

## CHAPTER 16: PLANKTON DATA

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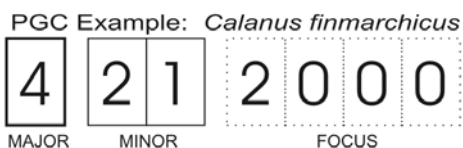
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### 16.1. INTRODUCTION

The term 'plankton' comes from the Greek '*planktos*' (drifter). Plankton refers to floating or drifting organisms with limited powers of locomotion (Kennish, 1990). Planktonic organisms range in size from less than two microns to more than two centimeters (Levinton, 1995). The major plankton subdivisions include bacteria, phytoplankton, zooplankton, and temporary plankters which are planktonic only during some part of their life cycle, *e.g.*, eggs and larvae of fishes and other organisms (Kennish, 1990). Plankton participate across many levels of the pelagic ecosystem; from primary production and re-mineralization, to the transfer of materials and energies to higher trophic levels such as fishes, birds, reptiles, and marine mammals (Harris *et al.* 2000). For these reasons it is important to have plankton observational data along with physical and chemical ocean profile data in the World Ocean Database. This opens up opportunities for finding interactions between plankton and other ocean variables (temperature, salinity, oxygen, nutrients, *etc.*) and for better understanding and preservation of pelagic ecosystems.

The plankton subset of the *World Ocean Database 2009* (WOD09) includes and extends the content of the previously released *World Ocean Database 2005* (Baranova *et al.*, 2006), *World Ocean Database 2001* (O'Brien *et al.*, 2001), and *World Ocean Database 1998* (Conkright *et al.*, 1998). The WOD09 plankton data subset is a collection of measurements from serial bottle and plankton net-tow. The plankton measurements are represented in WOD09 as quantitative and qualitative abundance, and biomass data. The plankton measurements are stored in the OSD dataset (see Chapter 2).

Scientific taxonomic names in the WOD09 are stored using the corresponding ITIS (Integrated Taxonomic Information System, <http://www.itis.gov>) Taxonomic Serial Number (TSN). ITIS TSN's are not available for all plankton descriptions and biomass. WOD09 negative taxonomic codes (sequentially assigned numbers) were developed to preserve the original descriptions. In addition to ITIS or negative taxonomic codes, each plankton description has a *Plankton Grouping Code* (PGC) developed by O'Brien (2007). The PGC code follows the taxonomic hierarchy presented in *The Five Kingdoms* (Margulis & Schwartz 1998). The PGC is an ancillary code which places each taxon into broader groups (*e.g.*, *phytoplankton*, *diatoms*, *zooplankton*, *copepods*) and allows the WOD09 user access to hundreds of individual taxa by using a single PGC code. The PGC is 7-digit code divided into Major group (*e.g.* *Bacteria*, *Phytoplankton*, *Zooplankton*), Minor group (*e.g.*,



*cyanobacteria, diatoms, crustaceans*), and Focus group (e.g., *copepods*). For example, the copepod *Calanus finmarchicus* has a PGC code of "4212000", specifying that it is in Major Group "4" (zooplankton), Minor Group "21" (crustaceans), and

Focus Group "2000" (copepods). Earlier versions of the *World Ocean Database* (2001, 2005) used a PGC precursor called the Biological Grouping Code, BGC (O'Brien *et al.* 2001). The PGC combines the BGC's separate "protists" grouping with the "phytoplankton" group. WOD09 has replaced all BGC codes with their corresponding PGC codes.

The typical plankton cast, as represented in WOD09, stores taxon specific and/or biomass data in individual sets, called "Taxa-Record". Figure 16.1 demonstrates an example of a plankton cast in WOD09.

Longitude	Latitude	Year	Month	Day	Time	Cruise#	CC	Prof_#
-4.883	79.017	1991	6	9	---	10438	06	2087562
Mesh_size	200.000	Type_tow		2.000	Lge_removed	1.000		
Gear_code	118.000	net_mouth_area	0.300	Lge_removed	len	1.000		
Tow_speed_avg	1.944							
<b>Taxa-Record #1</b>								
Param_number	85263.000	upper_depth	0	lower_depth		100.000		
Taxon_lifestage	25.000	Taxon_count	18.600	Taxon_modifier		2.000		
Units	70.000	CBV_value	18.600	CBV_calc_meth		70.000		
CBV_flag	3.000	PGC_group_code		4282000.000				
<b>Taxa-Record #2</b>								
Param_number	-404.000000	upper_depth	0	lower_depth		100.000		
int_value	3100.000	Units	69.000	CBV_value	31.000			
CBV_calc_meth	69.100	CBV_flag	3.000	PGC_group_code		-404.000000		
<b>Taxa-Record #3</b>								
Param_number	85263.000	upper_depth	0	lower_depth		100.000		
Taxon_lifestage	26.000	Taxon_count	0.100	Taxon_modifier		2.000		
Units	70.000	CBV_value	0.100	CBV_calc_meth		70.000		
CBV_flag	3.000	PGC_group_code		4282000.000				<i>etc ....</i>

<b>Access#</b>	772
<b>Project</b>	435
<b>Platform</b>	199
<b>Institution</b>	892
<b>Cast_Number</b>	9617720
<b>Orig_Stat_Num</b>	7
<b>Bottom_Depth</b>	1413.000
<b>T-S_Probe</b>	7.000
<b>NODCorig</b>	3.000

**Figure 16.1. An example of a plankton cast in WOD09 (using provided output software).**

Each “Taxa-Record” contains a taxonomic code (“Param\_number”), depth range (the upper and lower depth) of observation, the original measurements (*e.g.*, abundance, biomass or volume), and all provided qualifiers (*e.g.*, lifestage, sex, size, etc.) required to represent the plankton observation.

In addition to the observed data, a cast may include additional originator’s metadata information such as the “institution” which collected and identified the species of plankton, the “voucher institution” (institution which stores samples), sampling gear (*e.g.*, Bongo Net, Continuous Plankton Recorder), net mesh size, sampling method (*e.g.*, vertical, horizontal, or oblique haul), meteorology, and other general header information which are described in detail in WOD09 documentation (Johnson *et al.*, 2009).

The alternative way to receive plankton data is a “csv” (comma-separated value) output file, which is available only through the WODselect – the online WOD09 database retrieval system (<http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html>).

```

CAST  ,,9617720,WOD Unique Cast Number,WOD code,,,,,,,,,
NODC Cruise ID,,06-10438  ,,,,,,,,,,
Originators Station ID,,7,,integer,,,,,,,,,
Originators Cruise ID,,,,,,,,,
Latitude,,79.0167,decimal degrees,,,,,,,,,
Longitude,,-4.8833,decimal degrees,,,,,,,,,
Year,,1991,,,,,,,,,
Month,,6,,,,,,,,,
Day,,9,,,,,,,,,
METADATA,,,,,,,,,
Country,,DE,NODC code,GERMANY, FEDERAL REPUBLIC OF,,,,,,,,,
Accession Number,,772,NODC code,,,,,,,,,
Project,,435,NODC code,IAPP (International Arctic Polynya Programme),,,,,,,,,,
Platform,,199,OCL code,POLARSTERN,,,,,,,,,
Institute,,892,NODC code,ALFRED-WEGENER-INSTITUTE (BREMERHAVEN),,,,,,,,,,
Bottom depth,,1413,meters,,,,,,,,,
Database origin,,3,WOD code,GODAR Project,,,,,,,,,
BIOLOGY METADATA,,,,,,,,,
Mesh size,,200,microns,,,,,,,,,
Type of tow,,2,WOD code,VERTICAL TOW,,,,,,,,,
Large plankters removed, ,1,WOD code,yes,,,,,,,,,
Gear,,118,WOD code,Bongo Net,,,,,,,,,
Net mouth area,,0.3,m2,,,,,,,,,
Min length removed,,1,cm,,,,,,,,,
Average tow speed,,2,knots,,,,,,,,,
BIOLOGY,Upper Z,Lower Z,Measuremnt Type,ORIGINAL VALUE ,F,Orig unit,WOD CBV value
,F,_unit,_meth,WOD PGC,ITIS TSN,mod,lif,
1,0. meters,100. meters,Taxon_count,18.6,0,#/m3,18.6,3,
#/m3,70,4282010,CALANUS,MODIFIER=spp. (multiple species),LIFE STAGE=C1:
COPEPODITE I
2,0. meters,100. meters>Total Dry Mass,3100,0,mg/m2,31,3,mg/m3,69.1,-404,Zooplankton Dry
Mass (mg/unit),,,,,,,,,,
3,0. meters,100. meters,Taxon_count,0.1,0,#/m3,0.1,3,
#/m3,70,4282010,CALANUS,MODIFIER=spp. (multiple species),LIFE STAGE=C2:
COPEPODITE II
.....
END OF BIOLOGY SECTION

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**Figure 16.2.** An example of a plankton cast in ‘csv’ output file available on-line through the WODselect

## 16.2. BASIC QUALITY CONTROL

Plankton numerical abundance and total biomass measurements are stored with the data originator's units in WOD09 (e.g., counts in units of “number per m<sup>3</sup>”, “wet mass per m<sup>2</sup>”, “displacement volume per haul”, “count per haul”, “count per ml”). To allow easier comparison of incoming measurements with different units, each numerical abundance or biomass measurement has been recalculated into a common unit named *Common Base-unit Value* (CBV). The CBV is calculated from the original value using sampling metadata (e.g., towing distance, water volume filtered) but does not account for differences in mesh size, gear efficiency, or sampling depth intervals. The calculation method used to create the CBV is stored in the *CBV calculation method* field and described in detail in WOD09 documentation, Appendix 5.11, (Johnson *et al.*, 2009). Table 16.1 lists CBV units by data type.

**Table 16.1. Measurement Type and/or Groups and their corresponding CBV unit.**

Measurement Type or Group	CBV unit
Total Biomass (displacement volume, settled volume)	ml / m <sup>3</sup>
Total Biomass (wet mass, dry mass, ash free dry mass)	mg / m <sup>3</sup>
Zooplankton Abundance	# / m <sup>3</sup>
Phytoplankton Abundance	# / ml
Bacterioplankton Abundance	# / µl
Ichthyoplankton Abundance	# / m <sup>3</sup>

The addition of the PGC and CBV to each plankton measurement allows for individual value checks against broad, group-based ranges (O'Brien *et al.*, 2001). Grouped by major PGC groups (Table 16.2) and Total Biomass types (Table 16.3), these broad range checks are used to detect and flag extremely large or small values.

**Table 16.2. WOD09 broad group-based ranges for plankton abundance.**

Group	Min Value	Max Value	Units
Bacteria	0.001	5,000	# · µl <sup>-1</sup>
Phytoplankton	0.001	50,000	# · ml <sup>-1</sup>
Zooplankton	0.001	200,000	# · m <sup>-3</sup>
Ichthyoplankton	0.001	200,000	# · m <sup>-3</sup>

**Table 16.3. WOD09 broad group-based ranges for biomass.**

<b>Group</b>	<b>Min Value</b>	<b>Max Value</b>	<b>Units</b>
Total Displacement Volume	0.005	10	ml · m <sup>-3</sup>
Total Settled Volume	0.025	50	ml · m <sup>-3</sup>
Total Wet Mass	0.5	10,000	mg · m <sup>-3</sup>
Total Dry Mass	0.01	500	mg · m <sup>-3</sup>
Total Ash-free Dry Mass	0.001	100	mg · m <sup>-3</sup>

WOD09 applied quality flags to Common Base-unit Values as follows:

0 - accepted value

1 - range outlier (outside of broad range check)

2 - questionable value\*

\* The contents from an entire net tow may be flagged as “questionable” in cases of gross gear failure (*e.g.*, a broken net or leaking bottle). Individual observations may also be flagged in cases of gear-incompatible capture (*e.g.*, phytoplankton cells snagged in a large mesh net, presence of a single copepod caught in a Nansen bottle).

### **16.3. DATA SOURCES**

The plankton data that comprise WOD09 have been contributed by 31 countries, 135 institutions and more than 40 projects. Significant amounts of data (98,500 casts) have no information about the project. Among them are data provided by the Instituto del Mar del Peru (IMARPE). This contribution (~23,000 casts) comes from a joint data rescue effort with the IMARPE and the Intergovernmental Oceanographic Commission’s Global Oceanographic Data Archaeology and Rescue project (GODAR), which digitized over forty-five years of IMARPE phytoplankton monitoring data. Substantial amounts of historical biomass and abundance data are from the archives of the National Oceanographic Data Center (NODC) and the World Data Center for oceanography, Silver Spring.

Table 16.4 summarizes data contributing countries. The top five contributors are United States, Japan, Peru, Russia, and the United Kingdom. Within the United States, the National Marine Fisheries Service (NMFS) has played a cooperative or leading role in major sampling and monitoring programs which were responsible for collecting ~70% of the US contribution, and 40% of the total global content. The NMFS-associated programs are indicated with asterisks in Table 16.5.

A considerable portion of biomass data (~47,000 casts) was received from Coastal and Oceanic Plankton Ecology Production and Observation Database (COPEPOD)<sup>1</sup> as a result of collaboration between NODC and National Marine Fisheries Service (NMFS).

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<sup>1</sup> Data acquired through the COPEPOD database were provided in COPEPOD format and mainly include data from CalCOFI, MARMAP, and SEAMAP projects.

**Table 16.4. National contributions of plankton casts in WOD09.**

<b>NODC Country Code</b>	<b>Country Name</b>	<b># Casts</b>	<b>% of Total</b>
US	United States	110,911	50.7
JP	Japan	41,372	18.9
PE	Peru	22,874	10.6
SU	Soviet Union	17,362	8.0
GB	Great Britain	15,680	7.2
ID	Indonesia	2,098	1.0
PT	Portugal	1,611	0.7
IN	India	970	0.4
DE	Germany	868	0.4
AU	Australia	763	0.4
FR	France	752	0.3
CA	Canada	656	0.3
PL	Poland	405	0.2
NO	Norway	403	0.2
EC	Ecuador	352	0.2
MX	Mexico	293	0.1
BR	Brazil	199	0.1
KR	Korea Republic of	193	0.1
PH	Philippines	184	0.1
TW	Taiwan	141	0.1
ZA	South Africa	141	0.1
NC	New Caledonia	136	0.1
CO	Colombia	97	> 0.1
ES	Spain	71	> 0.1
BE	Belgium	38	> 0.1
NL	Netherlands	36	> 0.1
SG	Singapore	35	> 0.1
PK	Pakistan	22	> 0.1
AR	Argentina	11	> 0.1
SE	Sweden	11	> 0.1
TH	Thailand	10	> 0.1
	<i>Total</i>	<i>218,695</i>	<i>100.00</i>

Another large portion (38,980 casts) of the zooplankton and biomass data was acquired through the California Cooperative Oceanic Fisheries Investigations (CalCOFI) project. The CalCOFI project was initiated in 1949 to study the collapse of the U.S. west coast sardine fishery. Hydrographic casts have been occupied from 1950 to the present along cross-shelf transects. Additional information can be found on CalCOFI's Web Page, <http://www.calcofi.org>.

The Marine Resources Monitoring Assessment and Prediction (MARMAP) program is one of the important contributors of the plankton data (19,646 casts). The NMFS-wide MARMAP project was established in 1974. Data collected over time includes

biological surveys of fishes, fish eggs and larvae.

A significant amount of data (11,996 casts) was received through the Southeast Area Monitoring and Assessment Program (SEAMAP). Since its beginning in 1981 SEAMAP monitoring of marine resources within Gulf of Mexico, South Atlantic, and Caribbean regions <http://www.seamap.org/> .

The Outer Continental Shelf Environmental Assessment Program (OCSEAP) contributed another large portion of the plankton data (7,920 casts). The OCSEAP was established in 1984 by basic agreement between the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of the Interior (USDOI), Minerals Management Service (MMS) for environmental studies of Alaskan Outer Continental Shelf waters considered for oil development (Truett, J.C., 1985).

Another source of data was the Eastern Tropical Pacific Ocean (EASTROPAC) program (5,544 casts). The first EASTROPAC survey (February 1967 through March 1968) was a cooperative effort towards the understanding of the oceanography of the eastern Tropical Pacific Ocean. Participating scientists were primarily from the NMFS, Scripps Institution of Oceanography, and the Inter-American Tropical Tuna Commission. Kuroshio Exploitation and Utilization Research (KER) project provided 4,234 casts. KER was designed to study the subtropical circulation system, marine ecology, and fishery around Japan. The project was conducted in 1977 – 1995.

Table 16.5 gives project contributions of plankton casts sorted by percent contribution from each project.

**Table 16.5. Project contributions of plankton casts sorted by percent contribution from each project.**

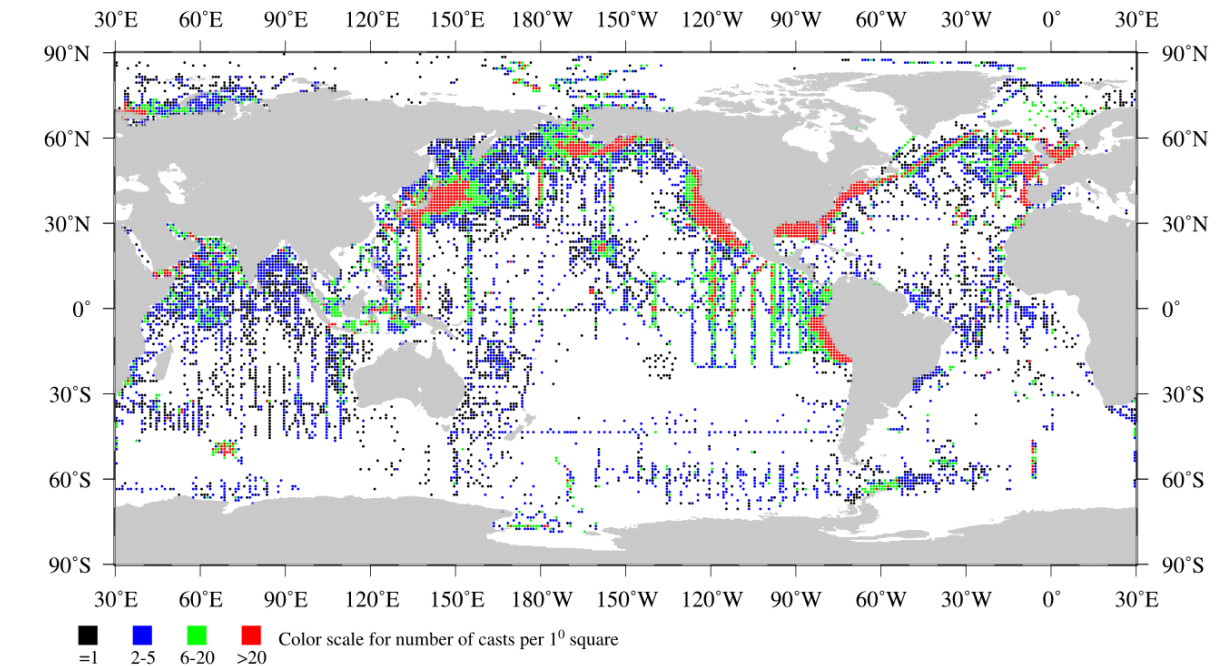
<b>NODC Project Code</b>	<b>Project Name</b>	<b># Casts</b>	<b>% of Total</b>
33	*CalCOFI: California Cooperative Oceanic Fisheries Investigation	38,980	32.4
51	*MARMAP: Marine Resource Monitoring Assessment Prediction Program	19,646	16.4
121	*SEAMAP: Southeast Area Monitoring and Assessment Program	11,996	10.0
81	*OCSEAP: Outer continental shelf environmental assessment program	7,920	6.6
174	*FOCI: Fisheries-Oceanography Cooperative Investigations	6,663	5.5
3	*EASTROPAC (1967-1968)	5,544	4.6
526	GENERAL FISHERIES RESEARCH (YugNIRO)	5,438	4.5
243	KER: Kuroshio exploitation and utilization research (1977 - 1995)	4,234	3.5
93	BRINE DISPOSAL	4,198	3.5
25	IIOE: International Indian Ocean Expedition	2,045	1.7
240	USAP or USARP : United States Antarctic Research Project	1,770	1.5
344	*POFI: Pacific Oceanic Fisheries Investigations	1,310	1.1



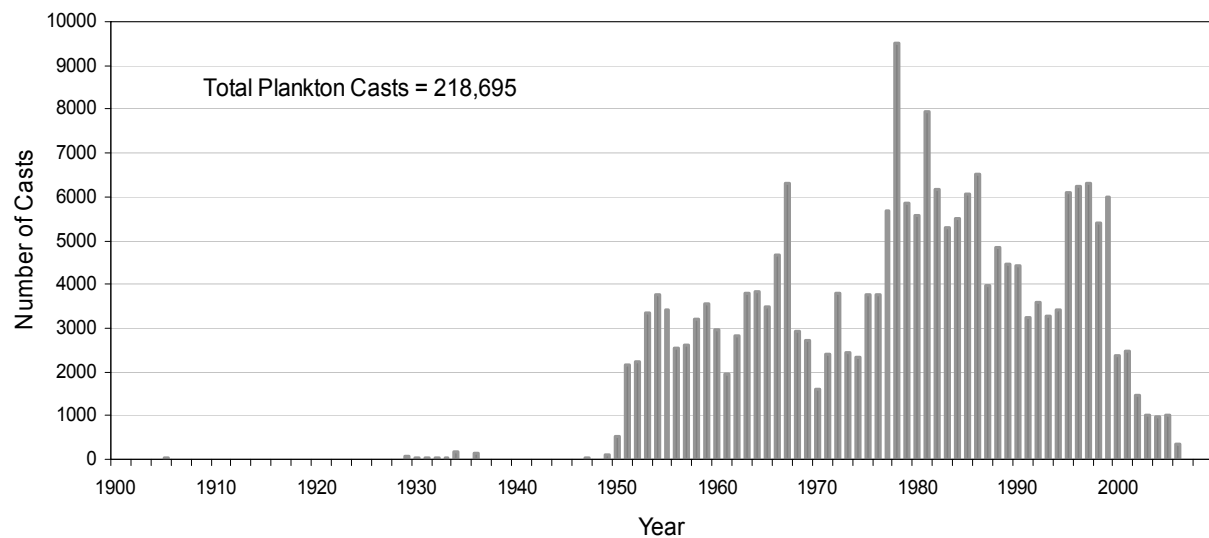
<b>NODC Project Code</b>	<b>Project Name</b>	<b># Casts</b>	<b>% of Total</b>
372	OMEX: Ocean margin exchange project	1,234	1.0
367	GLOBEC: Georges Bank Program	951	0.8
361	JGOFS/AESOPS: US JGOFS Antarctic Environments Southern Ocean Process Study	943	0.8
345	NORTH SEA PROJECT	827	0.7
241	BIOMASS: Biological Investigations of Marine Antarctic Systems and Stocks	712	0.6
322	*SKIPJACK	684	0.6
365	JGOFS/ARABIAN: Arabian Sea Process Studies	657	0.6
31	CSK: Cooperative Study of the Kuroshio	599	0.5
83	OCS-SOUTH: Texas	533	0.4
275	JGOFS/BATS: Bermuda Atlantic Time Series	495	0.4
82	PSERP: Mesa Puget Sound	396	0.3
200	JGOFS: Joint Global Ocean Flux Study	363	0.3
273	EASTROPIC: Eastern Tropical Pacific 1955	323	0.3
410	TASC: Trans Atlantic Study of <i>Calanus</i>	300	0.3
310	JGOFS/EQPAC: Equatorial Pacific basin study	279	0.2
96	EPA: Buccaneer oil field	214	0.2
321	BOFS: Biogeochemical Ocean Flux Study	180	0.2
443	IMECOCAL: Investigaciones Mexicanas De La Corriente De California	174	0.1
34	MAZATLAN	119	0.1
255	CTZ: Coastal Transition Zone	100	> 0.1
245	SEFCAR: South Eastern Florida and Caribbean Recruitment	88	> 0.1
328	SIBEX: Second International Biomass Experiment - Fr	63	> 0.1
312	CEAREX: Coordinated Eastern Arctic Experiment	63	> 0.1
435	IAPP: International Arctic Polynya Programme	41	> 0.1
90	ONR: Office of Naval Research	39	> 0.1
71	IDOE/CUEA	30	> 0.1
434	ARCTIC OCEAN SECTION: Canada/U.S. joint expedition	18	> 0.1
77	SCOPE	11	> 0.1
447	Marine Food Chain Research Group	10	> 0.1
444	GSP: Greenland Sea Project	5	> 0.1
	<i>Total</i>	120,195	100.00

## 16.4. PLANKTON DATA DISTRIBUTIONS

The WOD09 plankton subset consists of 218,695 globally distributed casts (Figure 16.3). The temporal distribution of plankton sampling covers period from 1905 to 2006 year (Figure 16.4). Table 16.6 gives the yearly counts of plankton casts in the WOD09.



**Figure 16.3. Geographic distribution of plankton (218,695 casts) in WOD09.**



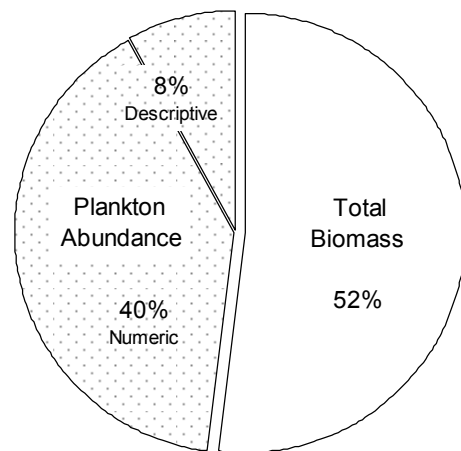
**Figure 16.4. Temporal distributions of plankton casts in WOD09 as a function of year.**

**Table 16.6. Number of plankton casts in WOD09 as a function of year for the World Ocean**  
**Total Number of Casts = 218,695**

YEAR	CASTS	YEAR	CASTS	YEAR	CASTS	YEAR	CASTS
1905	34	1947	24	1968	2932	1988	4842
1913	6	1949	98	1969	2716	1989	4449
1914	5	1950	514	1970	1605	1990	4432
1915	9	1951	2149	1971	2419	1991	3256
1921	17	1952	2247	1972	3801	1992	3590
1925	17	1953	3354	1973	2449	1993	3284
1927	16	1954	3758	1974	2318	1994	3428
1928	2	1955	3423	1975	3761	1995	6114
1929	71	1956	2548	1976	3752	1996	6223
1930	46	1957	2602	1977	5673	1997	6313
1931	36	1958	3222	1978	9500	1998	5393
1932	18	1959	3539	1979	5838	1999	6002
1933	19	1960	2962	1980	5581	2000	2369
1934	179	1961	1959	1981	7951	2001	2491
1936	123	1962	2814	1982	6152	2002	1461
1938	6	1963	3784	1983	5307	2003	1009
1939	10	1964	3816	1984	5507	2004	972
1940	2	1965	3473	1985	6053	2005	1025
1942	2	1966	4682	1986	6508	2006	342
1946	6	1967	6319	1987	3966		

### 16.5. PLANKTON CONTENT

The plankton measurements are represented in WOD09 as descriptive and numeric abundance, and biomass data. The majority (52 %) of plankton measurements are total biomass. Contributions of plankton casts by measurement type are shown in Figure 16.5.



**Figure 16.5 Contributions of Plankton casts by measurement type.**

### 16.5.1. Abundance

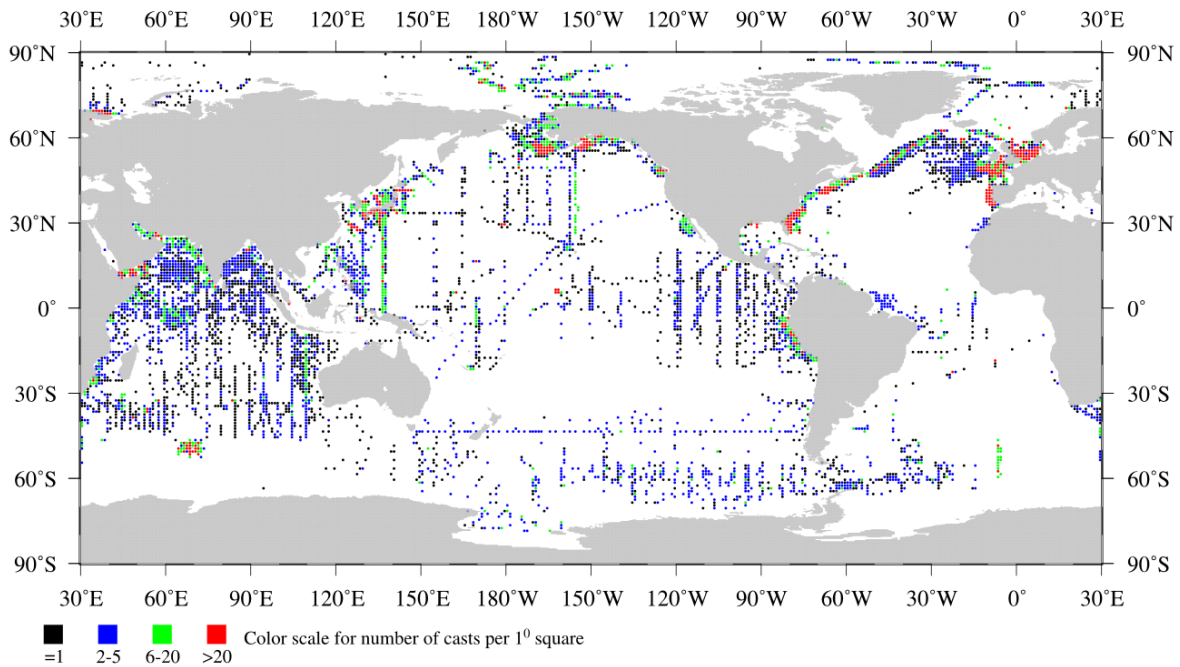
The majority (84%) of plankton abundance measurements in WOD09 are numeric (*e.g.*, the number of individuals counted per sample or haul), while descriptive abundance measurements (*e.g.*, individual was "rare", "common", or "abundant" in sample or haul) are present in a smaller amount (16 %) of total abundance. The WOD09 plankton abundance content, listed by major plankton groups and sub-groups, is summarized in Table 16.7.

**Table 16.7 WOD09 abundance measurements content.**

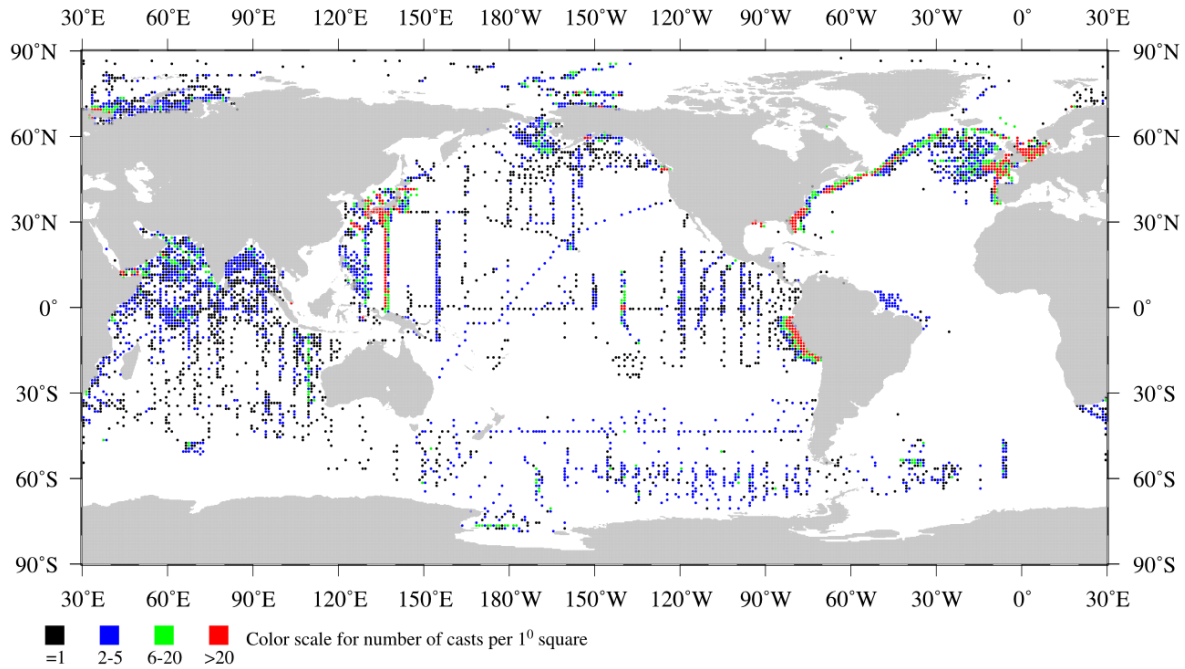
PGC	Plankton Group	Numeric abundance (casts #)	Descriptive abundance (casts#)
<b>1000000</b>	<b>BACTERIA</b> ( <i>all sub-groups</i> )	1986	26
1050000	Cyanobacteria	974	25
<b>2000000</b>	<b>PHYTOPLANKTON</b> ( <i>all sub-groups</i> )	37461	21472
2040000	Granuloreticulosa (Foraminifera)	5506	96
2070000	Dinomastigota (Dinoflagellata)	14452	20406
2080000	Ciliophora (ciliates)	4632	6578
2100000	Haptomonada (Coccolithophorids)	5341	363
2110000	Cryptomonada (Chrytophyta)	1910	8
2120000	Discomitochondria	1333	242
2130000	Chrysomonada (Chrysophyta)	5181	4762
2160000	Diatoms (Bacillariophyta)	22487	19346
2270000	Actinopoda (amoeba)	3699	313
2280000	Chlorophyta (green algae)	1060	59
<b>4000000</b>	<b>ZOOPLANKTON</b> ( <i>all sub-groups</i> )	44307	4299
4030000	Cnidaria (coelenterates)	15114	2184
4040000	Ctenophora (comb jellies)	3745	97
4050000	Platyhelminthes (flat worms)	2038	0
4090000	Nemertina (ribbon worms)	2326	1
4130000	Rotifera (rotifers)	2051	92
4180000	Entoprocta	2157	0
4190000	Arthropoda: Chelicerata	841	152
4200000	Arthropoda: Mandibulata ("insects")	4125	31
4210000	Arthropoda: Crustacea ( <i>all sub-groups</i> )	38249	3943
4211000	<i>Crustacea</i> : Ostracoda	12378	179
4212000	<i>Crustacea</i> : Copepoda	34941	3692
4213000	<i>Crustacea</i> : Cirripedia (barnacles)	6789	489
4214000	<i>Crustacea</i> : Mysidacea	1045	8
4216000	<i>Crustacea</i> : Isopoda	3828	48
4217000	<i>Crustacea</i> : Amphipoda	14238	1369
4218000	<i>Crustacea</i> : Euphausiacea	16717	1649
4219000	<i>Crustacea</i> : Decapoda	14506	1025
4220000	Annelida (segmented worms)	13495	1771
4230000	Sipuncula	2075	2
4260000	Mollusca ( <i>all sub-groups</i> )	18314	1118
4262500	<i>Mollusca</i> : Gastropoda (snails & slugs)	15973	364
4265000	<i>Mollusca</i> : Bivalvia (bivalve molluscs)	3189	115

PGC	Plankton Group	Numeric abundance (casts #)	Descriptive abundance (casts#)
4267500	<i>Mollusca</i> : Cephalopoda	4103	26
4300000	Brachiopoda (lamp shells)	2100	1
4310000	Phoronida	1230	0
4320000	Chaetognatha (arrow worms)	25695	2720
4330000	Hemichordata	2003	0
4340000	Echinodermata	5711	475
4350000	Urochordata ( <i>all sub-groups</i> )	19066	2794
4352500	<i>Urochordata</i> : Ascidiacea (sea squirts)	869	0
4355000	<i>Urochordata</i> : Thaliacea (salps & doliolids)	6607	53
4357500	<i>Urochordata</i> : Larvacea / Appendicularia	17345	662
4360000	Cephalochordata / Leptocardia	2458	17
<b>5000000</b>	<b>ICHTHYOPLANKTON</b>	<b>53179</b>	<b>177</b>

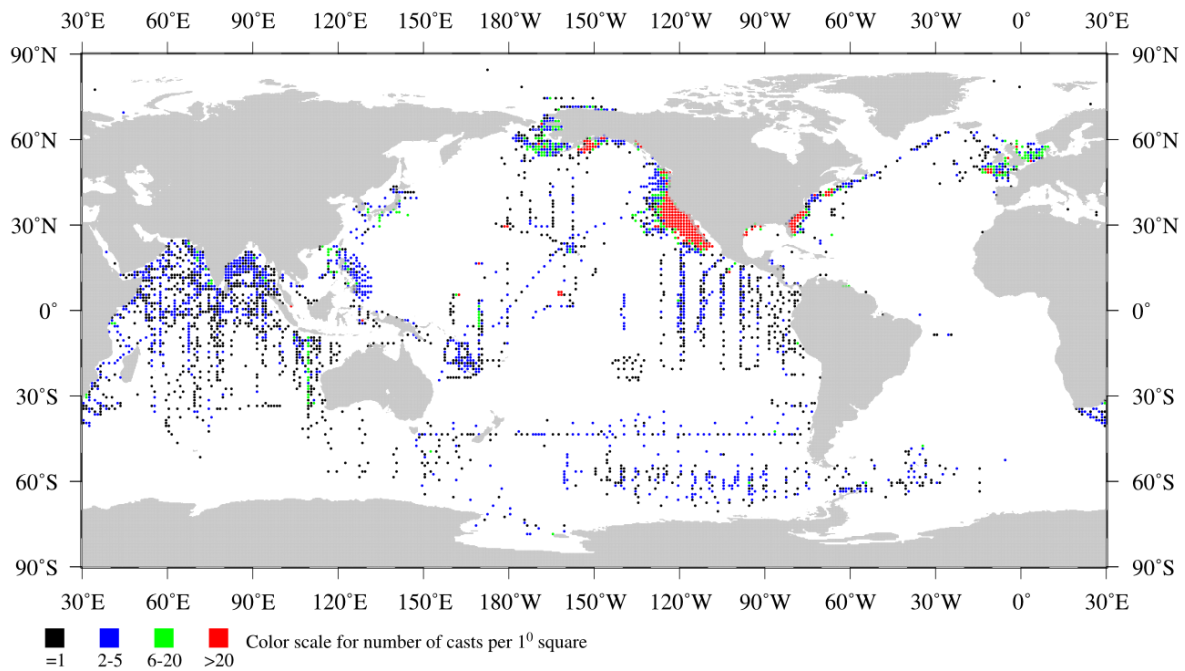
The geographic distribution of numerical abundance casts of major plankton groups for WOD09 is shown in Figures 16.6 – 16.9.



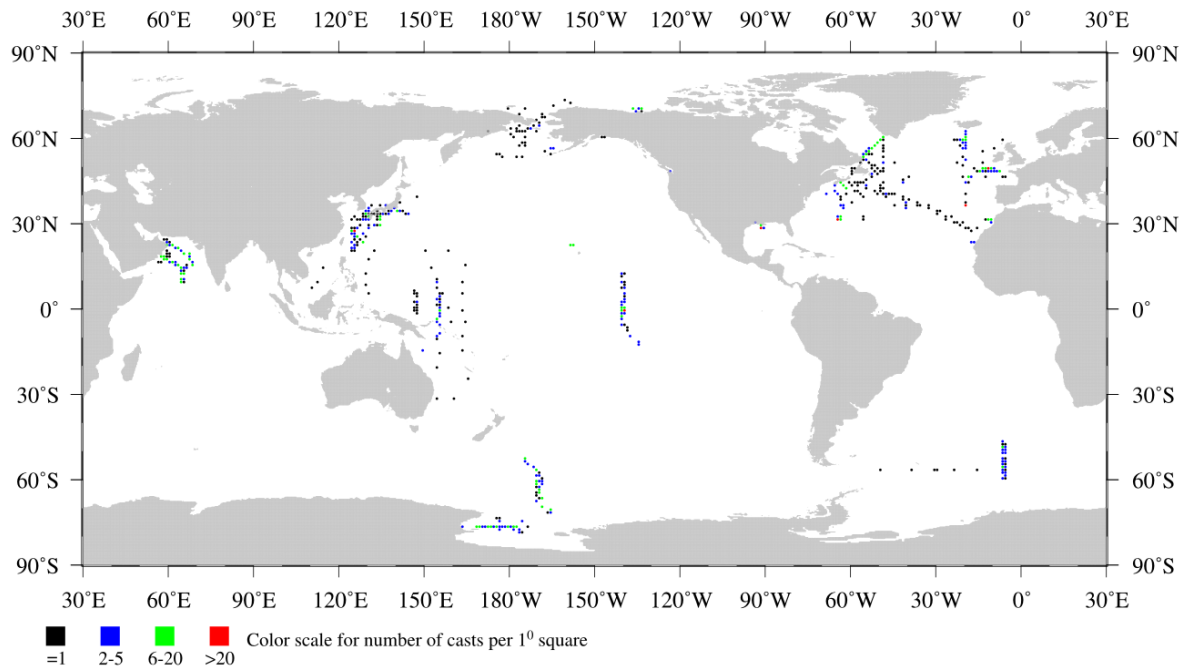
**Figure 16.6. Geographic distribution of zooplankton numerical abundance (44,307 casts) in WOD09.**



**Figure 16.7. Geographic distribution of phytoplankton numerical abundance (37,461 casts) in WOD09.**



**Figure 16.8. Geographic distribution of ichthyoplankton numerical abundance (53,179 casts) in WOD09.**



**Figure 16.9. Geographic distribution of bacterioplankton numerical abundance (1,986 casts) in WOD09.**

### 16.5.2. Total Biomass

The WOD09 total biomass data type represents measurement for which the entire contents of the plankton net are measured as a single, undifferentiated mass. This “mass” can be quantified using a settled volume, a displacement volume, a wet mass, a dry mass, or an ash-free dry mass. Although the sampling methods of total biomass data represented in the WOD09 may differ between projects and institutions, the general definitions and methods per Omori and Ikeda (1984) are:

*Total Settled volume:* the volume of a plankton sample poured into a graduated cylinder or sedimentation tube of 50-100 ml in volume and allowed to settle for 24 hours.

*Total Displacement volume:* the volume of plankton estimated by the volume of water displaced after adding the plankton sample into a graduated cylinder.

*Total Wet Mass:* the mass of plankton determined after eliminating as much surrounding water as possible.

*Total Dry Mass:* the mass of plankton determined after removal of all water and heat dried to a final mass at 60-70°C.

*Total Ash-free Dry Mass:* a known weight of the dry sample ashed to a final weight at 450-500°C.

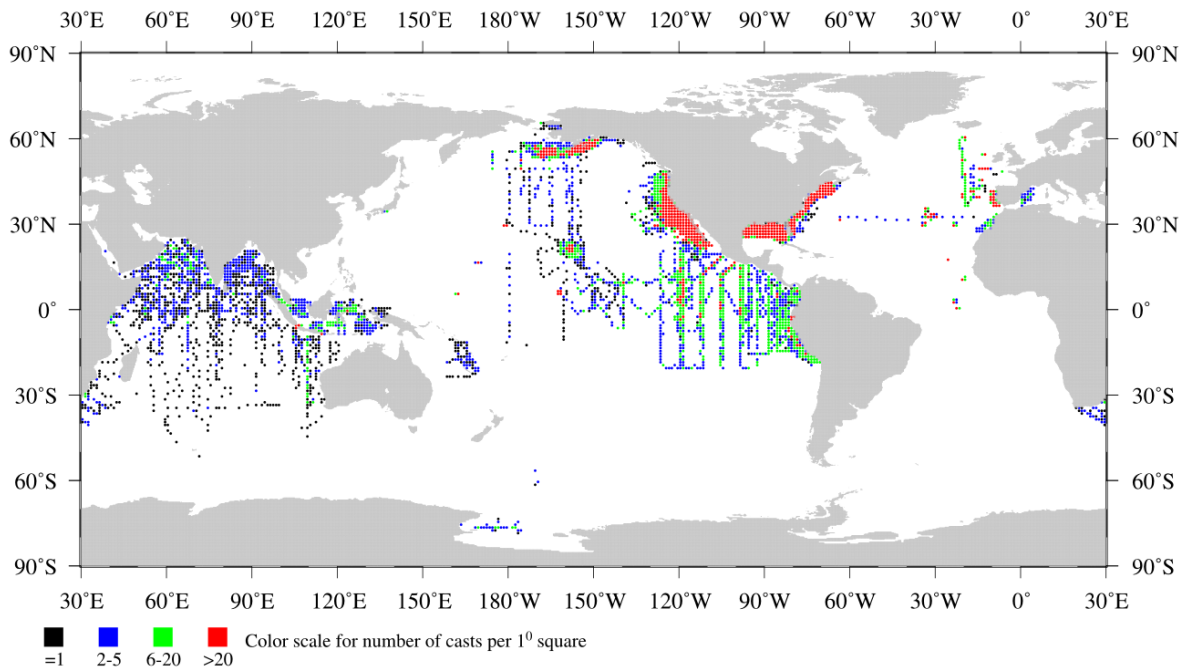
**Table 16.8. WOD09 biomass measurements content.**

PGC Code	Taxonomic Description	# Casts	% of Total
-401	Total Displacement Volume	104,623	70.32
-402	Total Settled Volume	8,223	5.53
-403	Total Wet Mass	33,820	22.73
-404	Total Dry Mass	1,008	0.68
-405	Total Ash-free Dry Mass	274	0.18

The majority of WOD09 plankton biomass measurements are total displacement volume and total wet mass (Table 16.8). Total biomass data were mostly sampled using nets ranged from 200 to 500  $\mu\text{m}$  mesh size, predominantly with standard nets 333  $\mu\text{m}$  mesh size. Samples within this mesh range might include fish eggs, larvae, and small amounts of large phytoplankton, such as diatoms.

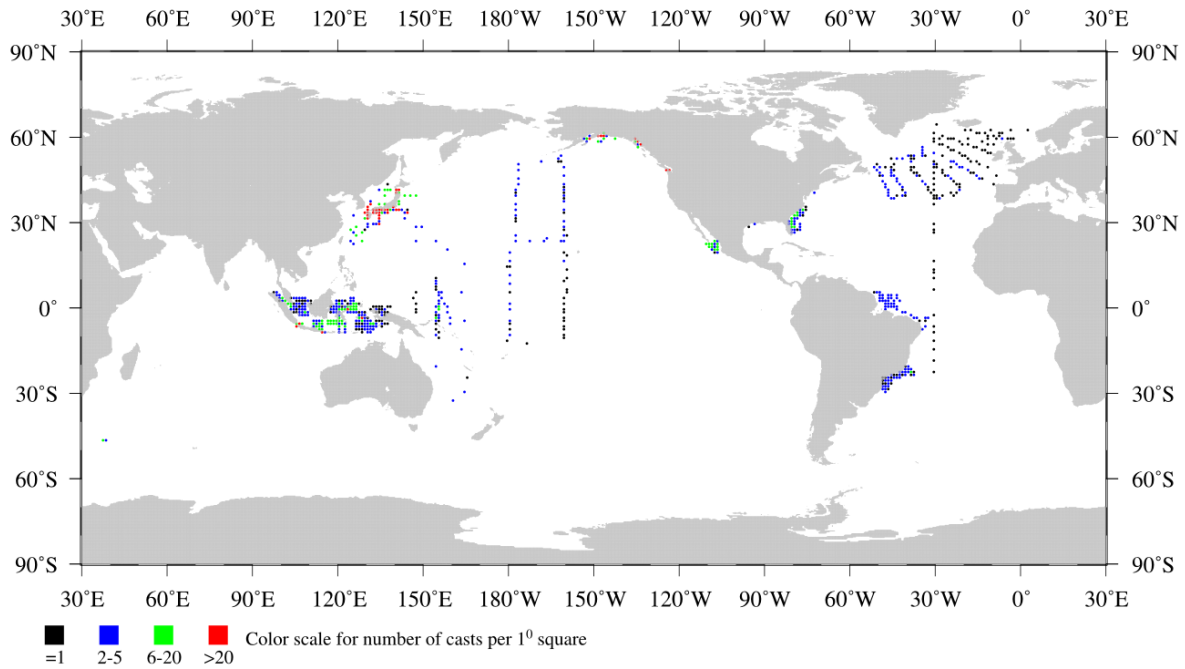
Additional information about measurement methods, as well as the protocol followed for removing large organisms, is stored in the Biological Headers described in detail in WOD09 documentation, Table. 6 (Johnson *et al.*, 2009).

The geographic distribution of biomass casts for WOD09 is shown in Figures 16.10. – 16.14.

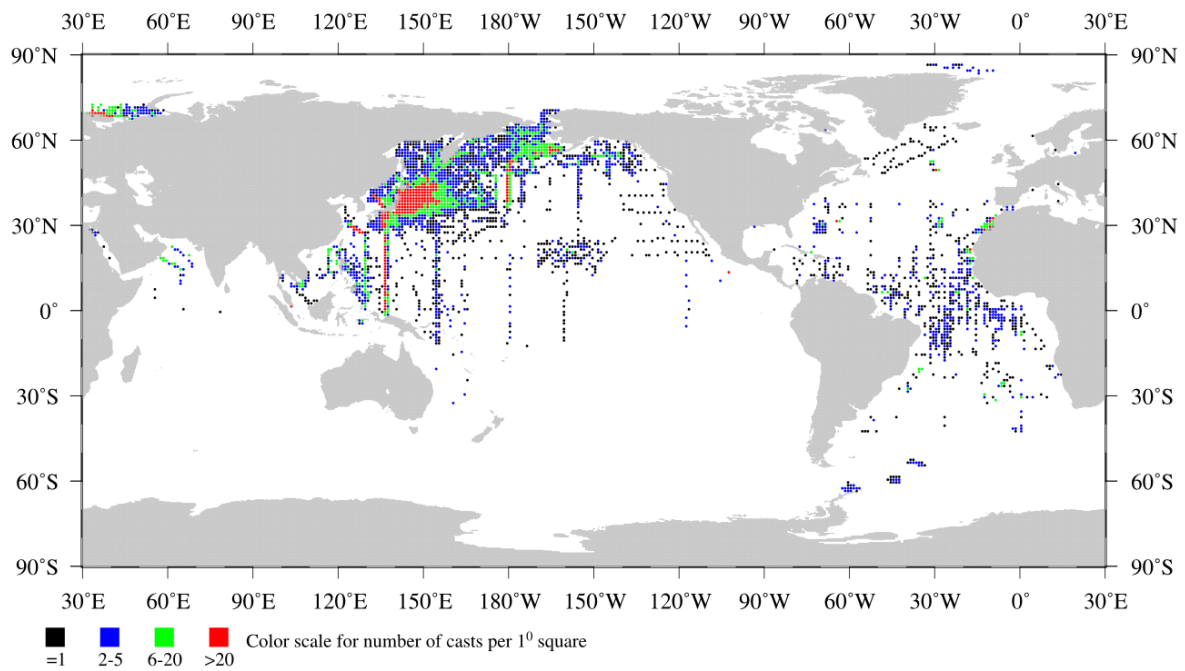


**Figure 16.10. Geographic distribution of total displacement volume (104,623 casts) in WOD09.**

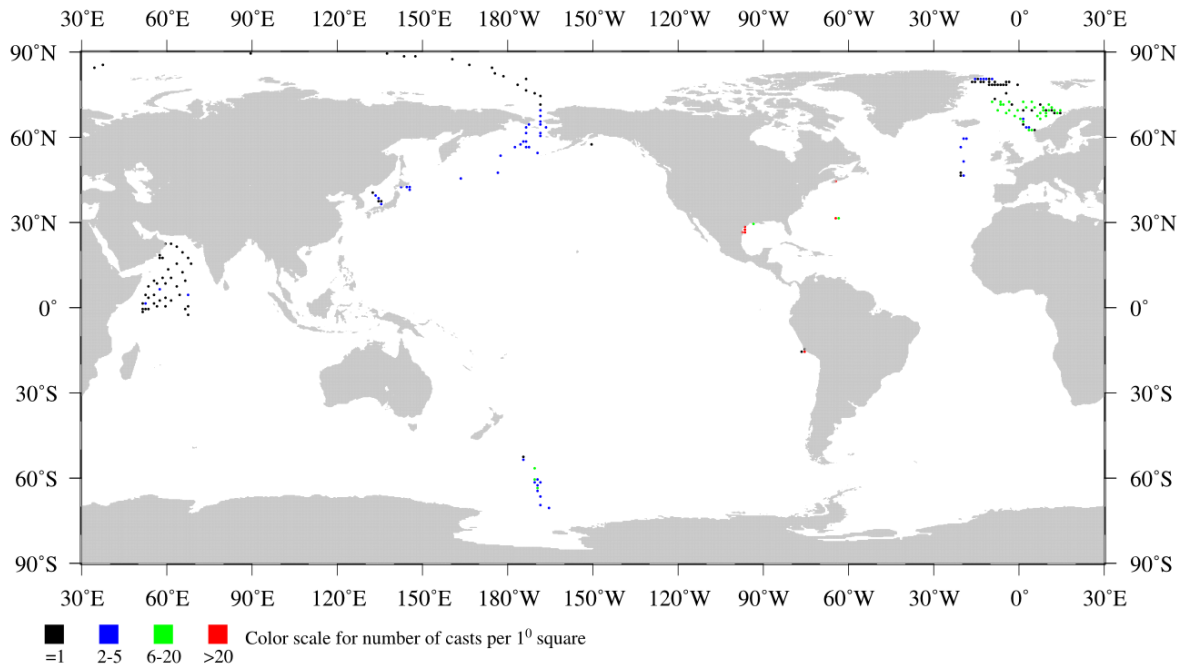




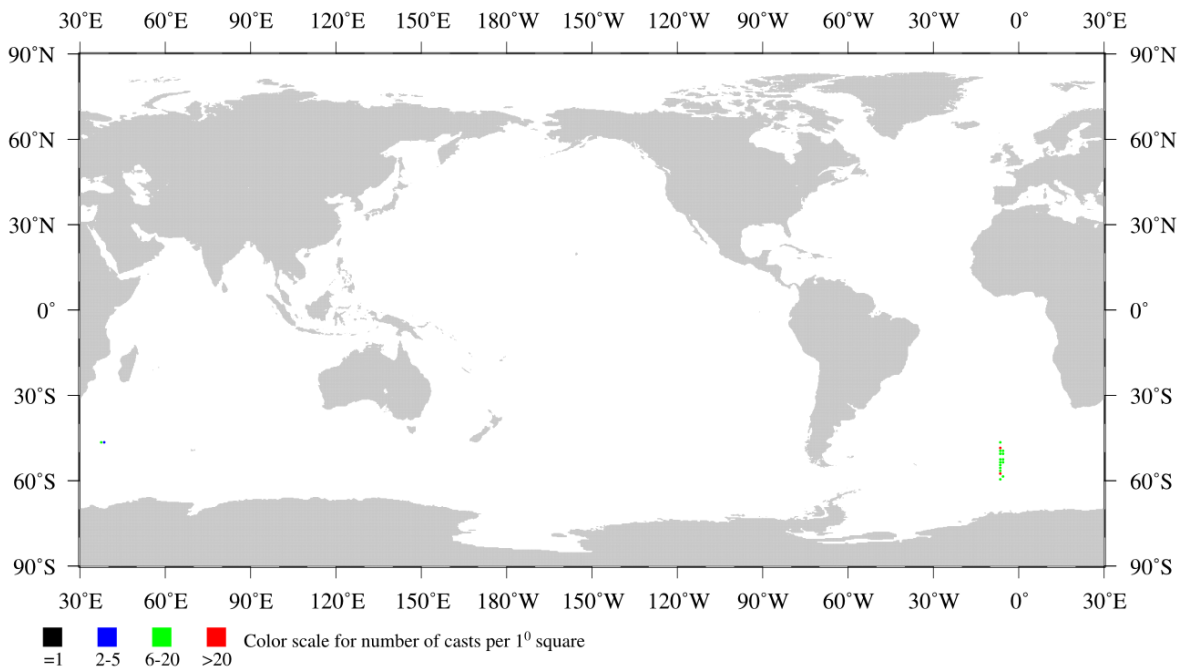
**Figure 16.11. Geographic distribution of total settled volume (8,223 casts) in WOD09.**



**Figure 16.12. Geographic distribution of total wet mass (33,820 casts) in WOD09.**



**Figure 16.13. Geographic distribution of total dry mass (1,008 casts) in WOD09.**



**Figure 16.14. Geographic distribution of total ash-free dry mass (274 casts) in WOD09.**

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