DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF—1728

ABSTRACT

A new free-air gravity anomaly map of the Bering Sea and Aleutian arc-trench system has been compiled from surface ship gravity data collected by the U.S. Geological Survey (USGS) combined with previously collected surface ship and pendulum data. This map covers parts of the Alaska and Siberian Continental Shelf underlain by large sedimentary basins, including St. George, Navarin, and Norton Basins, and parts of Bristol Bay Basin. The map extends into the Gulf of Anadyr over the Siberian Shelf.

INTRODUCTION

Between 1975 and 1981, the USGS collected an extensive amount of marine gravity data throughout the Bering Sea, while in the process of exploring the large sedimentary basins that are located in that region (fig. 1). These new data have been combined with those from previous surveys in the same area (carried out primarily under the auspices of the National Oceanographic and Atmospheric Administration, formerly Environmental Earth Science Administration, and Lamont Doherty Geological Observatory) to create a new free-air gravity anomaly map of the entire Bering Sea region, from south of the Aleutian Arc to the Bering Strait. Much of this area was included in a free-air anomaly map of the north Pacific compiled by Watts (1975) with data collected in the late 1960's and early 1970's. In areas where little or no new data were available, particularly over the Aleutian Trench and in the southeastern Bering Sea (west of long 175° E.), the contours were drawn directly from the Watts map. Other published charts used in this compilation were: U.S. Coast and Geodetic Survey (1969); Fisher and others (1982); National Oceanographic and Atmospheric Administration (1971a,b; 1973a,b); Marlow and others (1983, fig. 21). The extent of each of these charts is indicated in figure 2. Each of the cruises that were used in this compilation is listed in table 1, which also includes details of the cruise and data collection. Pendulum stations were taken from Worzel (1965). More detailed free-air gravity maps at scales of 1:1,000,000 are in preparation for the Umnak Plateau region (Childs and others, in press(a)) and for the central and northern Bering Sea (Childs and others, in press(b)).

DATA REDUCTION

All of the USGS data were collected with LaCoste-Romberg[1] sea gravimeters (S32 and S33) mounted on two- or three-axis inertial stabilized platforms. The theory of operation and calculation methods are described by LaCoste and others (1967) and Valliant and LaCoste (1976). Gravity values were calculated from spring tension and a correction term that included components due to beam motion and inherent cross coupling errors (LaCoste and others, 1967). Prior to digital recording, the gravity values were filtered with a 6-minute averaging filter to remove the effects of ship motion, and data from the three-axis gravimeter were filtered with an additional 84-minute notch filter to remove Schuler period oscillations (Bell, 1969). Observed gravity values were adjusted for meter drift by linear time interpolation between harbor station ties. Eötvös corrections were calculated from 1- or 2-minute fixes of computer-smoothed navigation. Occasional failure of the navigation recording system necessitated the use of longer intervals picked from hand-smoothed navigation plots. Absolute gravity values were obtained by tying to the Alaska gravity base station network (Barnes, 1968), which the USGS extended to harbor stations as ports of call.

The free-air gravity for all of the USGS data was originally calculated with reference to the Earth ellipsoid defined by the 1967 Geodetic Reference System (International Association of Geodesy, 1971), and the IGSN-71 datum (International Association of Geodesy, 1974). However, to facilitate the incorporation of the Watts map, free-air values were converted to the datum defined by the 1930 International Gravity formula (Cassinis, 1930). The free-air anomaly with respect to the 1930 datum is more positive than the anomaly with respect to the 1967 datum. The 1930 value exceed the 1967 values by 4.3 milligals (mGal) at 90° N. and 8.6 mGal at 65° N. (Barnes, 1977).

Compiling data from numerous sources requires careful analysis of errors between different data sets. Prior to contouring, nearly 300 trackline crossings were examined to determine the cross-tie discrepancies. These crossings included both intercruise and intracruise (when a trackline crosses itself) intersections. The mean crossing error between every pair of intersecting cruises was calculated. Two of the older cruises were then discarded as unreliable. The most internally consistent cruise, that of the R/V *Thomas Washington* (Childs and others, in press(a)) and for the central and northern Bering Sea (Childs and others, in press(b)).

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The free-air anomalies were initially contoured by a machine algorithm that mapped all of the data onto an orthogonal grid (approximately 400 by 200 cells) and fit a third-order spline (minimum curvature) surface to the grid values (Briggs, 1974). The machine contours were then modified to accurately intersect the tracklines.

The free-air anomalies were contoured at 10-mGal intervals over the Alaskan Continental Shelf and at 25-mGal intervals elsewhere. The change in contour interval over the continental shelf was justified by the higher density of data and by the greater detail required to describe the anomaly field. The demarcation between the contour intervals is the 0-mGal contour that extends northwest to southeast (approximately following the shelf break) and the 50-mGal contour that parallels the Aleutian Islands to the north between Atka Island and the Alaskan Peninsula. Several contours directly north of Atka Island were interrupted to accomplish the change in interval.

The errors in the gravity data arise primarily from navigational uncertainty, which affects not only the positional accuracy but also the calculation of the Eötvös effect. Secondly, errors arise in correlating the relative marine measurements to absolute datum at harbor ties. The first type of correlating the relative marine measurements to absolute datum at harbor ties. The first type of errors are random, while the second are systematic (or constant) for a particular cruise. The base-tie inaccuracies would be partly or totally corrected by the correction method described above. Figure 3 is a histogram of the absolute value of the differences measured at 281 trackline intersections, after adjustment for cross-tie discrepancies. The root mean square difference was 5.4 mGal. More than 50 percent of the differences were less than 4 mGal, 70 percent less than 6 mGal, and only 10 percent were greater than 10 mGal.

Other geological and geophysical maps in the Bering Sea region that may be useful in the interpretation of this gravity data include: bathymetry — Schumacher (1976) and Gardner and others, 1980; sediment thickness — Cooper and others (1979) and Marlow and others (1979); marine magnetics — Cooper and others (1976), Bailey and others (1976) and Childs and others (1981); land geology — Beikman (1980).

ACKNOWLEDGMENTS

We thank Mike Marlow, Mike Fisher, Jim Gardner, Tracy Vallier, and other chief scientists of the USGS research vessels S.P. Lee and Sea Sounder for the use of gravity data collected during their scientific cruises.

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[1] Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S. Geological Survey.

Bathymetric base map from Schumacher, 1976

This map is not intended for navigational purposes.

TABLE 1. Details of marine gravity surveys, Bering Sea

[na, not available]

Ship	Year	Cruise	Number of values	Ports of call	Navigation	Gravimeter	Platform	Correction for cross coupling
Vema	1964	V3606	255	Midway–Tokyo	Celestial	Gss2 No. 12	Alidade	No
Do—	1965	V3111	886	Adak–Dutch Harbor	—do—	—do—	—do—	Do.
Crawrd	1966	C1009	745	Adak–Adak	—do—	Gss2 No. 6	Anschütz	Do.
Do—	1968	C1208	113	Adak–Honolulu	Satellite	Gss2 No. 31	—do—	Do.
Do—	1969	C1220	842	—do—	—do—	—do—	—do—	Do.
Do—	1971	C1408 C1407	3,375	Adak–Adak	—do—	—do—	—do—	Yes
Hudson	1970	HD01	305	Vancouver–Resolute	—do—	Gss2 No. 17 and vibrating string accelerometer	—do—	Do.
Explia	—do—	na	226	na	na	na	na	na
Rainier	—do—	na	6,095	na	na	na	na	na
Sea Sounder	1976	547SBS	17,078	Dutch Harbor–Nome	Integrated system: Satellite Loran C	LaCoste and Romberg S-32	Gimbal mounted two axis	Yes
Do—	1977	557TBS	7,703	Nome	—do—	—do—	—do—	Do.
Do—	—do—	567TBS	12,300	Dutch Harbor–Dutch Harbor	—do—	—do—	—do—	Do.
Do—	1979	567DOP	7,345	—do—	—do—	—do—	—do—	Do.
S. P. Lee	1975	BERSTSNA	3,315	—do—	Integrated system: Satellite Doppler sonar Loran C	LaCoste and Romberg S-33	—do—	Do.
Do—	1976	L576BS	13,116	Kodiak–Dutch Harbor-Nome	—do—	—do—	—do—	Do.
Do—	—do—	L776BS	4,401	Nome–Adak	—do—	—do—	—do—	Do.
Do—	1977	L877BS	13,838	Kodiak–Nome	—do—	—do—	Gimbal mounted three axis	Do.
Do—	1978	L478BS	5,350	—do—	—do—	—do—	—do—	Do.
Do—	1980	L680BS	11,030	Dutch Harbor–Nome	—do—	—do—	Gimbal mounted two axis	Do.

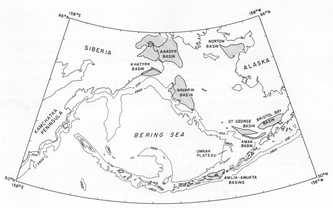

Figure 1. — Reference map of the Bering Sea indicating physiographic features and locations of the major sedimentary basins (shaded), as defined by the 1.5- or 2-km isopach.

SCALE 1:2 500 000

ALBERS EQUAL AREA PROJECTION
BASED ON STANDARD PARALLELS
OF 55° AND 65° NORTH

FREE-AIR GRAVITY ANOMALY MAP OF THE BERING SEA

By

J.R. Childs, H.W. Magistrale, and A.K. Cooper

1985

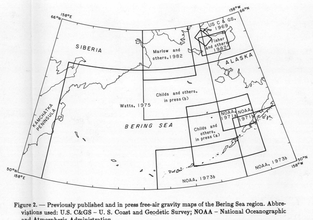

Figure 2. — Previously published and in press free-air gravity maps of the Bering Sea region. Abbreviations used: U.S. C&GS – U. S. Coast and Geodetic Survey; NOAA – National Oceanographic and Atmospheric Administration

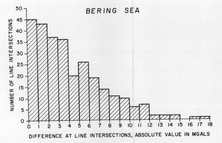

Figure 3. — Histogram of the absolute values of the differences measured at 281 trackline intersections, after adjustment for cross-tie discrepancies.

EXPLANATION

- FREE-AIR GRAVITY (1930 DATUM)— Contour interval 10 and 25 milligals. H,L indicate local highs and lows
- SUBMARINE GRAVITY STATION
- SHIP TRACKLINE
- LAND AREA
- 200 BATHYMETRIC CONTOUR

Interior—Geological Survey, Reston, Va.—1985

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