised the punctuation accordingly.
22. We revised the report to clarify that Pacific hake live in mid-water habitat.
23. The footnote placement and citation are in accordance with GAO guidelines. For this reason, we did not change the report.
24. We believe that our report has addressed this issue. By referring to the West Coast Groundfish Research Plan by its complete title, we adequately distinguish between the two reports. For this reason, we did not change the report.

25. We changed “health” to “stock abundance.”
26. The footnote placement is repositioned in report.
27. We revised the report to include assessment “improvements.”
28. As indicated in our report, we illustrate some of the actions that the Northwest Center took to improve data quantity and did not intend to provide a comprehensive list of all actions conducted to improve data quantity coast wide. However, we added footnote 16 to clarify the actions taken by the Southwest Center.
29. The example we provided is not intended to be a comprehensive list of all ecosystem research conducted on the west coast. Instead, it illustrates the type of work the Northwest Center is conducting and the opportunities for improving ecosystem research. For this reason, we did not change the report.
30. After reviewing the report we believe no change is required because of subject-verb agreement.
31. We added clarifying language.
32. We believe that table 2 notes “a” and “b” in our report already adequately address this issue. Annotations for projects that do not separate out groundfish funds occur only in items that are annotated as Southwest Center projects. For this reason, we did not change the report.
33. We changed “survivability” to “sustainability.”
34. We changed “survivability” to “sustainability” and added fishery “resources” for clarification.
35. NOAA commented that GAO does not adequately convey the different degrees of precision associated with the stock assessments and GAO’s conclusion that the reliability of the five assessments we reviewed is questionable and could easily be misconstrued to mean all these assessments are an unreliable basis for management of the west coast groundfish fishery. NOAA also commented that the five assessments GAO reviewed all passed scientific review and are serving as the basis for formal status determination and fishery management. Our report

acknowledges that stock assessments are scientifically reviewed and are a key tool for managing fisheries. However, we found the reliability of the five assessments questionable for the three reasons we highlighted in our report, and we recommended actions on how to improve the reliability of the stock assessments. We added clarification to the report to show that stock assessments are a key tool for managing fisheries and are important in making decisions about setting harvest levels and developing plans to rebuild overfished stocks.

NOAA also commented that quality assurance for non-NMFS data is not absent. As stated in our response number 20, we found that although NMFS does have collection and quality assurance procedures for state-collected non-NMFS data, NMFS does not check or have a standard process to verify that these data have been reviewed for reliability. As discussed in our report, some assessors chose to review the raw data, while others did not. Assessors who voluntarily reviewed raw non-NMFS data found mistakes that either made some of the data unusable or could have impaired the accuracy of the stock assessments. For these reason, we did not change the report.

36. NOAA commented that it is more pertinent to focus on the degree of standardization of the survey data than the source. By categorizing data as NMFS data and non-NMFS data, we were not implying that non-NMFS organizations could not conduct useful fishery-independent surveys. We categorized the data in this manner because NMFS currently conducts nearly all of the fishery-independent surveys and non-NMFS organizations collect most of the fishery-dependent data. Footnote 7 in the report states that NMFS generally refers to its data as fishery-independent data and to non-NMFS data as fishery-dependent data. For these reasons, we did not change the report.
37. We believe the Pacific hake biomass estimates are questionable because the assessment used non-NMFS data that NMFS did not check or subject to standard data reliability testing. Assessors who reviewed raw non-NMFS data for other stock assessments found mistakes that either made some of the data unusable or could have impaired the accuracy of the stock assessments. For this reason, we did not change the report.
38. NOAA commented that bocaccio, canary, and darkblotched assessments all obtain adequate abundance trend information from the NMFS bottom trawl surveys. NOAA also commented that although

bottom trawl survey cannot access the roughest habitat, it is useful as an index of relative changes in the overall abundance. As stated in our report, we found that the NMFS survey data used in these assessments were limited in scope because the surveys were conducted only in trawlable areas. Assessors estimated overall biomass using the NMFS data collected from the trawlable area, which has a different abundance rate than the untrawlable area. Stock assessors commented that relying on survey data from trawlable waters only increases the uncertainty of stock assessments. For these reasons, we did not change the report.

39. As noted in our report, the National Research Council found that the inclusion of NMFS survey data was the best option for a reliable estimate of abundance because such surveys use an unbiased statistical design, control sampling locations, and provide for quality assurance. Northwest Center officials said that to obtain reliable results, each stock assessment should include at least one source of NMFS-collected data of sufficient scope and accuracy because such surveys are unbiased and scientifically designed. NMFS data were unavailable for the yelloweye assessment. Northwest Center officials also raised concerns about basing assessments solely on non-NMFS data such as commercial and recreational catch data. Catch data do not provide the species' relative or absolute biomass, according to NMFS officials. Catch data alone are insufficient because fishermen are not randomly sampling the ocean, but are fishing areas that they are allowed to fish and they believe have the most fish; fishing restrictions, such as a total allowable catch, can limit the amount of fish being caught; and catch data have often been inaccurate for a variety of reasons, such as imprecise accounting for dead fish tossed back into the ocean. For these reasons, we did not change the report.
40. NOAA commented that the doubling of estimated bocaccio biomass in 2003 was due to factors that would not be addressed in a standard statistical analysis. Although a standard statistical analysis may not fully address the doubling of an estimate, an assessment without an uncertainty range does not quantify and communicate any of the uncertainty. For this reason, we did not change the report.

GAO Contact and Staff Acknowledgments

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**Staff
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