

Areas of shallow water in the North Atlantic

MICHAEL E.Q. PILSON¹ & SYBIL P. SEITZINGER²

¹*Graduate School of Oceanography, University of Rhode Island;* ²*Institute of Marine and Coastal Science, Rutgers/NOAA CMER Program, Rutgers University*

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Abstract. We report here estimates of the areas of water that are between 1 and 100 m and between 1 and 200 m deep in the North Atlantic, including the Caribbean Sea, the Gulf of Mexico, Hudson Bay and the North Sea, but excluding estuaries. The total areas within these depths, from the equator to 70° N, are $3.91 \times 10^6 \text{ km}^2$ and $5.66 \times 10^6 \text{ km}^2$, respectively. We also report the respective areas by selected geographic regions.

Introduction

While many factors influence the rates of biogeochemical processes in seawater and at the seafloor, characteristically the depth of the water is an important variable. In shallow water the seafloor plays an important role in the sum of biogeochemical processes (e.g. Seitzinger & Giblin, *this volume*). In order to calculate the rates of processes on the continental shelves, the areas of selected portions of the shelves are needed. A previous estimate (Levitus 1982; Levitus & Boyer 1994) was derived from chart measurements made by Smith et al. (1966). The latter measurements were made by summing visual estimates of the average depths of one-degree squares (60 nautical miles on a side at the Equator); for shallow regions the results are therefore somewhat uncertain.

Methods

The source of data for this compilation was the file called ETOPO5, supplied by the National Geophysical Data Center (NGDA 1993) on CD-ROM. This global data set is presented as elevations and depths, in meters, at the intersections of each 5-minute line of latitude and longitude.

Our procedure was to acquire the data in blocks of one to five degree squares or rectangles for all shallow water regions in the North Atlantic and adjacent marine waters (excluding the Mediterranean and the Baltic), carry the data into Excel, eliminate overlaps, and count the number of values falling

between -1 and -100 m, and between -1 and -200 m. An area of 25 square minutes was assigned to each count, and the area corrected according to latitude. The respective areas were accumulated according to latitude band and also according to various regions.

An estimate of the quality of the data source was obtained by selecting regions on several charts at appropriate scales, picking off the depths at the intersections of the five-minute latitude and longitude lines, converting to meters where necessary, and comparing these with the ETOPO5 data.

Results

a. *Data quality.* As can be seen from Figures 1 and 2, there are numerous discrepancies between the depths obtained at specific locations using the ETOPO5 data and using navigational charts. The larger features of the ocean depths are certainly represented reasonably well (Figure 1). On a smaller scale, and in shallow water, there are many startling discrepancies (Figure 2). Nevertheless, the ETOPO5 values tend to be rather randomly distributed around those from the navigational charts, a conclusion drawn from viewing about 20 graphs such as those in Figures 1 and 2. These figures were selected to show the overall general trend on the large scale, and examples of the poorer fits on the small scale in that limited data set. There is, of course, some error in picking depths off the navigational charts, but from a detailed comparison it is evident to us that these cannot be as large as appear in the figures presented. It is not our purpose here to perform an exhaustive analysis of the problems with ETOPO5, as we hope that it will soon be superseded by a much more accurate data set. Figures 1 and 2 indicate that the general trend in the larger scale and the errors on the smaller scale are such that the derived values of the areas of the continental shelves and other shallow water regions, averaged over the selected regions, will not be grossly distorted.

An additional check on the accuracy of the data was carried out by comparing the areas obtained between 1 and 200 m water depth and between 30° N and 35° N on the SE coast of the United States. Planimetry on Defense Mapping Agency Chart 108 for this region, excluding Pamlico Sound, yielded a value of $85.7 \times 10^3 \text{ km}^2$. Evaluation of the area from a detailed USGS data set gave a value of $81.9 \times 10^3 \text{ km}^2$ (Michael Crowley, pers. comm., areas calculated from a compilation of USGS bathymetry data obtained from John Breckenridge, NRL South, Stennis Space Center), while the ETOPO5 data set yielded a value of $84.0 \times 10^3 \text{ km}^2$. This comparison provides some sense of the accuracy with which the individual areas are known. We did not attempt a detailed point-by-point comparison to isolate the discrepancies.

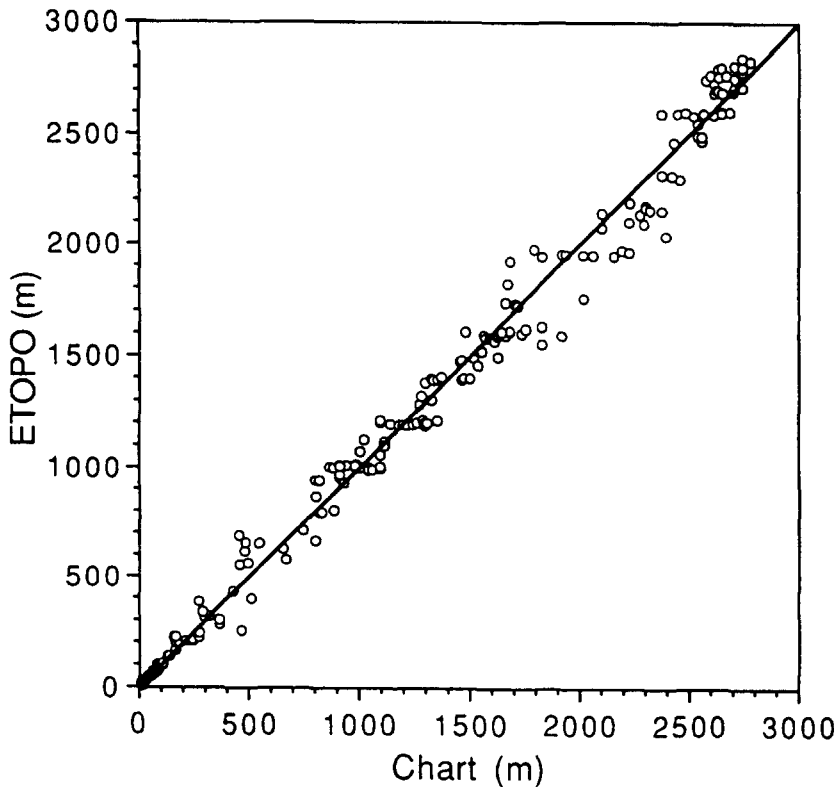


Figure 1. Comparison of depths at the intersections of five-minute latitude and longitude lines obtained using data from ETOPO5 with data from navigational charts. Here data are combined from three one-degree squares on the following charts: NOAA Chart No. 12300, Approaches to New York, fathoms, 40N 71W–39N 70W; NOAA Chart No. 11300, Gulf Coast, Galveston to Rio Grande, fathoms, 28N 97W–27N 96W, 27N 96W–26N 95W.

After the comparisons noted above were completed, we came across a paper (Smith 1993) wherein is included a comparison of ETOPO5 data with shipboard depth data. The evaluation deals mostly with the deep sea, but two cruise tracks on the southern Argentine shelf show evident discrepancies with ETOPO5, and the general evaluation is consistent with our conclusions here.

b. *Areas of the shelves.* The areas of shallow water in the North Atlantic were cumulated in five-degree latitude bands for the west and east sides of the N. Atlantic and totalled (Table 1). The total area between 1 and 100 m depth is 3.91 million square kilometers, and between 1 and 200 m depth it is 5.66 million square kilometers. These values are 88 and 64 % greater, respectively, than those listed in Levitus (1982) and Levitus & Boyer (1994).

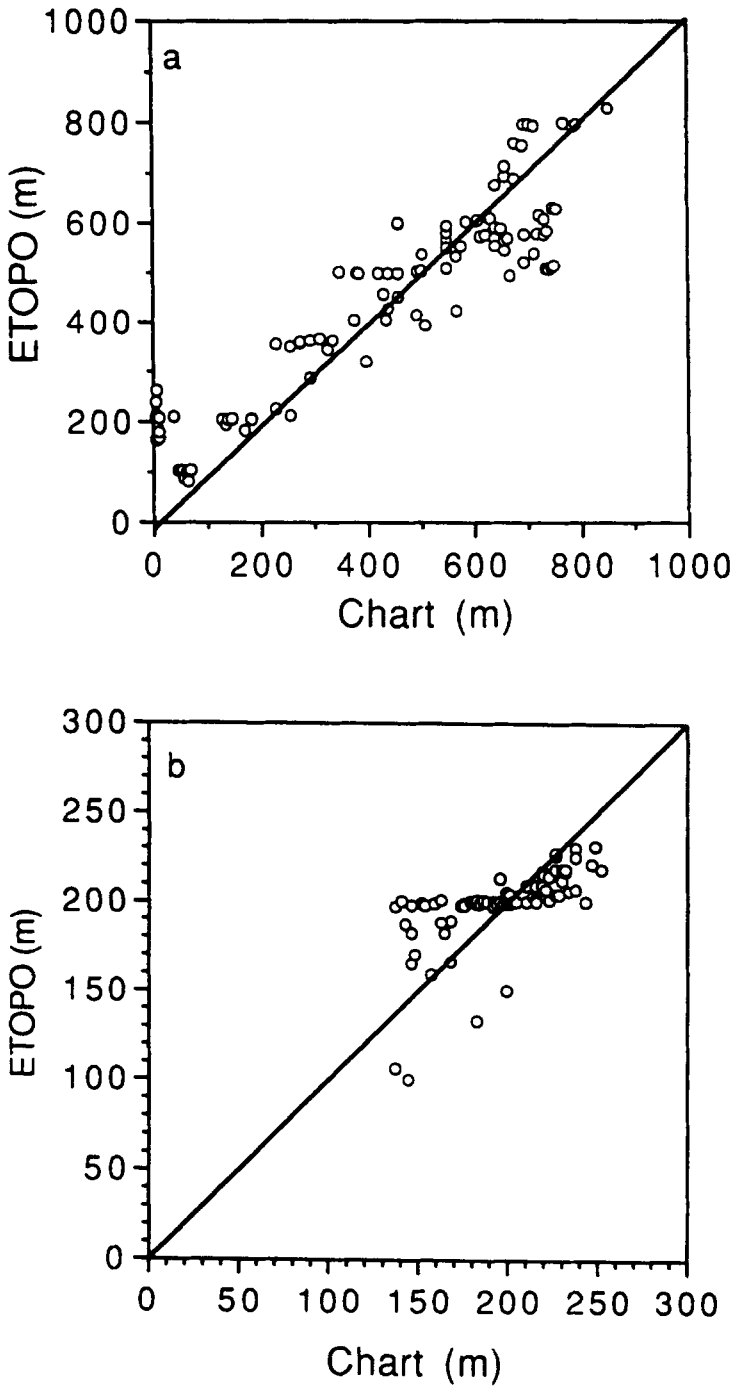


Figure 2. Comparison of depths at the intersections of five-minute latitude and longitude lines obtained from ETOPO5 with equivalent data from navigational charts. a) NOAA Chart No. 11460, Florida Cape Canaveral to Key West, fathoms, 28N 80W–27N 79W. b) NOAA Chart 13260, Bay of Fundy to Cape Cod, fathoms, 44N 68W–43N 67W. Several other charts gave similar results.

Table 1. Summary of the areas of shallow water in the North Atlantic, by five-degree latitude band, extracted from the ETOPO5 data set. Areas are listed both from 1 to 100 m depth and from 1 to 200 m depth. Values are given in units of 1000 km². Estuaries and small bays are not included (e.g. Chesapeake Bay is not included, neither is the Baltic, but Hudson Bay, the Bay of Fundy, and the Gulf of St. Lawrence up to Quebec City are included). For comparison, equivalent data from Levitus (1982) and Levitus and Boyer (1994) are also listed. Areas are listed from 10° S. latitude to 70° N. latitude for the west and east sides of the Atlantic. Island areas are allocated to either the west side or east side of the basin (see Table 2). The totals are given only for the region from the Equator north to 70° N. latitude.

	From ETOPO5						From Levitus	
	West side, to		East side, to		Total, E+W		Total, E+W	
	100 m	200 m	100 m	200 m	100 m	200 m	100 m	200 m
Areas in each band (10 ³ km ²)								
10S to 5S	21.87	28.31	19.92	29.41	41.79	57.72	20	20
5S to Eq.	130.57	138.77	30.23	38.26	160.80	177.03	120	130
Eq. to 5N	176.26	186.68	63.02	80.78	239.28	267.46	150	220
5N to 10N	196.14	214.45	80.41	94.43	276.56	308.88	220	240
10N to 15N	157.31	186.04	68.22	74.32	225.53	260.35	50	100
15N to 20N	133.20	178.01	19.83	27.10	153.03	205.11	30	110
20N to 25N	265.68	314.26	43.04	50.48	308.72	364.73	100	210
25N to 30N	326.11	377.82	30.72	42.50	356.83	420.32	150	270
30N to 35N	98.35	105.73	14.11	23.09	112.46	128.82	30	40
35N to 40N	65.70	71.83	13.29	22.49	78.99	94.32	60	60
40N to 45N	220.98	355.29	23.08	33.99	244.06	389.27	110	300
45N to 50N	242.76	408.67	88.31	195.93	331.07	604.60	260	510
50N to 55N	115.51	168.88	310.62	384.04	426.13	552.92	260	280
55N to 60N	283.59	541.53	337.19	467.30	620.78	1,008.83	210	440
60N to 65N	185.80	455.57	71.08	174.39	256.88	629.97	60	150
65N to 70N	211.02	280.37	65.19	142.35	276.21	422.73	390	530
Totals (10 ³ km ²)								
Eq. to 70N	2,678	3,845	1,228	1,813	3,907	5,658	2,080	3,460

For the purpose of assessing biological and geochemical processes in various shelf regions and other shallow water areas (e.g. Seitzinger and Giblin, *this volume*; Nixon et al., *this volume*), we have calculated the areas of various geographical or biotic regions (Table 2).

Discussion

The earlier data presented in Levitus (1982) and Levitus & Boyer (1994) were derived by visual inspection and assigning a single depth to one-degree

Table 2. Areas of shallow marine water in the North Atlantic, arranged by region. The criteria used for selecting areas to measure are given in the text and in Table 1. In this compilation, the northern limit of measurement is 70° N, and the southern limit is the Equator. Values are given in units of 1000 km².

Region	Areas down to a depth of	
	100 m	200 m
Greenland	88.92	159.90
Hudson Bay	402.49	780.18
Labrador, Foxe Basin, Baffin Island, Hudson Strait, Ungava Bay	306.13	496.31
Gulf of St. Lawrence & Grand Banks	315.77	519.00
Nova Scotia to Cape Hatteras	230.78	361.04
Cape Hatteras to S. Florida	123.34	137.36
West Florida	126.24	145.13
Northern Gulf of Mexico	178.17	204.40
West and South Gulf of Mexico	196.52	224.03
Caribbean Islands	142.99	194.96
Caribbean Shelf, Central & South America	238.08	279.80
Amazon Shelf	359.58	389.56
Faroes, Azores, Rockall Bank, Madiera, Cape Verdes	11.32	33.73
African Shelf (Equator to Strait of Gibraltar)	319.33	392.89
Spain and Portugal (to 45° N)	33.99	51.44
France, Great Britain, West. Europe, North Sea, (from 45° N to 60° N)	741.53	1,087.43
Norway Shelf (N from 60° N)	44.71	93.88
Iceland	46.69	107.27
Totals	3,907	5,658

squares. This procedure probably produces a reasonably accurate estimate of the volume of the ocean basins, but is not suitable for accurately assessing the areas of shallow water, where many squares may overlap dry land, shallow water and deep water. The ETOPO5 data set is certainly suspect; however, it has coverage at relatively dense five minute intervals. Accordingly, we believe that it provides values for the selected areas that are more accurate than those previously available. Until a better global data set is available, and the areas extracted, the values derived here will have to do.

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