Regional Geologic and Geophysical Base Maps of Western North America and Adjacent Oceans

by

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This report is preliminary and has not been edited or reviewed for conformality with Geological Survey standards and nomenclature.

The Cartography-Physiography Project of the Office of Marine Geology is producing new regional geologic and geophysical base maps of the continental shelf of western North America. Paramount requirements for the new base maps are that they edge-join to published base maps of onshore areas and that they preserve the property of equal-area. Two series of maps were constructed since both specifications could not always be met on the same base map.

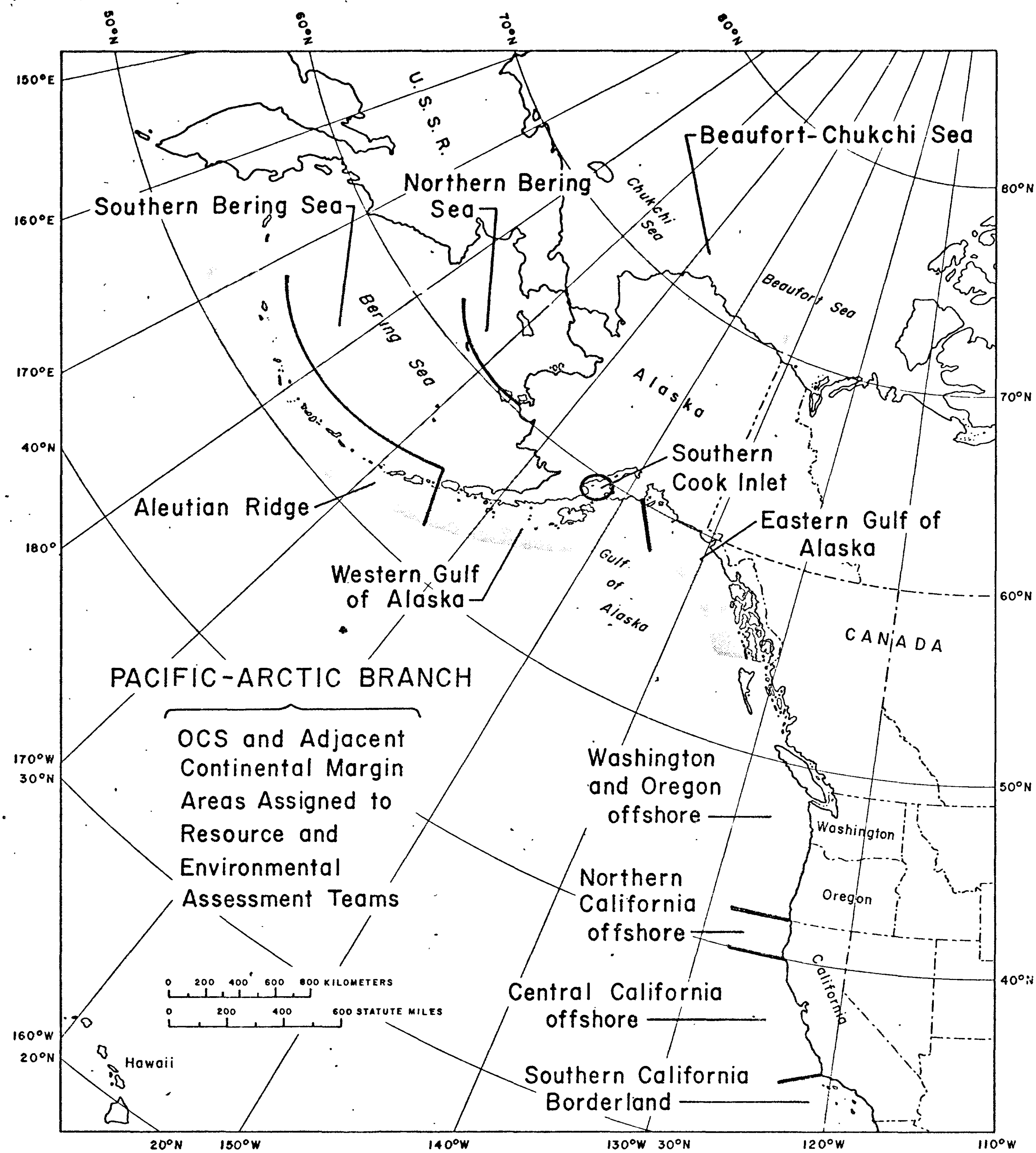
For the areas offshore of Washington, Oregon, and California a wide-band Lambert conic conformal projection with standard parallels at 33°N and 45°N was chosen to edge-join with state base maps. The Albers conic equal-area with standard parallels of 29.5°N and 45.5°N was selected for uses requiring an equal-area projection and to edge-join with The National Atlas of the United States of America (U.S. Geol. Survey, 1970).

For the areas offshore of Alaska in the Pacific and Arctic oceans we have extended the Alaska state map and the National Atlas plates. The Alaska state map, Alaska map "E" (1973 version), was used for one series, and National Atlas Albers conic equal-area map projection with standard parallels at 55°N and 65°N was selected for equal-area uses.

Both the Lambert conic conformal and the Albers conic equal-area are excellent projections for offshore geologic and geophysical maps, since at any scale they retain map properties and their internal sheets may be edge-joined so that regional maps may be developed with no modification to the projection.

The Office of Marine Geology within the Geologic division of the U.S. Geological Survey is involved in the assessment of environmental and regional resources of the ocean floor of North America (Fig. 1). The Pacific-Arctic Branch's area of responsibility extends from 20°N near Hawaii to 80°N in the Arctic Ocean and from 115°E near Kamchatka in the U.S.S.R. to 110°W

Figure 1. Operational areas of the Pacific-Arctic Branch of Marine Geology.



Beaufort-Chukchi Sea
U.S.S.R.
Northern Bering Sea
Southern Bering Sea
Chukchi Sea
Beaufort Sea
Bering Sea
Alaska
Southern Cook Inlet
Aleutian Ridge
Eastern Gulf of Alaska
Western Gulf of Alaska
Gulf of Alaska
CANADA
PACIFIC-ARCTIC BRANCH
OCS and Adjacent Continental Margin Areas Assigned to Resource and Environmental Assessment Teams
Washington and Oregon offshore
Washington
Oregon
Northern California offshore
California
Central California offshore
Southern California Borderland
Hawaii
0 200 400 600 800 KILOMETERS
0 200 400 600 STATUTE MILES
50°N
60°N
70°N
80°N
150°E
160°E
170°E
180°
170°W
160°W
40°N
30°N
20°N
80°N
70°N
60°N
50°N
40°N
20°N
150°W
140°W
130°W 30°N
120°W
110°W

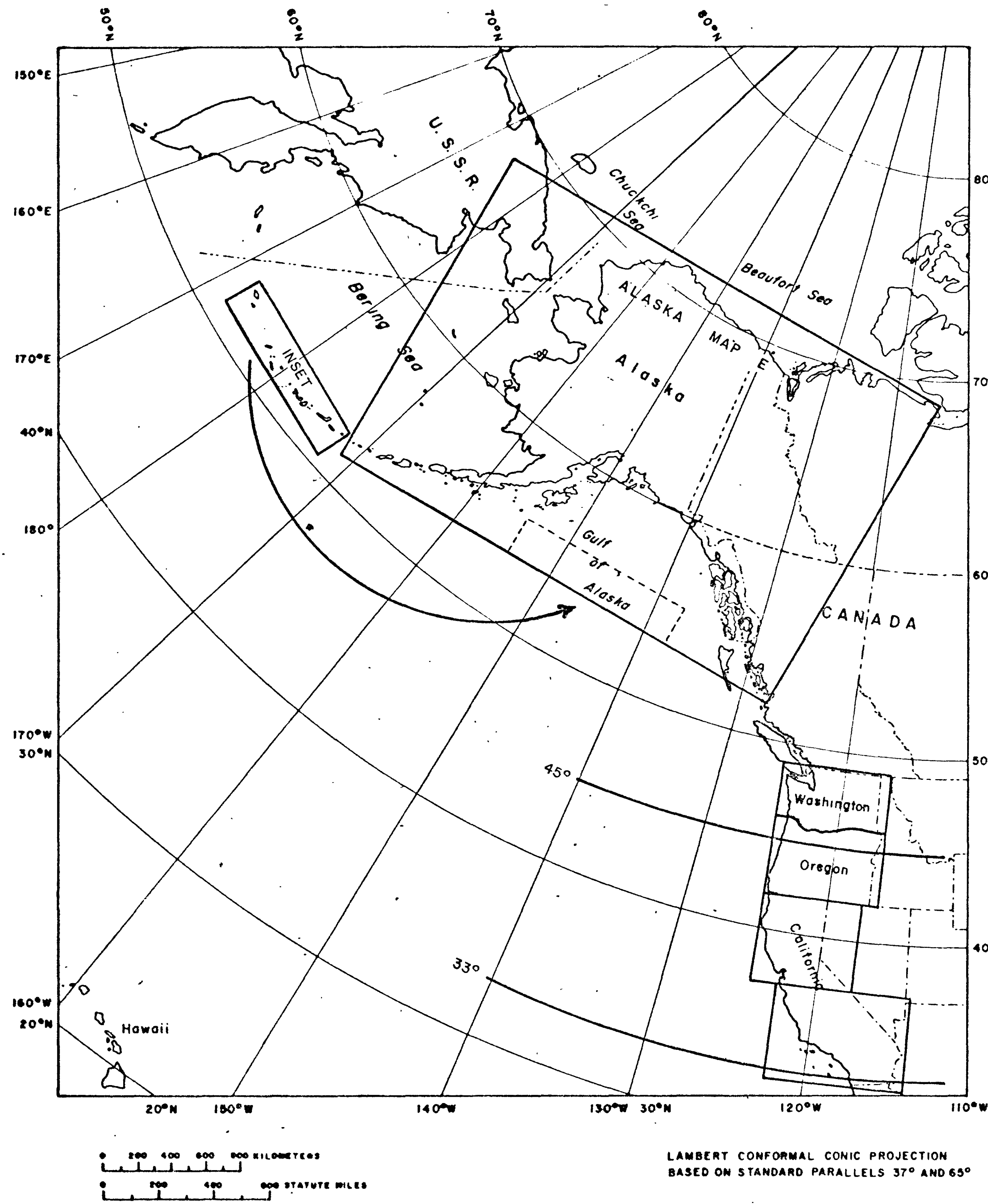
which includes the west coast of North America. For the offshore areas the only map projection base that previously existed was the Mercator. National Ocean Survey Nautical Charts are published on a Mercator projection at diverse scales depending on the area covered. With a common scale nautical charts would edge-join with each other, but not with the onshore base maps. The Mercator map projection does preserve a rhumb line, which is important for navigation, but it is not suitable for portraying areas and does not edge-join with onshore base maps.

One of the responsibilities of the Cartography and Physiography Project of the Pacific-Arctic branch within the Geologic Division is to prepare regional geologic and geophysical base maps of the ocean floor for areas where regional base maps do not exist. The purpose of this report is to document why specific maps projections were considered appropriate for the new offshore geologic and geophysical, regional base maps by examining the distinct properties of selected map projections and explaining the need for offshore maps to edge-join with the published onshore, base maps (Fig. 2 and 6).

Onshore regional resource and environmental maps have been published for many years. A "regional" base map covers an area the size of a large western state, at scales of 1:500,000 or smaller; such maps have existed for some time for all states (Fig. 2), but until recently there has not been a need for regional offshore base maps. Now with the increased activity in offshore, environmental and resource investigations, a need has developed for regional base maps that embody particular and distinct properties.

Regional Geologic and Geophysical base maps belong in the category of thematic maps since the purpose is to portray spatial and areal relationships. Most thematic maps are thus developed on an equal-area map projection, in which every part, as well as the whole, has the same area as on a globe of

Figure 2. State base maps by the U.S. Geological Survey. Alaska map "E: is a modified Transverse Mercator projection. Lambert conic conformal map projection is used for the base maps of Washington, Oregon, and California.



LAMBERT CONFORMAL CONIC PROJECTION
BASED ON STANDARD PARALLELS 37° AND 65°

corresponding scale. The Geologic Map of the United States (King and Beikman, 1974) is an example of a regional thematic map on an equal-area (Albers) map projection. Most atlases are based on equal-area map projections; an excellent example is The National Atlas of the United States of America (U.S. Geol. Survey, 1970). Logic suggests that since similar studies are being carried out in the ocean as have been pursued onshore that they should be compiled and published on compatible projections which can be edge-joined so that the two regions can be compared.

Most of the published, regional geologic and geophysical maps are based on state base maps produced by the Topographic Division of the U.S. Geological Survey. California, Oregon, and Washington have state base maps at a scale of 1:500,000 that are based on the Lambert conic conformal map projection with standard parallels of 33°N and 45°N. The state maps can be edge-joined with one another, and measurements, comparisons, and examinations can be easily made. The much larger state of Alaska has a base map, Alaska map "E", at 1:2,500,000 which employs a modification and does not edge-join with any other of the tranverse Mercator projection series of base maps (Fig. 2). Geologic and geophysical maps of Alaska are published on this state base.

Other onshore regional base maps are founded on the Albers equal-area map projection, with standard parallels of 29.5°N and 45.5°N; examples include The National Atlas of the United States (U.S. Geol. Survey, 1970; Fig. 3) and the Geologic Map of the United States (King and Beikman, 1974).

Maps and charts of offshore areas, published by The National Ocean Survey in the form of bathymetric maps portraying the coastal areas of California, Oregon, and part of Washington, are published at a scale of 1:250,000 on a tranverse Mercator projection (Fig. 4). They edge-join in a north-south direction but not east-west. These bathymetric maps have the same

Figure 3. Albers equal-area map projection coverage from The National Atlas, U.S. Geological Survey. Numbers refer to The National Atlas plate numbers.

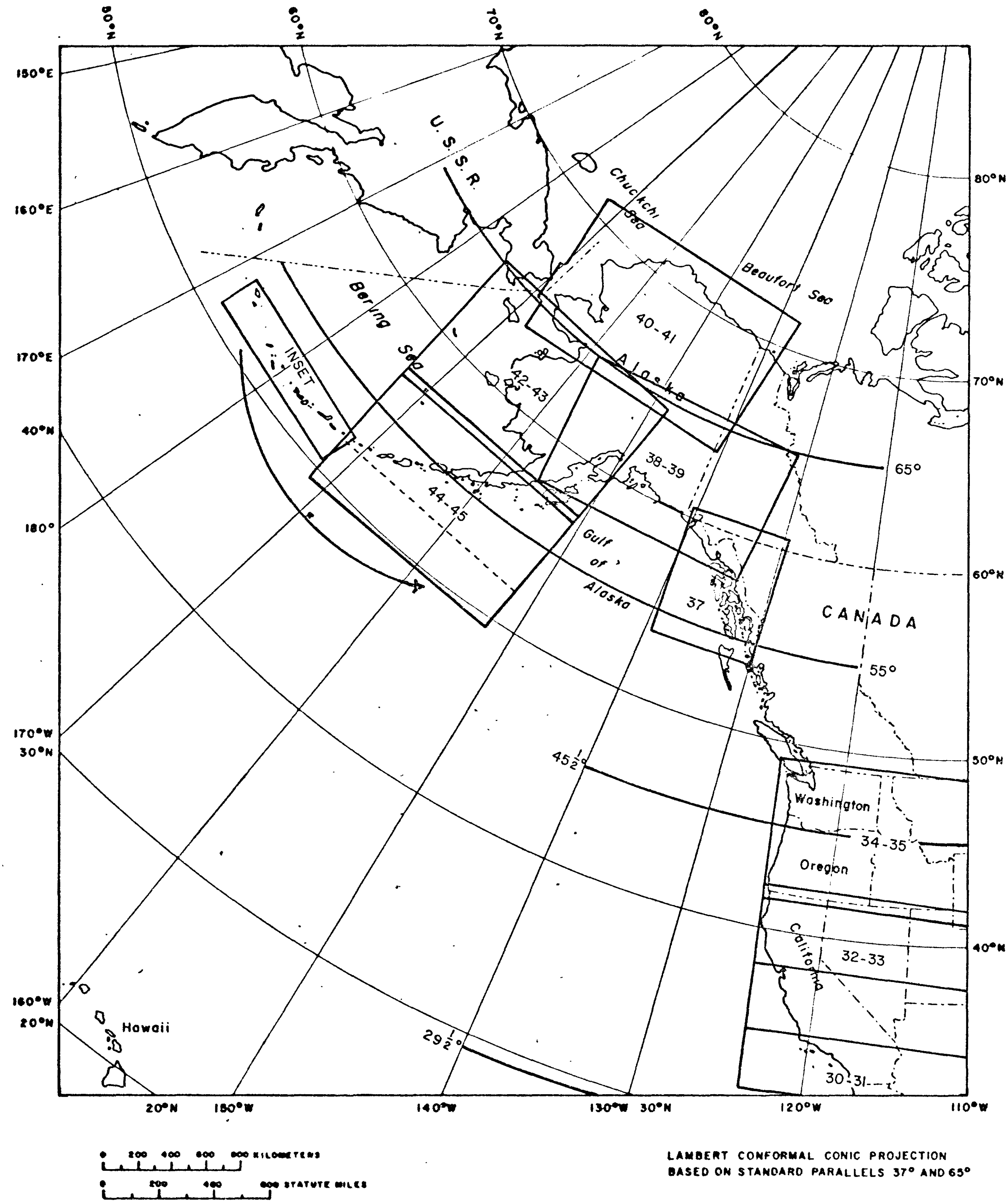


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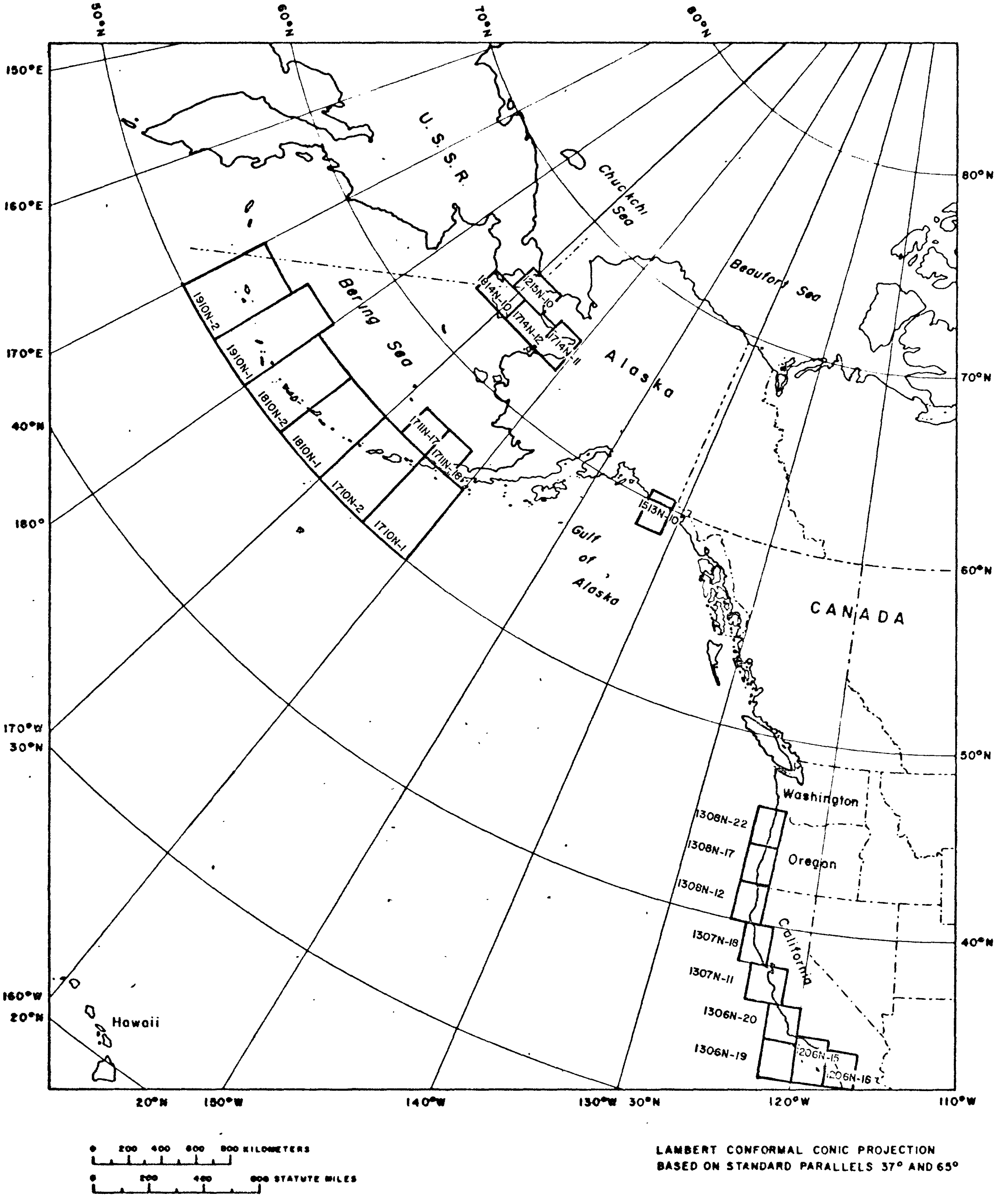
Figure 4. Transverse Mercator Bathymetric maps published by the National Ocean Survey.



LAMBERT CONFORMAL CONIC PROJECTION
BASED ON STANDARD PARALLELS 37° AND 65°

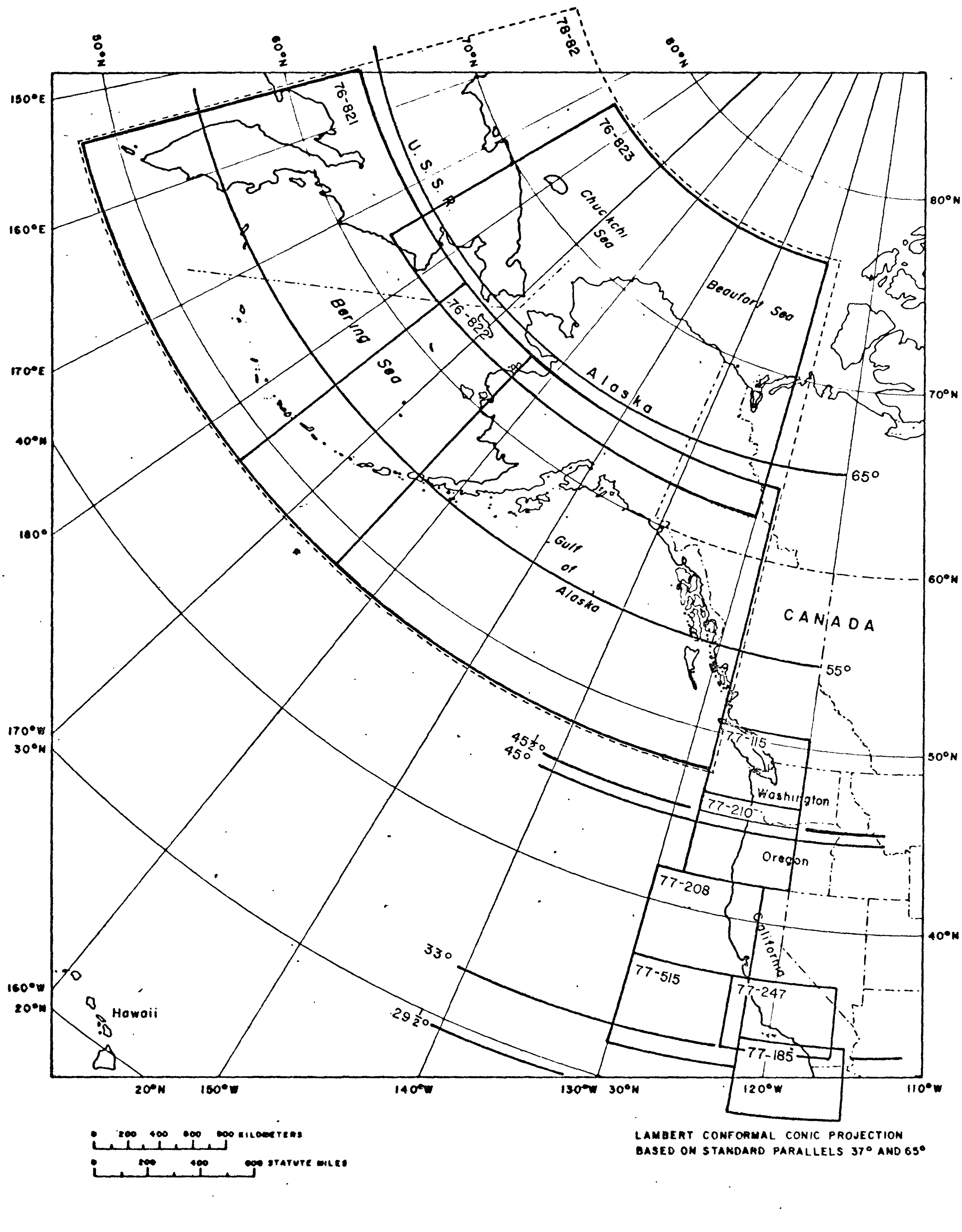
scale as the National Topographic Maps, 1:250,000 scale series, but do not edge-join with them because different tangent meridians were selected for each series.

A tranverse Mercator projection can be thought of as a cylinder tangent to a meridian just as the Mercator projection can be thought of as a cylinder tangent to the equator. The tangent meridian has true scale, and the other meridians are curved concave toward it. The tranverse Mercator projection should be used to represent a band of earth no wider than 15^{o} in longitude (east-west) because of the increase of scale away from the tangent meridian. Bands of this projection cannot be edge-joined without modifying the projection.

The Lambert conic conformal projection can be thought of as a cone that intersects the earth at two places (secant). These two intersections can coincide with two parallels which have true scale and are called standard parallels. The Lambert conic conformal retains the property of conformality. A map projection is conformal when the scale factor of each point is the same in any direction (but is different at each point), and the lines of longitude and latitude intersect at 90^{o}. A conformal map projection preserves the shapes of small areas and preserves angles with short sides.

Albers conic equal-area projection is similar to the Lambert conic conformal in that both have two standard parallels. New regional offshore maps based on the Albers conic equal-area map projection were developed with the aid of a computer, for the same offshore areas as the Lambert and the modified tranverse Mercator base maps. For the offshore areas of California, Oregon, and Washington the same standard parallels of 29.5^{o}N and 45.5^{o}N are used as for the Geologic Map of the United States (King and Beikman, 1974), and thematic maps within The National Atlas (Fig. 5). In The National Atlas

Figure 5. Regional geologic and geophysical base maps produced by the cartography physiography project. Numbers refer to U.S. Geological Survey Open-file numbers.



76-821
U.S.S.R.
76-823
Chuckchi Sea
Beaufort Sea
Bering Sea
76-822
Alaska
Gulf of Alaska
CANADA
78-82
77-115
Washington
77-210
Oregon
77-208
California
77-515
77-247
77-185
Hawaii
65°
55°
45½°
45°
33°
29½°
50°N
60°N
70°N
80°N
150°E
160°E
170°E
180°
170°W
160°W
40°N
30°N
20°N
150°W
140°W
130°W
120°W
110°W
0 200 400 600 800 KILOMETERS
0 200 400 600 STATUTE MILES
LAMBERT CONFORMAL CONIC PROJECTION
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the standard parallels of the Albers conic equal-area plates for the state of Alaska are 55°N and 65°N. Therefore, the same standard parallels were chosen for the new Albers conic equal-area offshore base maps of Alaska (Fig. 5).

The first offshore regional base map that the Cartography-Physiography project produced was the base map of the Aleutian-Bering Sea region (Scholl, 1974). This base map was associated with an oblique map and covered the Aleutian-Bering Sea, including the Kamchatka Peninsula, and edge-joined with the modified tranverse Mercator Alaska map "E" (post 1973 edition). The Alaska map "E" was modified from a tranverse Mercator projection 8° wide and approximately 18° long which has repeated east and west to construct a map 72° wide. The Alaska map "E" tranverse Mercator projection has been twice modified: in the pre-1973 editions the meridians are curved toward the center of the projection; in the post-1973 editions the meridians are straight.

Since the Aleutain-Bering Sea Base map (Scholl, 1974), all of the new regional offshore base maps have been composed of two sheets, one, the same projection as the adjacent state base map, and the other an Albers equal-area map projection (Fig. 6). Each sheet preserves different map projection properties, but both have the same scale, delineate the same area, and express the same offshore bathymetric data.

In the Alaska and Arctic areas the new offshore base maps were developed with the assistance of a computer for the Chukchi and Beaufort seas, the Bering Sea, and the Gulf of Alaska, all extensions of the modified tranverse Mercator Alaska map "E" post 1973 ed. at the scale of 1:2,500,000 (Schumacher, 1976a, b, c; Fig. 5).

Using the Lambert conic conformal map projection with the same standard parallels as the state base maps a new series of base maps have been developed for offshore California, Oregon, and Washington (Gerin, 1977; Schumacher, 1977; Gerin, 1977, Gerin and Shyrock, 1977; Gerin and Schumacher, 1977; Schumacher and Gerin, 1977; Fig. 5).

A new Albers conic equal-area base map of all of Alaska and part of Northeastern Siberia was constructed using the same standard parallels of 55°N and 65°N at the scale of 1:5,000,000 (Alpha, 1978; Fig. 6). Using the Albers capability of edge-joining we have constructed new maps at 1:1,000,000 of the Bering Sea shelf and the Kodiak Island shelf, and of the western Gulf of Alaska including the Aleutian shelf and trench.

Offshore regional geologic and geophysical base maps were developed by the Cartography and Physiography project of the office of Marine Geology because other than the Mercator no regional map projection existed (Fig. 5 and 6). Regional base maps, at scales between 1:500,000 to 1:6,000,000 are needed by resource and environmental assessment teams to plan, record, and publish geologic and geophysical data. Two distinct series of regional base maps with internal edge-joining were constructed by the Cartography-Physiography project for offshore western North America. (1) A series that edge-joins with existing state base maps, which are the Lambert conic conformal and the modified transverse Mercator map projections. (2) A series that edge-joins with The National Atlas of the United States of America and preserves the property of equivlalence of area, a quality of thematic maps, the Albers equal-area.

Figure 6, Specific map projections and scales used for offshore regional Geologic and Geophysical base maps.

Title of Published map	Map Projection and Scale: Albers conic equal-area	Lambert conic conformal	modified Transverse Mercator
Base Map of the Aleutian - Bering Sea Region - Misc. Inv. Series, Map I-879 (1974)			1:2,500,000
Topographic and bathymetric map of the Northern Bering Sea region. Plate 1 <u>in</u> Hopkins, D.M., and others 1976, Physiographic Subdivisions of the Chirkov Basin, Northern Bering Sea. U.S. Geol. Survey Prof. Paper 759-B.		1:1,000,000	
Bathymetric map of Chukchi Sea and Arctic Ocean, U.S. Geol. Survey Open-file 76-823 map, 2 sheets (1976)	1:2,500,000		1:2,500,000
Bathymetric map of the Aleutian trench and Bering Sea U.S. Geol. Survey Open-file 76-821 map, 2 sheets (1976)	1:2,500,000		1:2,500,000
Bathymetric map of the Gulf of Alaska, U.S. Geol. Survey Open-file 76-822 map, 2 sheets (1976)	1:2,500,000		1:2,500,000
Bathymetric map of Pacific Coast-Vancouver Island to Tillamook Bay, U.S. Geol. Survey Open-file 77-115 map, 2 sheets (1977)	1:500,000	1:500,000	
Bathymetric map of Pacific Coast-Santa Catalina Island to Punta San Antonio, Mexico, U.S. Geol. Survey Open-file 77-185 map, 2 sheets (1977)	1:500,000	1:500,000	
Bathymetric map of Pacific Coast-Crescent City to Davenport, California, U.S. Geol. Survey Open-file 77-208 map, 2 sheets (1977)	1:500,000	1:500,000	

Title of Published map	Map Projection and Scale Albers conic equal-area	 Lambert conic conformal	 modified Tranverse Mercator
Bathymetric map of Pacific Coast-Columbia River to Cape Ferrelo, Oregon, U.S. Geol. Survey Open-file 77-210 map, 2 sheets (1977)	1:500,000	1:500,000	
Bathymetric map of Pacific Coast-Monterey Bay to Gulf of Santa Catalina, U.S. Geol. Survey Open-file 77-247 map, 2 sheets (1977)	1:500,000	1:500,000	
Bathymetric map of Pacific Coast-Southwest of Point Santa Cruz, California; U.S. Geol. Survey Open-file 77-515 map, 2 sheets (1977)	1:500,000	1:500,000	
Equal-area base map of Alaska and northeast Siberia; U.S. Geol. Survey Open-file 78-82 map, 1 sheet (1977)	1:500,000,000		
Equal Area Base Map of Norton Sound and the Northern Bering Sea; U.S. Geol. Survey Open-file 78-286 map (1978)	1:1,000,000	1:1,000,000	

Acknowledgments

The culmination of offshore base maps has been the result of cooperation between the Topographic and the Geologic Division of the U.S. Geological Survey. Special thanks is given for flexibility and leadership to Jack Church and Jack Minta of the Topographic Division. In the realm of regional base maps, the science of Cartography becomes somewhat of an art.

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Gerin, M., 1977, Bathymetric map of Pacific Coast-Vancouver Island to Tillamook Bay: U.S. Geol. Survey Open-file 77-115 map, 2 sheets (scale 1:500,000).

Gerin, M., 1977, Bathymetric map of Pacific Coast -- Crescent City to Davenport, California: U.S. Geol. Survey Open-file 77-208 map, 2 sheets (scale 1:500,000).

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