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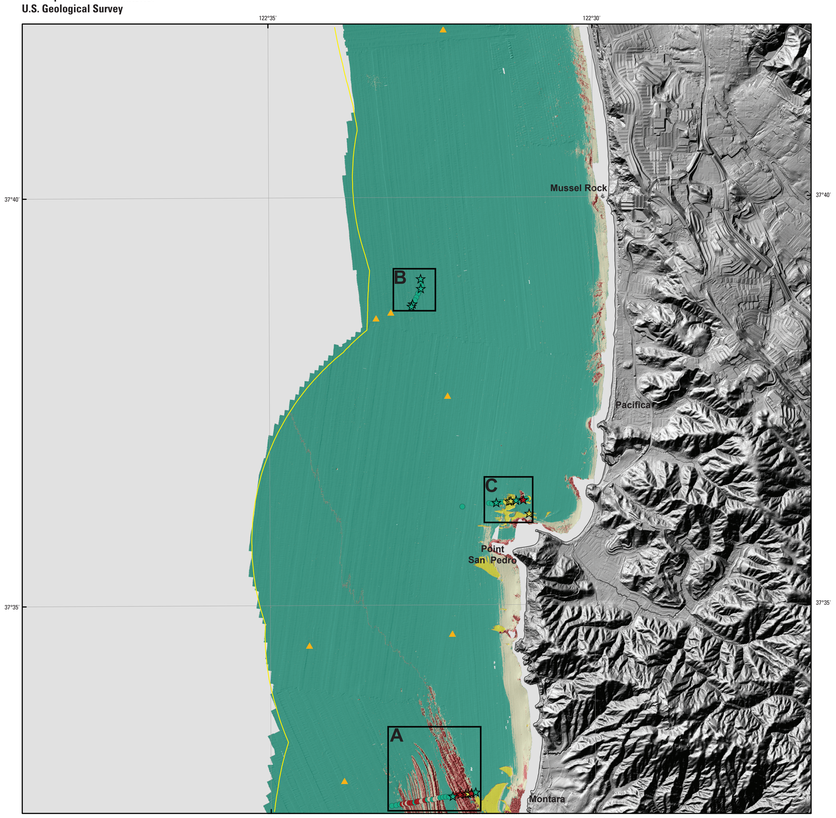
U.S. Department of the Interior
U.S. Geological Survey

Open-File Report 2014–1260
Sheet 6 of 10
Pamphlet accompanies map



Onshore elevation data collected by Photoscience in 2005 for U.S. Geological Survey and County of San Mateo. Offshore shaded-relief bathymetry from map on sheet 2, this report. California's State Waters limit from NOAA Office of Coast Survey

Universal Transverse Mercator projection, Zone 10N

NOT INTENDED FOR NAVIGATIONAL USE

APPROXIMATE MEAN DECLINATION, 2014

SCALE 1:50 000

2 0 2 MILES
7000 3500 0 7000 FEET
1 0.5 0 1 KILOMETER

ONE MILE = 0.869 NAUTICAL MILES

MAP LOCATION

Seafloor-character map simplified from map on sheet 5, this report. Video observations recorded and digital still photographs taken in 2007. Sample localities from usSEABED (Reid and others, 2006)

GIS database and digital cartography by Nadine E. Golden and Elwyne L. Phillips

Manuscript approved for publication December 22, 2014

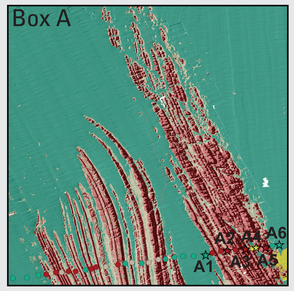


Figure 1A. Detailed view of seafloor character mapped west of Montara, approximately 1 km offshore (see Box A, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 1C through 1H) from camera line CAM23, cruise F–3–07–NC.

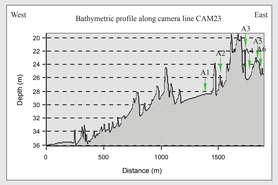


Figure 1B. Bathymetric profile along camera line CAM23 (see fig. 1A for location), showing seafloor relief along camera-sled trackline; green arrows show locations of digital still photographs A1 through A6 (figs. 1C through 1H, respectively). Profile generated using ArcGIS 3D Analyst. Vertical exaggeration, 60x.

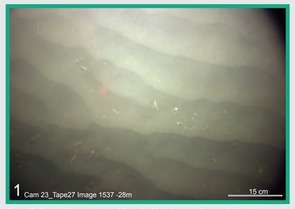


Figure 1C. Digital still photograph no. A1 (see fig. 1A for location). Unconsolidated, fine- to medium-grained sand and scattered shell debris, with sharp-crested, symmetrical, bifurcating ripples (water depth, 28 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

Figure 1D. Digital still photograph no. A2 (see fig. 1A for location). Mixed, rounded to subrounded boulders and cobbles overlying rock (water depth, 24 m). Abiotic complexity is moderate to high, biotic complexity is absent, and biocover is moderate. Biocover includes sun star (sus), short-spined sea star (ssst), and encrusting sponges (spo). Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

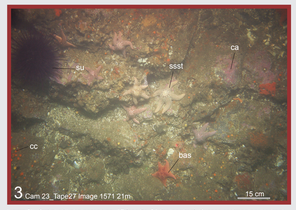


Figure 1E. Digital still photograph no. A3 (see fig. 1A for location). Rugose sedimentary bedrock with veneer of unconsolidated sediment (water depth, 21 m). Abiotic complexity is moderate to high, biotic complexity is absent, and biocover is high. Biocover includes bat stars (bas), short-spined sea star (ssst), cup corals (cc), sea urchin (su), and encrusting coralline algae (ca). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 1F. Digital still photograph no. A4 (see fig. 1A for location). Unconsolidated, coarse- to medium-grained sand and gravel and shell debris, with sharp-crested, symmetrical megaripples (water depth, 26 m). Ripple wavelengths of more than 1 m are confirmed in associated video. Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

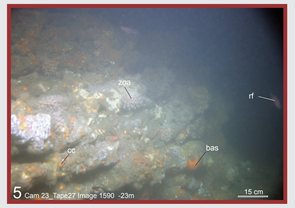


Figure 1G. Digital still photograph no. A5 (see fig. 1A for location). Rugose, layered sedimentary bedrock with steep slopes (water depth, 23 m). Abiotic complexity is high, biotic complexity is absent, and biocover is high. Biocover includes rockfish (rf), bat star (bas), zoanthids (zoa), and cup corals (cc). Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

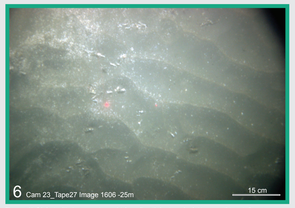
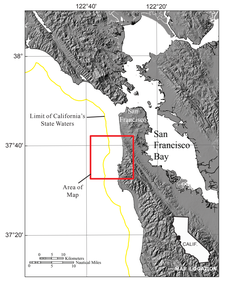


Figure 1H. Digital still photograph no. A6 (see fig. 1A for location). Unconsolidated, fine- to medium-grained sand and scattered shell debris, with sharp-crested, symmetrical, bifurcating ripples (water depth, 25 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.



DISCUSSION

Between 2006 and 2007, the seafloor in the Offshore of Pacifica map area in northern California was mapped by Fugro Pelagos and California State University, Monterey Bay (CSUMB), using multibeam echosounders (see sheets 1, 2, 3). These mapping missions combined to collect bathymetry and acoustic-backscatter data from about the 10-m isobath to out beyond the 3-nautical-mile limit of California's State Waters. In order to characterize the bathymetry and acoustic-backscatter data into geologically and biologically useful information, the USGS ground-truth-surveyed the data by towing a camera sled (fig. 4) over specific locations throughout the map area in 2007.

During the ground-truth-survey cruise, the camera sled was towed 1 to 2 m over the seafloor, at speeds of between 1 and 2 nautical miles/hour. The sled housed two standard-definition (640×480 pixel resolution) video cameras (one forward looking, the other downward looking), a high-definition (1,080×1,920 pixel resolution) video camera, and an 8-megapixel digital still camera, which captured a digital still photograph once every 30 seconds. The video was relayed in real time to the research vessel, where USGS and National Oceanic and Atmospheric Administration (NOAA) scientists recorded both the geologic and biologic character of the seafloor once every minute, using programmable keypads. The location and directions of the camera-sled tracklines were chosen in order to visually inspect areas thought to represent the full range of bottom hardness and rugosity in the map area.

In the context of marine-fisheries management, benthic-habitat complexity can be divided into abiotic (geologic) and biotic (biologic) components. Benthic-habitat complexity refers to the visual classification of local abiotic and biotic vertical relief and structure that may provide potential refuge for both juvenile and adult forms of various species. Only abiotic attributes (primary- and secondary-substrate composition) were used in the production of the seafloor-character map on sheet 5. Classifications of primary and secondary substrate are based on the Wentworth (1922) scale of sediment grain-size categories, and the sand, cobble, and boulder sizes are classified as in Wentworth (1922). However, the difficulty in distinguishing the finest divisions in the Wentworth (1922) scale during video observations made it necessary to aggregate some grain-size classes: the granule and pebble sizes have been grouped together into a class called "gravel," and the clay and silt sizes have been grouped into a class called "mud." In addition, hard bottom and clasts larger than boulder size are classified as "rock." Primary and secondary substrate, by definition, constitute greater than 50 and 20 percent of the seafloor during an observation, respectively.

This sheet contains a smaller, simplified (depth-zone symbology has been removed) version of the seafloor-character map (sheet 5), on which the camera-sled tracklines used to ground-truth-survey the sonar data are indicated by aligned colored dots, each dot representing the location of a recorded observation. Primary- and secondary-substrate compositions are shown by differently colored dots. The map also shows the locations of the detailed views of seafloor character along some of the tracklines (Boxes A through C) that are highlighted on this sheet (figs. 1A, 2A, 3A). Also shown are locations of samples (triangles) from usSEABED (Reid and others, 2006) that were used to supplement the ground-truth surveys.

The seafloor-character map shows that this area is dominated by sandy, unconsolidated sediment (see, for example, figs. 1C, 1H, 2C, 2D, 2E, 2F, 3C, 3F) that is characterized by sharp-crested, oscillatory (and often bidirectional) ripple patterns (typical wavelengths, 5 to 15 cm). The video images and still photographs document low densities of epifauna, although mobile species may have fled out of the field of view of the camera systems. The general absence of burrows documents sparse populations of mega-infauna capable of bioturbating the sandy seafloor at a scale observable by our camera systems and (or) a dynamic environment of mobile sediment that degrades or destroys evidence of burrowing. The sandy-shelf areas are typified by low abiotic complexity, low biotic complexity, and low biocover.

Each detailed view (figs. 1A, 2A, 3A) shows the locations of camera-sled tracklines (aligned colored dots), as well as of the photographs (colored stars) taken along the tracklines; bathymetric profiles (figs. 1B, 2B, 3B) show the variable seafloor relief along the lengths of the tracklines. The photographs, which are representative of the seafloor, are displayed with a description of the observed seafloor characteristics recorded by USGS and NOAA scientists (figs. 1C through 1H, 2C through 2F, 3C through 3H). Only primary and secondary substrates are reported, although individual photographs may show more substrate types. Organisms, when present, are labeled on the photographs.

Ground-truth surveys in the Offshore of Pacifica map area include approximately 5.5 trackline kilometers of video, 214 still photographs, and 27 sediment samples, in addition to 118 seafloor observations of abiotic and biotic attributes. A visual estimate of slope was also recorded.

GLOSSARY

Rugosity—A GIS-derived characterization of seafloor roughness, calculated as the ratio of the three-dimensional surface area of seafloor to the two-dimensional planar-base area, for each cell in the bathymetry grid.

Backscatter intensity—The amplitude of the reflected sonar signal (see sheet 3) used to infer the hardness of the bottom, determined after sonar-data processing has removed (as much as possible) the effects of water depth, angle of reflection, and bottom roughness.

Biocomplexity—The assessment of the presence or absence of biological structures that have the potential of providing shelter for fauna, determined by estimating the scale, the amount, and the morphology of biological relief (as described by Tissot and others, 2006).

Biocover—The visual estimate of the proportion of biologic cover by encrusting organisms: high, greater than 50 percent; moderate, between 50 percent and 10 percent; low, less than 10 percent.

REFERENCES CITED

Reid, J.A., Reid, J.M., Jenkins, C.J., Zimmerman, M., Williams, S.J., and Field, M.E., 2006, usSEABED—Pacific Coast (California, Oregon, Washington) offshore surficial-sediment data release: U.S. Geological Survey Data Series 182, available at http://pubs.usgs.gov/ds/2006/182/.

Tissot, B.N., Yoklavich, M.M., Love, M.S., York, K., and Amend, M., 2006, Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep sea coral: Fishery Bulletin, v. 104, p. 167–181.

Wentworth, C.K., 1922, A scale of grade and class terms for clastic sediments: Journal of Geology, v. 30, p. 377–392.

EXPLANATION

Substrate class

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Location of real-time video observation and interpreted substrate class of seafloor

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed

Mixed smooth sediment and rock—Moderate to very high backscatter, low rugosity; typically coarse-grained sand, gravel, cobbles, and bedrock

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Location of digital still photograph and interpreted substrate class of seafloor

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Interpreted substrate class depicted in digital still photograph—Indicated by colored frame around photograph (not shown on map; shown in figures only)

Fine- to medium-grained smooth sediment—Low backscatter, low rugosity; typically mud to medium-grained sand; often rippled and (or) burrowed

Rock and boulder, rugose—High backscatter, high rugosity; typically boulders and rugose bedrock

Medium- to coarse-grained sediment—Very high backscatter, low rugosity; typically medium- to coarse-grained sediment, with varying amounts of shell hash; in scour depressions

Sample localities

From usSEABED (Reid and others, 2006)

Area of "no data"—Areas near shoreline not mapped owing to insufficient high-resolution seafloor mapping data; areas beyond 3-nautical-mile limit of California's State Waters were not mapped as part of California Seafloor Mapping Program

3-nautical-mile limit of California's State Waters

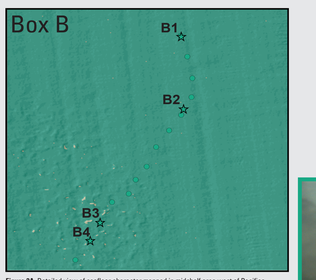


Figure 2A. Detailed view of seafloor character mapped in midshelf area west of Pacifica, approximately 4 km offshore (see Box B, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 2C through 2F) from camera line CAM25, cruise F–3–07–NC.

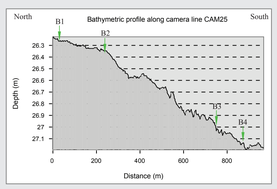


Figure 2B. Bathymetric profile along camera line CAM25 (see fig. 2A for location), showing seafloor relief along camera-sled trackline; green arrows show locations of digital still photographs B1 through B4 (figs. 2C through 2F, respectively). Profile generated using ArcGIS 3D Analyst. Vertical exaggeration, 55x.

Figure 2C. Digital still photograph no. B1 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand, with sharp-crested, oscillatory, bifurcating ripples and also secondary crossing ripples in troughs (water depth, 26 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Bright object at top of image is unidentified. Visibility is low. Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

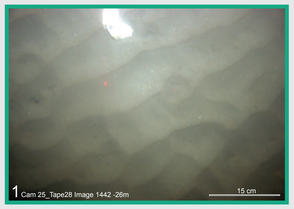


Figure 2D. Digital still photograph no. B2 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand with interference ripples (water depth, 26 m). Abiotic complexity is low, biotic complexity is present, and biocover is low. Biocover includes closed white plumed anemone, *Metridium* spp. (met). Visibility is low. Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

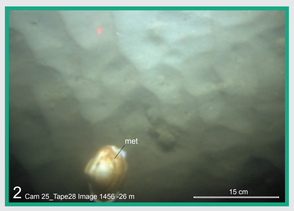


Figure 2E. Digital still photograph no. B3 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand and scattered shell debris, with sharp-crested interference ripples (water depth, 27 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Visibility is moderate. Distance between lasers (pairs of red and green dots) is 15 cm.

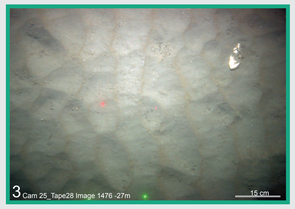


Figure 2F. Digital still photograph no. B4 (see fig. 2A for location). Unconsolidated, fine- to medium-grained sand and scattered shell debris, with symmetrical, bifurcating ripples (water depth, 27 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Visibility is very poor. Distance between lasers (green dots) is 15 cm.

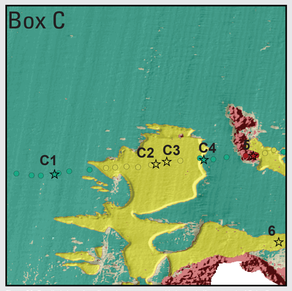


Figure 3A. Detailed view of seafloor character mapped in inner shelf area north of Point San Pedro, approximately 0.2 km offshore (see Box C, on map, for location), showing locations of periodic real-time video observations (dots) and digital still photographs (stars; see figs. 3C through 3H), from camera line CAM24 (figs. 3C through 3G) and in sediment-sampling trough (fig. 3H) on cruise F–3–07–NC.

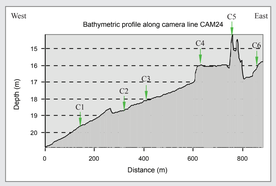


Figure 3B. Bathymetric profile along camera line CAM24 (see fig. 3A for location), showing seafloor relief along camera-sled trackline; green arrows show locations of digital still photographs C1 through C6 (figs. 3C through 3H, respectively). Profile generated using ArcGIS 3D Analyst. Vertical exaggeration, 70x.

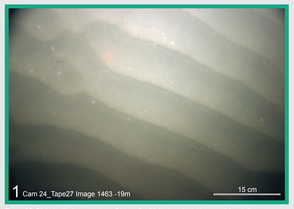


Figure 3C. Digital still photograph no. C1 (see fig. 3A for location). Unconsolidated, fine- to medium-grained sand and scattered shell debris, with sharp-crested, symmetrical, bifurcating ripples (water depth, 19 m). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

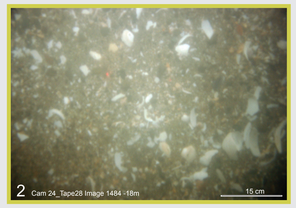


Figure 3D. Digital still photograph no. C2 (see fig. 3A for location). Unconsolidated, medium- to coarse-grained sand and gravel with shell hash (water depth, 18 m), on flank and in trough of megaripple (see fig. 3E) in area mapped as scour depression. Abiotic complexity is low, biotic complexity is absent, and biocover is low. Distance between lasers (red dots) is 15 cm.

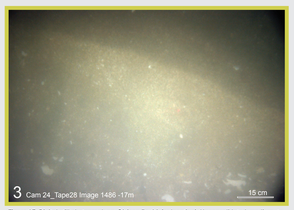


Figure 3E. Digital still photograph no. C3 (see fig. 3A for location). Unconsolidated, medium- to coarse-grained sand and gravel with shell debris (water depth, 17 m), along crest of megaripple in scour depression. Ripple wavelengths of more than 1 m are confirmed in associated video. Abiotic complexity is low, biotic complexity is absent, and biocover is low. Visibility is low. Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

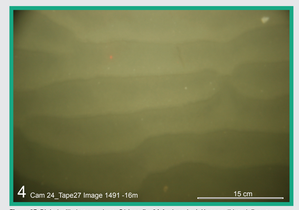


Figure 3F. Digital still photograph no. C4 (see fig. 3A for location). Unconsolidated, fine- to medium-grained sand with sharp-crested, symmetrical, bifurcating ripples (water depth, 16 m); note that about 1 m of steep relief lies between location of this photograph and megaripple sand and gravel shown in figures 3D and 3E (see fig. 3B). Abiotic complexity is low, biotic complexity is absent, and biocover is low. Visibility is very poor. Distance between lasers (only one red dot is visible in this image, but both are visible in previous video frame) is 15 cm.

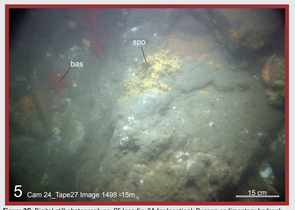


Figure 3G. Digital still photograph no. C5 (see fig. 3A for location). Rugose sedimentary bedrock with sparse coating of unconsolidated sediment and shell fragments (water depth, 15 m). Abiotic complexity is high, biotic complexity is absent, and biocover is moderate. Biocover includes bat stars (bas) and encrusting sponge (spo). Visibility is low. Distance between lasers (red dots are just out of view in this image but are visible in previous video frame) is 15 cm.

Figure 3H. Digital still photograph no. C6 of sediment sample OSP38 (see fig. 3A for location). Unconsolidated, medium- to coarse-grained sand with cobble, gravel, and shell hash (water depth, 15 m), on flank and in trough of megaripple in area mapped as scour depression. Scale determined from size of sediment-sampling trough.

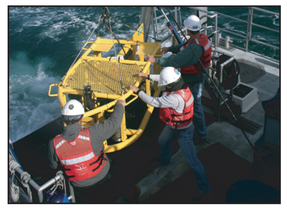


Figure 4. USGS-designed camera sled being loaded onto research vessel in preparation for ground-truth studies. Components onboard sled include four digital video camcorders, one 8-megapixel digital SLR camera, lasers for scale, and various strobe and video lights, as well as telemetry instrumentation that records depth, altitude, and compass heading.

Ground-Truth Studies, Offshore of Pacifica Map Area, California

By

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2014

[1]U.S. Geological Survey;
[2]National Oceanic and Atmospheric Administration, National Marine Fisheries Service

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