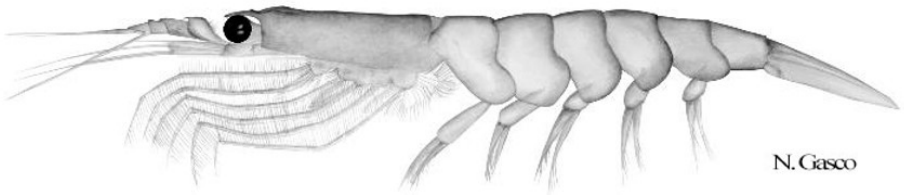
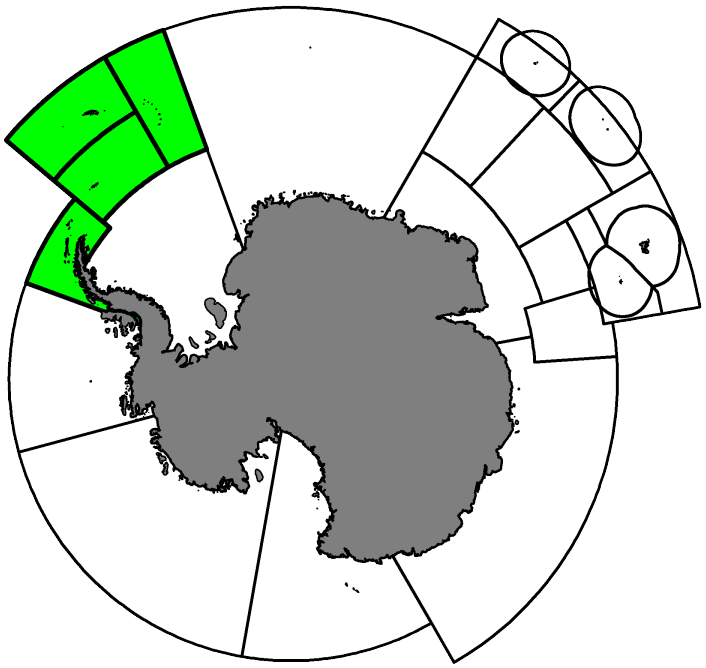
Fishery Report 2021: *Euphausia superba* in Area 48

CCAMLR Secretariat

27 May 2022



Antarctic krill, *Euphausia superba* Dana, 1850.



Map of the management areas within the CAMLR Convention Area. Subareas 48.1 to 48.4, the regions discussed in this report are shaded in green. Throughout this report, "2021" refers to the 2020/21 CCAMLR fishing season (from 1 December 2020 to 30 November 2021).

Contents

1. Introduction to the fishery

1.1. History

The commercial fishery for Antarctic krill (*Euphausia superba*) was initiated in 1961/62 when 47 tonnes were taken by two research vessels from the USSR. During the following decade, small catches of krill were reported by the USSR as part of the research phase of the fishery development. A multi-vessel multi-nation fishery for krill was active by the early to mid-1970s (Fig. 1).

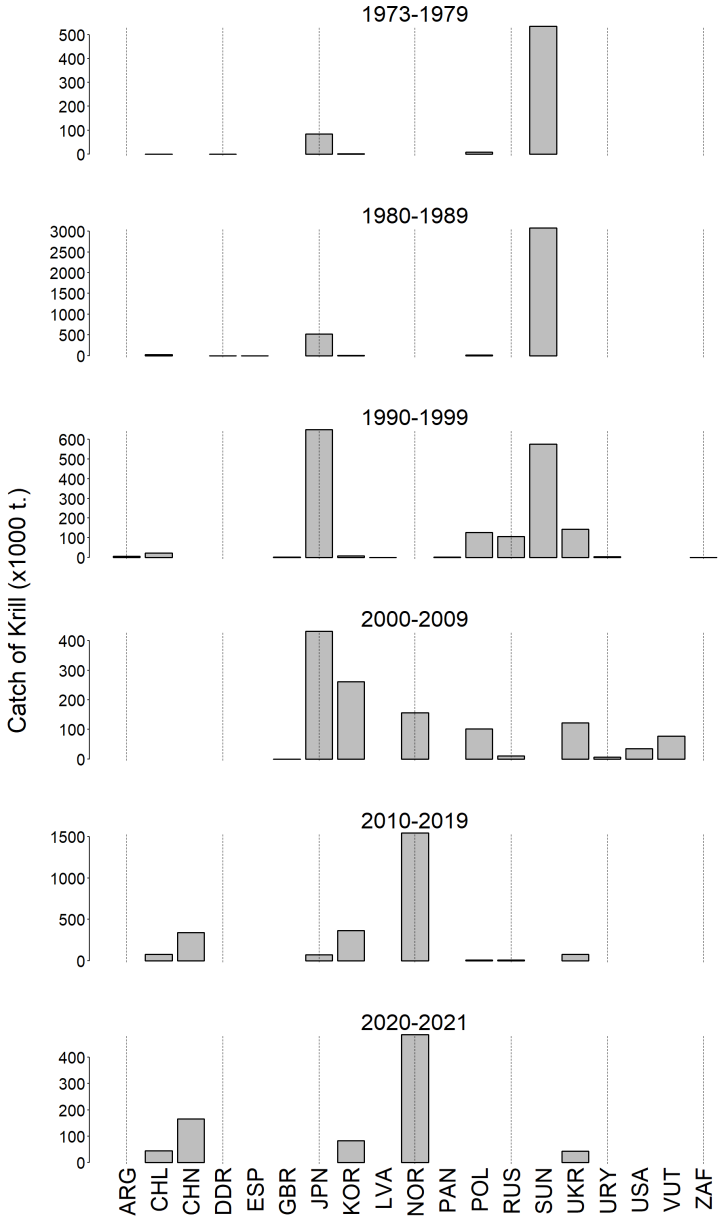


Figure 1. Catches of krill in the CAMLR Convention Area reported by Argentina (ARG), Chile (CHL), China (CHN), German Democratic Republic (DDR), Spain (ESP), United Kingdom (GBR), Japan (JPN), Republic of Korea (KOR), Latvia (LVA), Norway (NOR), Panama (PAN), Poland (POL), Russian Federation (RUS), USSR (SUN), Ukraine (UKR), Uruguay (URY), United States of America (USA), Vanuatu (VUT) and South Africa (ZAF). (Source: Statistical Bulletin and C1 data for most recent season).

The history of catches in the krill fishery (Fig. 2) shows the initial increase in catches followed by a sudden decrease in 1983 and 1984, associated with technical difficulties in the fishery (Budzinski et al., 1985) and/or with an ecosystem anomaly that also impacted the reproductive performance of krill predators at South Georgia in 1984 (Priddle et al., 1988). The large drop in catches from 1992 to 1993 reflects the redeployment of the eastern bloc far-seas fisheries fleet following the dissolution of the USSR. The increase in catches since 2010 is largely driven by catches by Norway, and, the catch in Area 48 in 2020 was the largest catch reported from that Area.

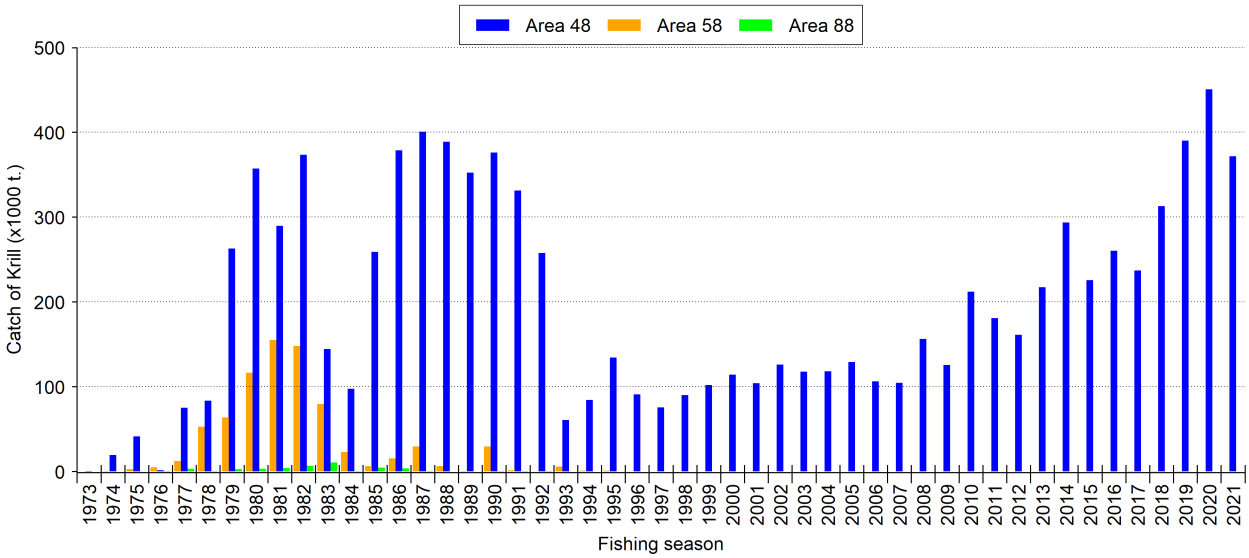


Figure 2. Annual catches of Antarctic krill (*Euphausia superba*) in the CAMLR Convention Area.

The CCAMLR database holds data on krill catches starting in 1973. The majority of the catch was reported by the USSR (41.3%), Norway (21%), Japan (16.8%) and the Republic of Korea (6.9%). The other fishing nations reported less than 5% of the catch. The CCAMLR Members that have fished for 20 years or more are Japan (40 years), Republic of Korea (34 years), Poland (33 years), Chile (23 years) and Ukraine (21 years). Catches of krill have been reported by 19 nations, including catches reported by Latvia in 1993, Panama in 1995 and Vanuatu in 2004 and 2005 (Fig. 1). In the period 2011-2021, seven Members have fished for krill, 61.7% of the total catch has been taken by Norway, 16.2% by China and 12.9% by the Republic of Korea.

The continuous fishing system (a system where the codend of the net is emptied via a pump connected to the vessel rather than being hauled aboard as in 'traditional' trawling) was first used in the krill fishery in 2004 by a Vanuatu-flagged vessel, this vessel also fished in 2005. It was replaced by a Norwegian vessel, also using the continuous fishing system, in 2006. Both this fishing method and the traditional trawling continue to be used in the krill fishery.

As the fishery developed, the location of fishing has moved from the Indian Ocean to the Atlantic Ocean sector and has focused almost entirely in the Atlantic sector since the early 2000s (Fig. 3). In the past 10 years, the spatial distribution of the fishery has become focused in the region of the Bransfield Strait off the Antarctic Peninsula (Subarea 48.1), to the northwest of Coronation Island (Subarea 48.2) and to the north of South Georgia (Subarea 48.3).

Given the geographic focus of the krill fishery in recent decades, the remainder of this report is focused on Area 48. There are catch limits for krill in Divisions 58.4.1 and 58.4.2 (see Conservation Measures 51-02 and 51-03) but there was no commercial krill fishing in these two divisions between 1991 and 2016 and only small level of catches since 2017.

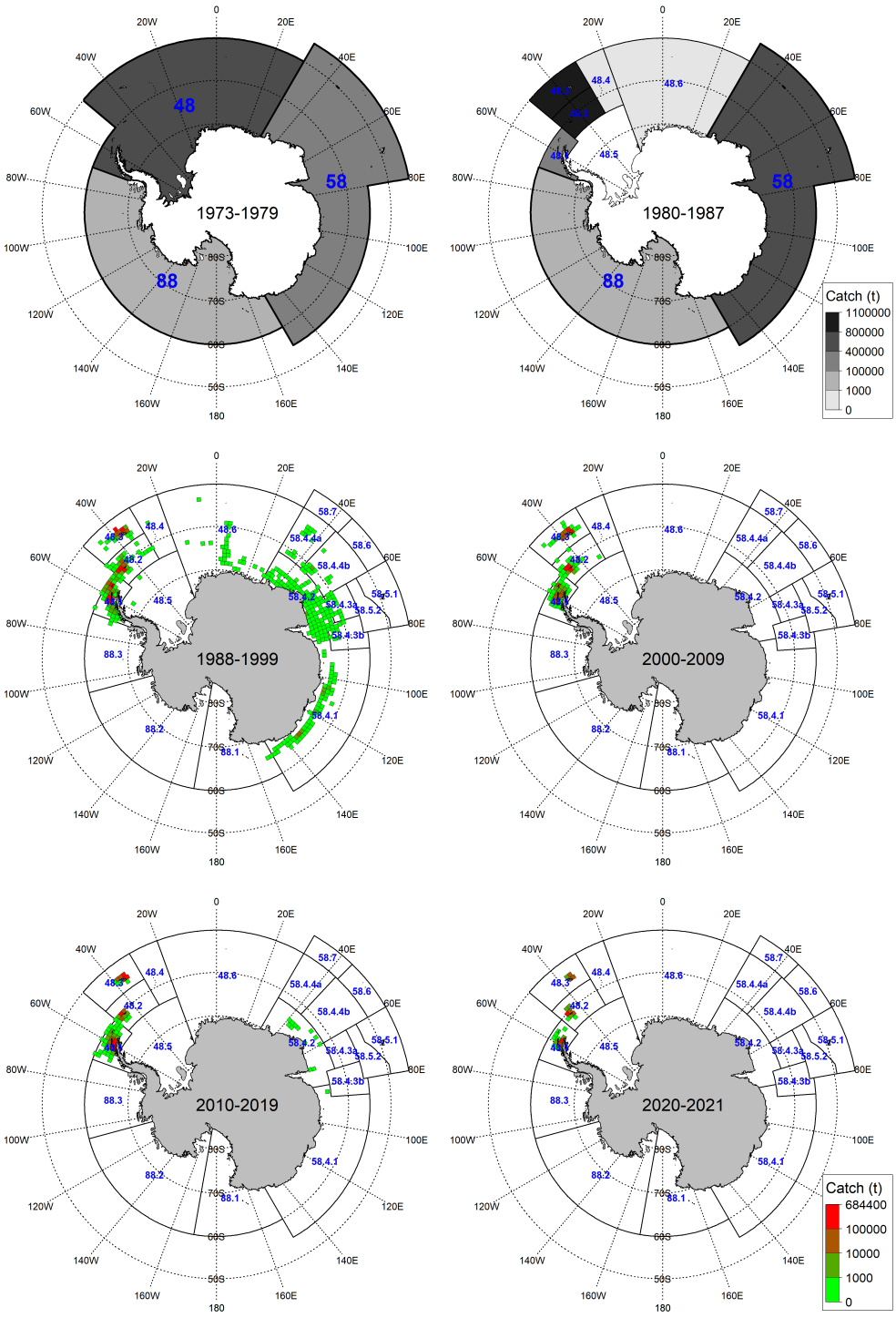


Figure 3. Spatial distribution of catches by decade in the krill fishery reported to CCAMLR (Source: FAO STATLANT data before 1988, C1 data since 1988). In the period 1973-1979, catches are reported at the scale of the FAO Major Fishing Areas: Area 48 (South Atlantic sector), Area 58 (Indian Ocean sector) and Area 88 (Pacific Ocean sector). In the period 1980-1987, this reporting includes catches by Subarea within Area 48. Since 1988 the provision of catch data to CCAMLR has either been at a spatial scale of 1 deg. longitude by 0.5 deg. latitude, with catches aggregated over monthly, 10-day and daily timescales, or, by individual haul. The aggregation of the data in the four lower panels uses equal area (100 km x 100 km) cells.

In 1991 CCAMLR agreed Conservation Measure 32/X in which the total catch of *Euphausia superba* in Statistical Area 48 was limited to 1.5 million tonnes in any fishing season based on the outcome of a krill yield model. That conservation measure also specified that catch limits, to be agreed by the Commission on the basis of advice of the Scientific Committee, would be applied to Subareas 48.1, 48.2 and 48.3 if the total catch in Area 48 in any fishing season exceeded 620,000 tonnes. In effect this set a constraint on the fishery by requiring an additional management approach if the catch exceeded 620,000 tonnes; a measure that was introduced to restrict the potential for all of the 1.5 million tonne catch limit being taken from a small part of the overall area.

The limit of 620,000 tonnes is based on historical catches in Area 48 and represents the sum of the maximum catch taken from each of the subareas over the history of the fishery (it should not be, but sometimes is, confused with the maximum catch ever taken in the whole of Area 48 in one year).

In 2000, following a large-scale survey of krill in Area 48 (which estimated the biomass to be 56 million tonnes), CCAMLR agreed Conservation Measure 32/XIX that set the revised catch limit in Statistical Area 48 to 4.0 million tonnes and divided this into subarea specific catch limits of 1.008 million tonnes in Subarea 48.1, 1.104 million tonnes in Subarea 48.2, 1.056 million tonnes in Subarea 48.3 and 0.832 million tonnes in Subarea 48.4. Conservation Measure 32/XIX also determined that if the total catch in Statistical Area 48 in any fishing season exceeded 620,000 tonnes that the subarea catch limits should be applied to smaller management units. In doing so Conservation Measure 32/XIX retained the practice of setting a catch limit for the whole of Area 48 and dividing it between subareas; furthermore it required catch limits to be in place for management units smaller than Subareas if fishing in any season exceeded 620,000 tonnes.

In 2007 CCAMLR agreed Conservation Measure 51-01 (2007) in which it revised the catch limit in Area 48 to 3.47 million tonnes in any fishing season, based on a reanalysis of the large scale survey from 2000 and a revised parametrisation of the yield model. It also introduced the term "trigger level" and stated that the total combined catch in Subareas 48.1, 48.2, 48.3 and 48.4 would be limited to a "trigger level" of 620,000 tonnes in any fishing season until the Commission defined an allocation of this total catch limit between smaller management units, based on the advice from the Scientific Committee.

In 2009, following extensive discussion in the Scientific Committee, CCAMLR agreed Conservation Measure 51-07 that created a distribution of the 620,000 tonne trigger level (specified in Conservation Measure 51-01) such that no more than 25% can be taken from Subarea 48.1, no more than 45% can be taken from Subarea 48.2 and Subarea 48.3 and no more than 15% from Subarea 48.4. These percentages deliberately sum to more than 100% in order to provide flexibility to the fishery while achieving the objective of distributing fishing effort. These limits remain in force in 2021 and are due to be reviewed in 2022.

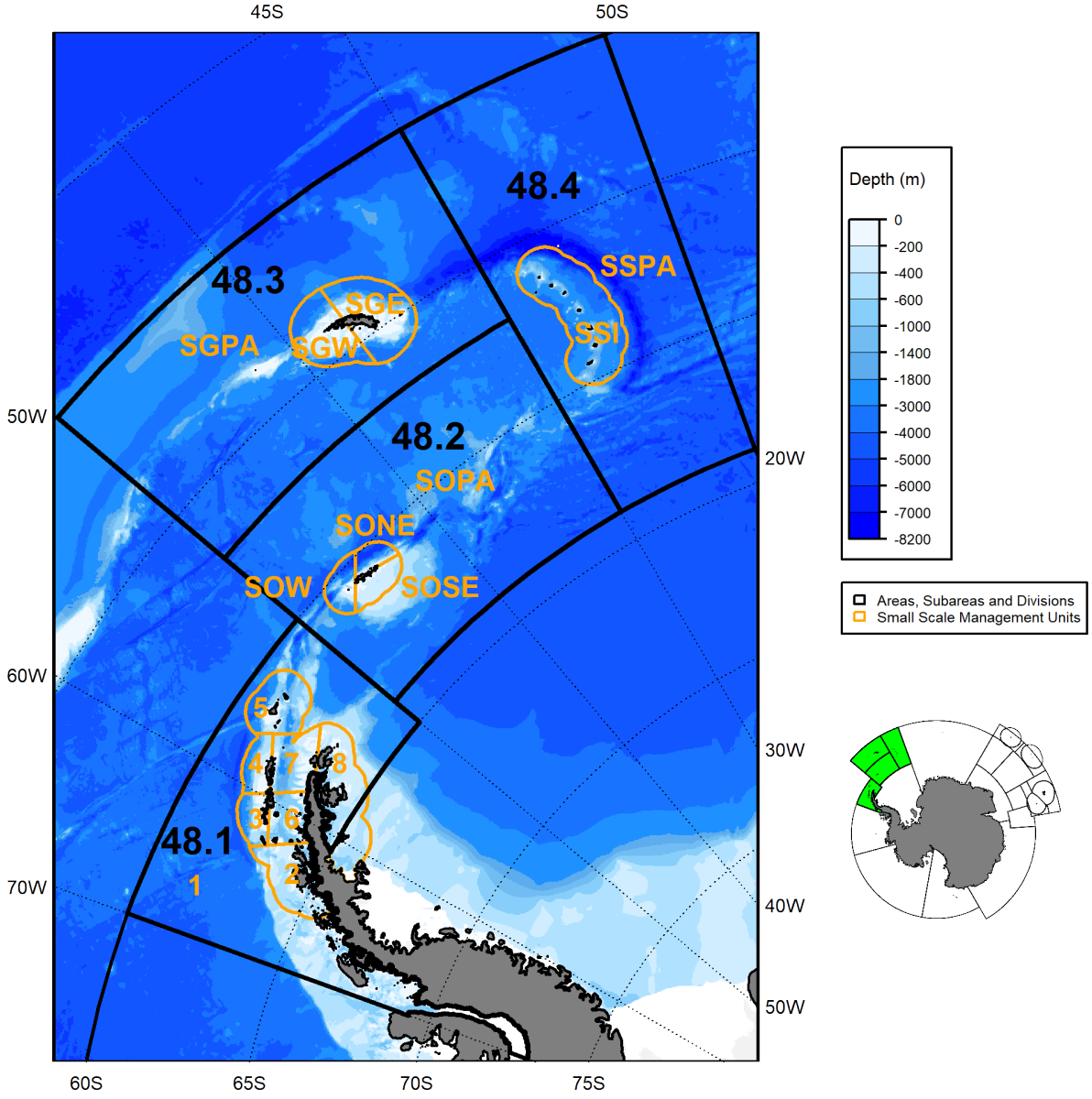


Figure 4. Location of Small Scale Management Units in Area 48. In Subarea 48.1: 1. Pelagic Area (APPA), 2. Antarctic Peninsula West (APW), 3. Drake Passage West (APDPW), 4. Drake Passage East (APDPE), 5. Elephant Island (APEI), 6. Bransfield Strait West (APBSW), 7. Bransfield Strait East (APBSE), 8. Antarctic Peninsula East (APE). These are grouped into 481PA (1), 481N (2, 3, 4 and 5) and 481S (6, 7 and 8) for the aggregation of length frequency distributions of krill (following the recommendation of WG-EMM-15 SC-CAMLR-XXXIV, Annex 6, paragraph 2.10). In Subarea 48.2: South Orkney Pelagic Area (SOPA), South Orkney West (SOW), South Orkney Northeast (SONE), South Orkney Southeast (SOSE). In Subarea 48.3: South Georgia Pelagic Area (SGPA), South Georgia West (SGW), South Georgia East (SGE). In Subarea 48.4: South Sandwich Pelagic Area (SSPA), South Sandwich Islands (SSI).

1.2. Conservation Measures currently in force

The limits on the fishery for krill in Area 48 are summarised in Table 1. The same provisions apply for the fishery for krill in Divisions 58.4.1 and 58.4.2, with the exception of the catch limits that are specified in Conservation Measures 51-02 and 51-03.

Table 1. Summary of CCAMLR limits in force and related Conservation Measures (CMs) for the krill fishery in Subareas 48.1, 48.2, 48.3 and 48.4.

Element	Limits in force
Target species	The target species is Euphausia superba and any species other than Euphausia superba is by-catch
Access (gear)	Trawling only
Notification	All Members intending to fish for krill must notify the Commission in accordance with CM 21-03
Catch limit	155,000 tonnes in Subarea 48.1 - 279,000 tonnes in each of Subareas 48.2 and 48.3 - and 93,000 tonnes in Subarea 48.4 (CM 51-07)
Move-on rule	No move-on rules apply
Season	1 December to 30 November of the following year
By-catch	By-catch rates as in CM 33-01 apply in Subarea 48.3
Bird and mammal mitigation	Specific advice requirements in accordance with CMs 25-03 and 51-01
Observers	Scientific observers should be deployed on vessels in accordance with CM 51-06
Data	Monthly and or five-day catch and effort reporting Haul-by-haul catch and effort data Data reported by the CCAMLR scientific observer
Research	No specific requirement
Environmental protection	Regulated by CM 26-01 during fishing operations

1.3. Active vessels

In 2021, 12 vessels fished in at least one of the three Subareas 48.1, 48.2 and 48.3 (Table 3).

Fishing notifications for next season Members intending to participate in established fisheries for krill in the 2022 fishing season (in Subareas 48.1, 48.2, 48.3 and 48.4 and Divisions 58.4.1 and 58.4.2) had to notify the Commission no later than 1 June 2021. The procedures for krill fishery notification submissions are described in Conservation Measure 21-03. For the 2022 Season, 5 Members notified their intention to fish for krill with a total of 13 vessels (Table 2); these notifications are often subject to revisions/withdrawals of vessels and the most up-to-date information can be found here.

Table 2. Notifications (N) of intention to fish for krill in 2022 by Subarea/Division.

Vessel Name	Member	Subarea 48.1	Subarea 48.2	Subarea 48.3	Subarea 48.4
Antarctic Endeavour	Chile	N	N	N	
Fu Yuan Yu 9818	China	N	N	N	N
Long Fa	China	N	N	N	N
Shen Lan	China	N	N	N	N
Long Teng	China	N	N	N	N
Fu Rong Hai	China	N	N	N	N
Sae In Champion	Korea, Republic of	N	N	N	
Sejong	Korea, Republic of	N	N	N	
Sae In Leader	Korea, Republic of	N	N		
Antarctic Sea	Norway	N	N	N	N
Saga Sea	Norway	N	N	N	N
Antarctic Endurance	Norway	N	N	N	N
More Sodruzhestva	Ukraine	N	N	N	
Total Members		**5**	**5**	**5**	**2**
Total Vessels		**13**	**13**	**12**	**8**

1.4. Catch and effort reporting

Aggregated catch and effort reporting in the krill fishery is on a 5-day basis, where reports of catch and effort in one 5-day period must be provided within 2 days of the end of that 5-day period. These data are used to monitor the progress of the fishery and to close the fishery as the catch limit is reached.

Detailed information for each haul in the krill fishery, including location, time, target and non-target catch is provided in the C1 reporting forms (with data required to be submitted by the end of the month following data collection). In order to accommodate data from the continuous fishing system, in a format that is compatible with the reporting system for conventional trawling, catches are reported in 'haul intervals' of two hours for the entire period that the trawl is in the water.

2. Reported catch

2.1. Latest reports and limits

In 2020 a total 450781 tonnes of *E. superba* was caught from Subareas 48.1, 48.2 and 48.3. In 2021 a total 371526 tonnes of *E. superba* was caught from Subareas 48.1, 48.2 and 48.3 (Table 3).

Table 3. Recent catch and effort history for *E. superba* by Subareas.

Season	Subarea 48.1		Subarea 48.2		Subarea 48.3		Total	
	Catch (tonnes)	Number of vessels	Catch (tonnes)	Number of vessels	Catch (tonnes)	Number of vessels	Catch (tonnes)	Number of vessels
2000	76984	11	16932	7	19346	5	113262	11
2001	52322	7	4998	4	35730	6	93050	7
2002	10700	4	54973	6	39912	7	105585	7
2003	32694	7	16940	7	66159	9	115793	9
2004	15643	7	48192	8	56144	10	119979	10
2005	7096	6	72262	9	48460	7	127818	9
2006	90570	8	3112	4	14901	3	108583	8
2007	15971	6	68021	5	20736	5	104728	6
2008	2582	2	88805	5	57629	7	149016	8
2009	34118	6	91588	7	0	1	125706	7
2010	154330	9	50492	9	8834	2	213656	10
2011	9215	9	115995	12	55801	6	181011	13
2012	75823	11	28997	5	56415	5	161235	12
2013	153254	11	30577	8	32221	7	216052	12
2014	146438	12	72455	10	75252	7	294145	12
2015	154177	12	17101	6	54354	7	225632	12
2016	154441	11	34301	6	71407	6	260149	12
2017	149334	9	69046	6	18558	5	236938	9
2018	151677	9	137880	7	23174	5	312731	9
2019	155795	10	162574	10	71799	5	390168	10
2020	157081	12	178382	12	115318	9	450781	12
2021	161772	12	209754	10			371526	12

Table 4. Monthly catch (tonnes) history for *E. superba* by Subarea/Division in the calendar year 2020.

Month	Subarea/Division			Total
	48.1	48.2	48.3	
December		5371		**5371**
January		63067		**63067**
February		59221		**59221**
March	27760	31377		**59137**
April	52070	15160		**67230**
May	77252			**77252**
June		239	18103	**18342**
July			35510	**35510**
August			43539	**43539**
September			18166	**18166**
Total	**157081**	**178382**	**115318**	**450782**

Table 5. Monthly catch (tonnes) history for *E. superba* by Subarea/Division in the calendar year 2021.

	Subarea/Division		
Month	48.1	48.2	Total
December	3623	11398	**15021**
January	4816	30742	**35558**
February	1343	66134	**67478**
March	23143	20403	**43546**
April	58799		**58799**
May	54589	3518	**58108**
June	15457	7033	**22491**
July		18989	**18989**
August		20272	**20272**
September		19925	**19925**
October		7509	**7509**
Total	**161772**	**209754**	**371526**

2.2. By-catch

Fish by-catch data are available from vessel-reported haul-by-haul data as well as from observer data. Detailed information on the fish by-catch reported from the krill fishery was provided in WG-FSA-2021/05. SISO observers collect a 25kg sample of krill from a point on the vessel where no pre-sorting of the catch has occurred for a subset of hauls. They then remove all fish from that sample, identify them to the most specific taxonomic level possible, record the total length for each fish and the total mass for each taxa. The total by-catch by species in the haul-by-haul data are reported in the 'fine-scale catch and effort (C1)' forms as specified in Conservation Measure 23-04. There are no by-catch limits in place for the krill fishery.

The relative frequency of fish by-catch in the C1 data is lower than in the SISO, reflecting the practicalities of the more detailed sampling by the scientific observers (Fig. 5).

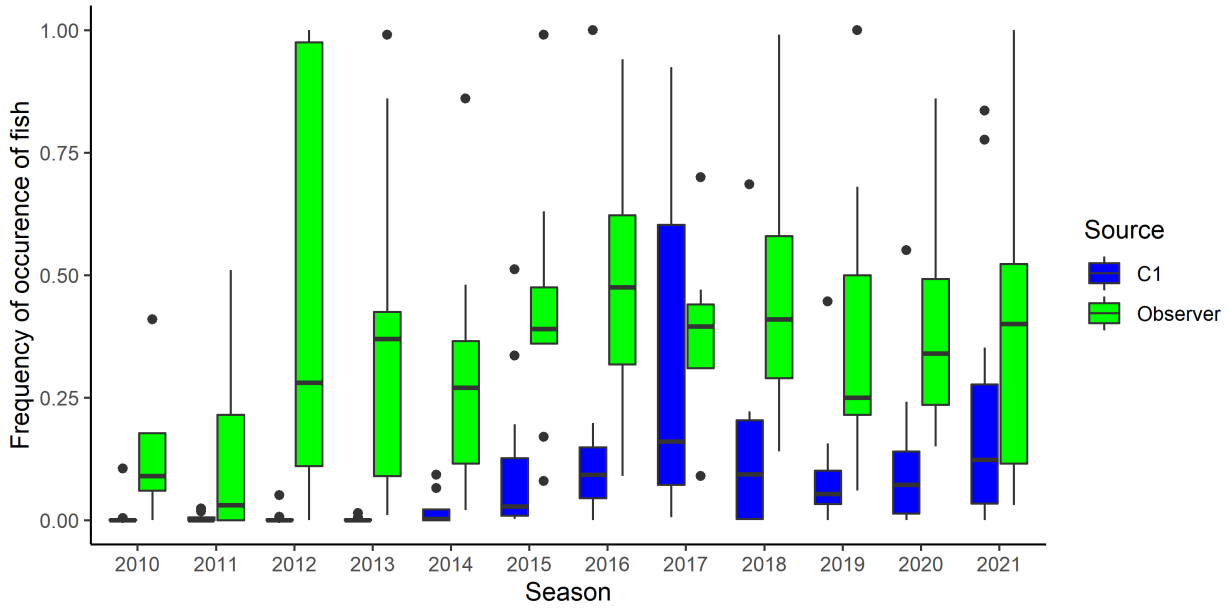


Figure 5. Frequency of occurrence of fish by-catch reported in the C1 data (excluding hauls that also have SISO data; blue) and in the SISO data (green) since 2010.

There is a high degree of overlap in the most frequently reported taxa in the C1 data and SISO data, with painted rockcod (*Lepidonothen larseni*) the most frequently reported in both datasets (WG-FSA-18/10). The spatial distribution of the most frequently occurring by-catch taxa indicates that they can be considered in three general groups, that include those taxa that are:

(i) restricted to Subarea 48.1 with rare occurrences in Subarea 48.2 (spiny icefish - *Chaenodraco wilsoni*)

(ii) recorded in all subareas but were more frequent in Subarea 48.1 (blackfin icefish - *Chaenocephalus aceratus*, *Chiodraco hamatus*, *Chionodraco rastrospinosus*, *Cryodraco antarcticus* and Antarctic silverfish - *Pleurogramma antarctica*), or

(iii) recorded in all subareas but were more frequent in Subarea 48.3 (mackerel icefish - *Champsocephalus gunnari* and *L. larseni*).

The length frequency distribution of all by-catch taxa for which >200 fish have been measured had a modal size class below 10cm, although many species show multi-moded length frequenciy distributions (WG-FSA-18/10).

2.3. Incidental mortality of seabirds and marine mammals

In 2021, 15 Cape petrel (*D. capense*) mortalities in Subareas 48.1 and 37 Snow petrel (*P. nivea*) mortalities in Subarea 48.2 were reported from the krill fishery (Table 6).

Table 6. Number of reported birds caught (killed or with injuries likely to substantially reduce long-term survival) in this fishery since 2010 in each Subarea.

Season	*Daption capense*	Pagodroma nivea	Other
Subarea 48.1			
2012	1		
2016	1		2
2017			1
2018		1	
2021	15	1	3
Subarea 48.2			
2016			1
2017			1
2018	1		
2019	2		
2021	1	37	2
Subarea 48.3			
2020			1

Prior to 2003, no incidental fur seal catches had been reported from the krill fishery. In 2003, discussions on the level of Antarctic fur seal mortality associated with the krill fishery first took place in the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF). This was prompted by information included in the Report of Members' Activities that in the krill fishery in Area 48, between 13 March and 26 August 2003, 73 Antarctic fur seals had been caught by one vessel in the krill fishery (of which 26 were killed and 47 were released alive). WG-IMAF recommended that vessel operators and researchers collaborate to

develop and implement mitigation methods and requested that the Scientific Committee address how best to arrange appropriate reporting from the krill fishery (SC-CAMLR-XXII, Annex 5, paragraph 6.231).

In 2004, data collected as part of SISO indicated that 292 fur seals were caught in Subarea 48.3. Some Members investigated and documented the use of mitigation devices to reduce seal entrapment in krill trawl nets and reported on the efficacy of seal-exclusion devices (SEDs). The Commission endorsed a recommendation by the Scientific Committee that a description of all methods be compiled into one document and distributed amongst CCAMLR Members (CCAMLR-XXIII, paragraph 5.20). WG-IMAF also discussed the apparent inconsistencies and inadequacies of observer data on incidental mortality of fur seals and recommended the Commission require all krill trawl vessels to carry an observer to improve bycatch mitigation management efforts (SC-CAMLR-XXIII, Annex 5, paragraph 7.236).

In 2005, the number of seals observed captured in Area 48 was reduced to 97, however, the Scientific Committee reiterated its recommendations that every krill fishing vessel should employ an SED and that observers should be required on krill trawl vessels to collect reliable data on mortalities and efficacy of mitigation devices (SC-CAMLR-XXIV, paragraphs 5.41i and ii). Observer reports were only received from four of nine trawl vessels in Area 48 in 2005 and this level of observer coverage was considered insufficient to estimate the total seal mortality in the fishery. WG-IMAF again recommended 100% coverage on all krill trawl vessels. One fur seal was captured in each of 2006 and 2007, although the level of observer coverage remained less than 100%. The Scientific Committee stressed the continued need for monitoring of incidental mortalities and for an improved reporting process on the use of mitigation devices within the trawl fishery in order to document which measures were successful (SC-CAMLR-XXVI, paragraph 5.13).

In 2008, six seal mortalities were observed in Subarea 48.3 and the Scientific Committee suggested the krill fishery notification pro forma should be amended to include specific information on gear configurations such as mesh size, net opening, presence and design of mammal exclusion devices (SC-CAMLR-XXVII, paragraph 4.11). The Commission agreed to amend the general mitigation provisions in Conservation Measure 25-03 to introduce the mandatory use of mammal exclusion devices on trawls in the krill fisheries in Area 48 (Conservation Measure 51-01) and Divisions 58.4.1 (Conservation Measure 51-02) and 58.4.2 (Conservation Measure 51-03). These Conservation Measures were adopted by the Commission and are still in force.

Since 2010, there were, notably, 19 mortalities of Antarctic fur seals (*A. gazella*) in 2018 (Table 7) which occurred on the same vessel as a result of a malfunction in the mammal exclusion devices (or SED); once the issue was identified and rectified there were no further seal mortalities on that vessel. In 2020, a total of 16 fur seal mortalities were recorded, although unlike in 2018, these were recorded across five vessels with no single cause for the entanglements identified.

In 2021, three humpback whales (*M. novaeangliae*) were recorded as bycatch in krill trawls (the first recorded cetacean mortalities observed in the krill fishery) in Subareas 48.1 and 48.2 (SC-CAMLR-40, paragraphs 3.113 to 3.136), noting that many of the bird mortalities reported in that year were associated with the hauls that caught whales due to entanglements with the net. The Scientific Committee reconvened the Working Group on Incidental Mortality Associated with Fishing (WG-IMAF) to better understand and mitigate any issues contributing to humpback whale and seal by-catch in the krill fishery (CCAMLR-40, paragraph 6.47).

Table 7. Number of reported mammal mortalities in this fishery since 2010 in each Subarea.

Season	*Megaptera novaeangliae*	*Otariidae, Phocidae*	Arctocephalus gazella
Subarea 48.1			
2011		1	
2021	2		
Subarea 48.2			
2021	1		1
Subarea 48.3			
2016		2	1
2018			19
2019			1
2020			16

2.4. Estimation of krill green weight

At its meeting in 2008, the Working Group on Ecosystem Monitoring and Management (WG-EMM) considered how the actual catches of krill are reported as the mass of product multiplied by a conversion factor to estimate the 'green weight' and expressed its concern over the inconsistency in the way the amount of krill removed from the ecosystem may be recorded. Given the different on-board processing methods used by vessels, and the resulting range of conversion factors used in the krill fishery, the need to have clarity on how the estimates of green weight are derived is important to accurately determine the true biomass of krill removed from the ecosystem. Conversion factors were reported from some vessels, either as pre-determined product-specific values or varying according to ongoing evaluation on the vessel.

In 2011, the Scientific Committee noted that there were several sources of uncertainty in estimating the green weight of krill that required further investigation (SC-CAMLR-XXX, paragraph 3.15). In order to progress analyses of uncertainty in green weight, the specific details of the method used for estimating catch on all krill vessels was included in the notification process and made a reporting requirement during fishing activities.

3. Illegal, Unreported and Unregulated (IUU) fishing

Illegal, Unreported and Unregulated (IUU) fishing for krill has not been reported to date.

4. Data collection

4.1. Data collection requirements

The implementation of the CCAMLR Scheme of International Scientific Observation (SISO) in the krill fishery has been the subject of extensive discussion in the Scientific Committee and Commission meetings (see WG-EMM-14/58, Annex 1). The development of a program for systematic observer coverage in the krill fishery was first implemented in 2010 (Conservation Measure 51-06). In 2016, the Commission agreed to revise Conservation Measure 51-06 to introduce a phased increase in the required observer coverage in the krill fishery to achieve a target coverage rate of no less than 50% of vessels during the 2017 and 2018 fishing seasons; no less than 75% of vessels during the 2019 and 2020 fishing seasons; and 100% coverage in subsequent fishing seasons.

The Scientific Committee agreed that, to provide a measure of the availability of observer data, observer coverage in the krill fishery should be defined as the number of days when an observer was on a krill fishing vessel as a percentage of the days fished. Since 2010 observer coverage has increased over time with some Subareas routinely achieving 100% observer coverage (Table 8).

Table 8. Percent observer coverage, calculated as the total number of days with an observer on board a krill fishing vessel as a percentage of the total number of days fished by all vessels, in Subareas 48.1, 48.2 and 48.3 since 2006.

	Subarea		
Season	48.1	48.2	48.3
2006	16	0	47
2007	17	36	31
2008	84	36	36
2009	10	54	100
2010	64	86	100
2011	81	76	96
2012	84	65	100
2013	96	83	71
2014	97	95	100
2015	89	92	100
2016	100	100	100
2017	65	87	100
2018	98	96	100
2019	100	100	100
2020	98	98	100
2021	100	99	100

The increase in scientific observer data available from the krill fishery has provided a basis for greater specification of sampling requirements, including those on the length, sex and maturity stage of krill, fish by-catch and the collection of acoustic data on krill.

4.2. Summary of available data

Both the vessel's crew and observers collect by-catch information. The vessel's crew report total catch of by-catch by coarse taxonomic groups given their limited ability to discriminate similar species. Observers collect biological information on krill and by-catch specimens at a finer taxonomic resolution, as well as data on individual specimens such as size and maturity.

Summaries of data recently reported to CCAMLR are given in Tables 9 and 10. Since the vessel's crew record by-catch on all hauls while observers inspect sub-samples of random hauls, the crew tends to identify more taxa than observers (Table 9). In 2021, in Subarea 48.3 (Table 9), catches were negligible and no catch was recorded or processed by the vessel's crew. Krill biological and by-catch data was recorded by the observer from the small amounts of krill collected from the net and deck after test hauls. The small amounts of catch were discarded after hauling was complete.

Table 9. Summary of by-catch and biological data reported by vessels crew and observers (from 25kg random sub-samples of the catch) in each of the last five seasons, per Subarea. By-catch records correspond to the number of observations of total weight and count of individuals for each taxon identified. Observers also measure the length of each krill specimen and some by-catch specimens, and, in most cases determine krill maturity stage and sex. Taxonomic identification may occur at different levels.

Data source	Data class	Variable	2017	2018	2019	2020	2021
Subarea 48.1							
Vessel crew	by-catch	taxa identified	59	46	43	39	51
		records	9502	3215	2224	2509	6448
Observer	Antarctic krill	specimens examined	59402	121400	92277	121590	134778
	by-catch	taxa identified	34	46	43	33	42
		records	1033	1406	1808	1938	1148
		length measurements	2908	6288	7428	13356	2089
Subarea 48.2							
Vessel crew	by-catch	taxa identified	37	42	30	43	68
		records	532	907	1471	2339	4785
Observer	Antarctic krill	specimens examined	9701	37928	67736	154010	77941
	by-catch	taxa identified	25	32	26	37	59
		records	95	331	790	1458	2402
		length measurements	441	657	2951	7236	5195
Subarea 48.3							
Vessel crew	by-catch	taxa identified	12	25	28	44	0
		records	252	428	327	1068	0
Observer	Antarctic krill	specimens examined	10800	31400	30800	31800	400
	by-catch	taxa identified	12	23	19	35	14
		records	186	356	386	1973	25
		length measurements	1285	1856	926	6656	39

Table 10. Summary of by-catch and biological data for predominant by-catch groups reported by observers (from 25kg random sub-samples of the catch) in each of the last five seasons, per Subarea. By-catch records correspond to the number of observations of total weight and count of individuals for each taxon identified. Observers also measure the length of some specimens. Taxonomic identification may occur at different levels.

By-catch group	Variable	2017	2018	2019	2020	2021
Subarea 48.1						
Icefish	taxa identified	11	13	12	11	14
	records	469	650	469	669	701
	length measurements	801	1894	1717	1462	1312
Other fish	taxa identified	29	35	35	27	35
	records	777	1310	1076	860	1006
	length measurements	2908	6253	4955	1769	2044
Salps	taxa identified	1	1	1	1	1
	records	151	48	678	943	76
	length measurements	0	5	2447	11549	41
Subarea 48.2						
Icefish	taxa identified	8	10	7	8	12
	records	40	180	369	374	859
	length measurements	343	494	1527	1548	4239
Other fish	taxa identified	22	26	19	28	45
	records	91	258	519	638	1282
	length measurements	437	646	2026	2345	5153
Salps	taxa identified	1	1	1	1	1
	records	1	21	56	718	170
	length measurements	0	0	2	4834	25
Subarea 48.3						
Icefish	taxa identified	2	5	2	3	0
	records	8	91	3	49	0
	length measurements	13	394	3	102	0
Other fish	taxa identified	10	19	9	23	6
	records	149	327	140	1017	8
	length measurements	1276	1855	923	6643	39
Salps	taxa identified	0	1	1	1	1
	records	0	4	91	152	2
	length measurements	0	0	0	0	0

4.3. Length frequency distributions

The length frequency distributions of krill reported by observers in Subareas 48.1, 48.2 and 48.3 for recent fishing seasons show interannual variability among seasons and areas (Fig. 6).

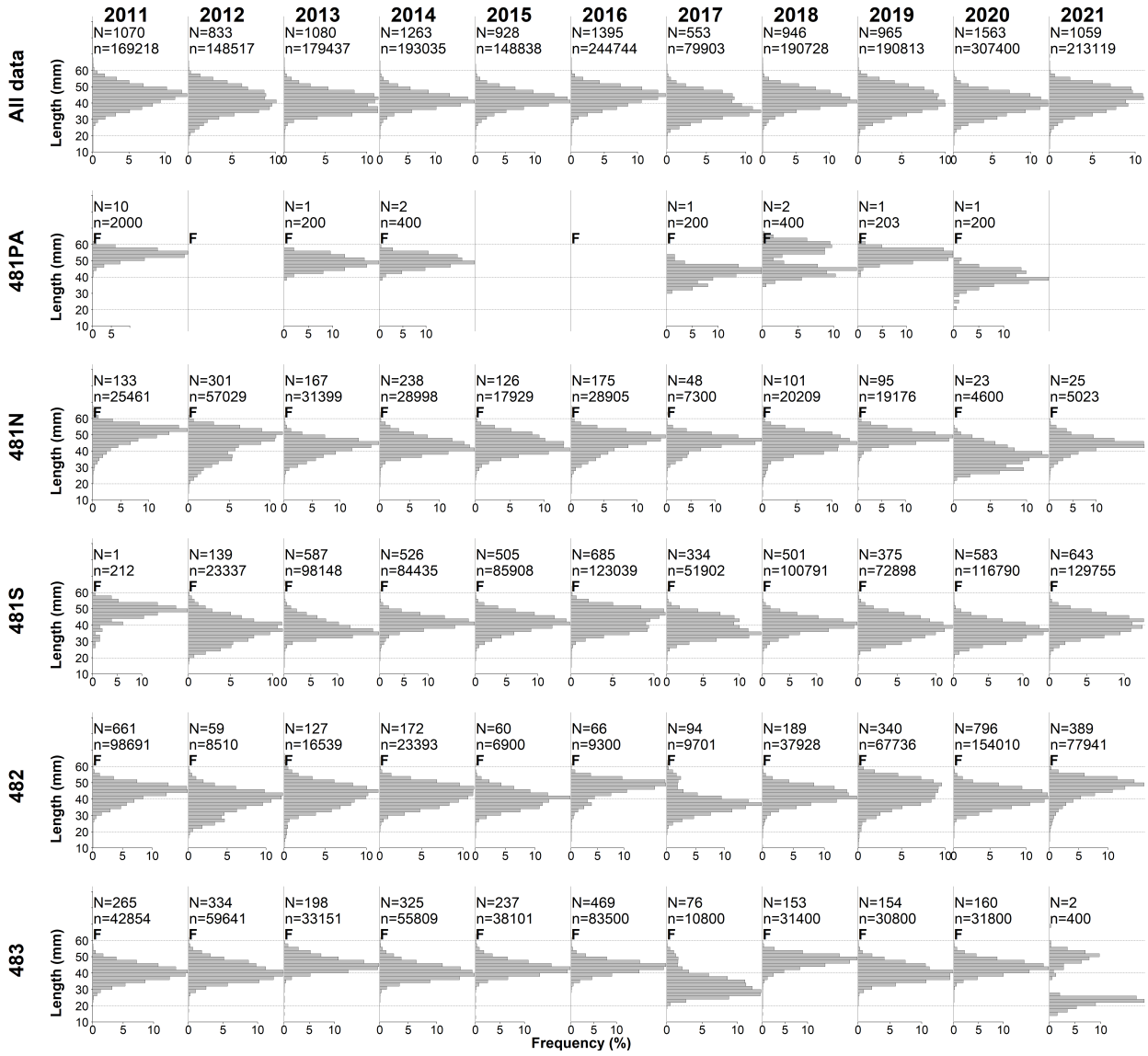


Figure 6. Recent annual length frequency distributions of krill in Area 48 (top panel) and in Subareas 48.1 (PA, N and S see Fig. 4), 48.2 and 48.3 (lower panels). The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each year are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

Analyses of the factors influencing variability in the length frequency distributions of krill collected by observers identified the greatest source of variability to be the timing and location of sampling (rather than a gear or vessel effect). Based on these analyses, the Working Group on Ecosystem Monitoring and Management (WG-EMM) recommended in 2015 that the observer data length frequency distributions could be aggregated by Subarea and month, with the additional recommendation that, in the case of Subarea 48.1, the length frequency distributions were further aggregated for areas to the north and south of the South Shetland Islands (Fig. 6).

The length frequency distributions by month and Subarea for the most recent complete season, 2020, are shown in Figure 7 and for all data available for 2021, are shown in Figure 8. The monthly length frequency distributions by Subarea for fishing seasons ranging from 2011 to 2019 are provided in Appendix 1.

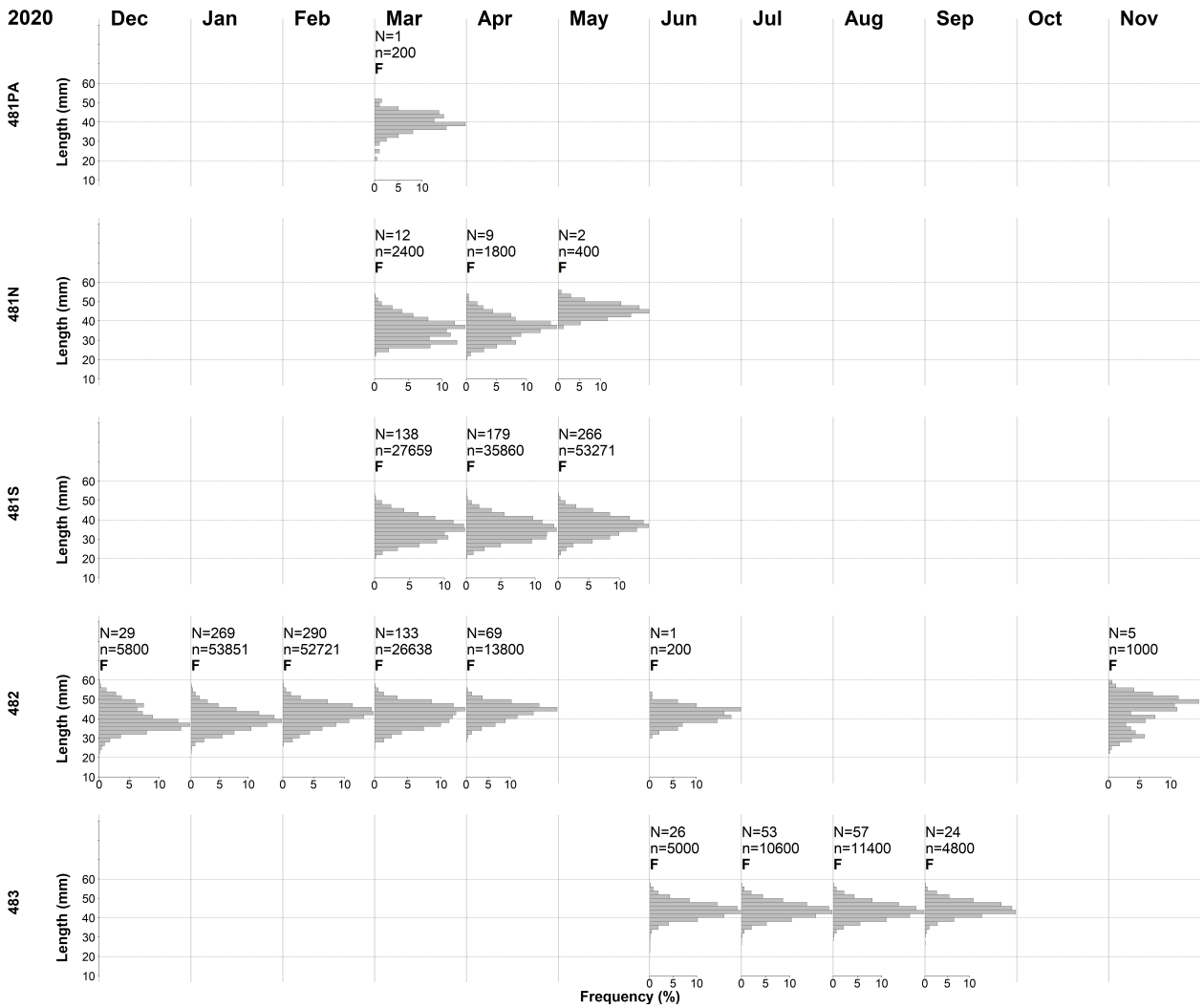


Figure 7. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2020. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a Subarea are indicated by the letter F.

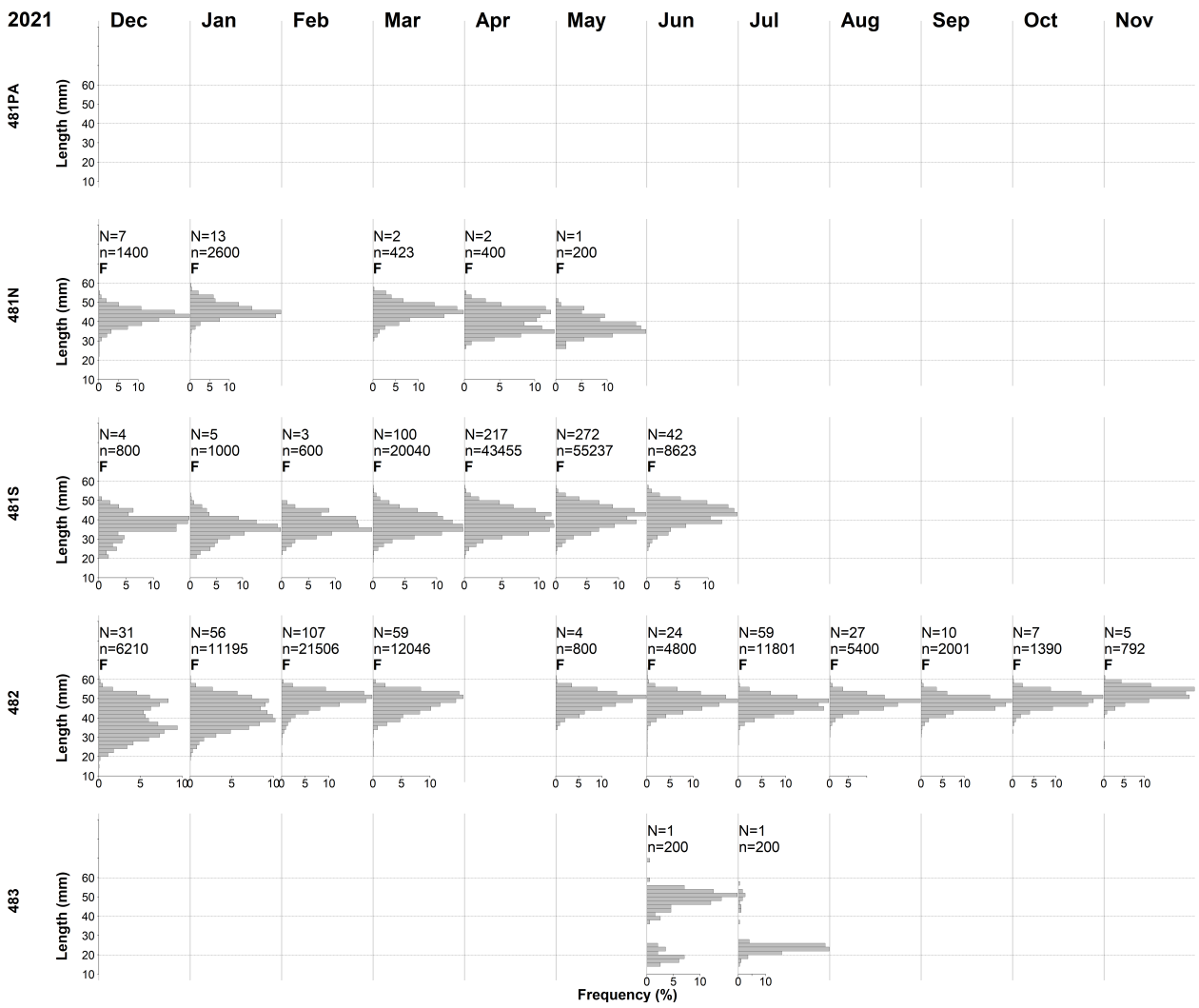


Figure 8. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2021. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a Subarea are indicated by the letter F.

5. Ecosystem implications and effects

Recognition of the central role of krill in the ecosystem is at the core of the approach taken by CCAMLR in the management of the krill fishery. One element of this, the CCAMLR Ecosystem Monitoring Program (CEMP), was established in 1985 to detect changes in the krill-based ecosystem to provide a basis for regulating harvesting of Antarctic marine living resources in accordance with the 'ecosystem approach'. The program aims to:

- Detect and record significant changes in critical components of the ecosystem, to serve as a basis for the conservation of Antarctic marine living resources
- Distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological.

Further information and analysis on CEMP can be found in WG-EMM-16/08, WG-EMM-16/09 and WG-EMM-16/10.

The CEMP Combined Standardised Index (CSI) approach combines multiple CEMP parameters into a single index to monitor changes in krill predator performance. The CSIs include data from the CEMP parameters that reflect the conditions experienced by predators during the breeding season only (*e.g.*, foraging performance and breeding success); they do not include multi-year parameters such as breeding population size (Reid et al., 2005).

The latest CSI time series for Subareas 48.1, 48.2 and 48.3 are shown below (Figs. 9-11).

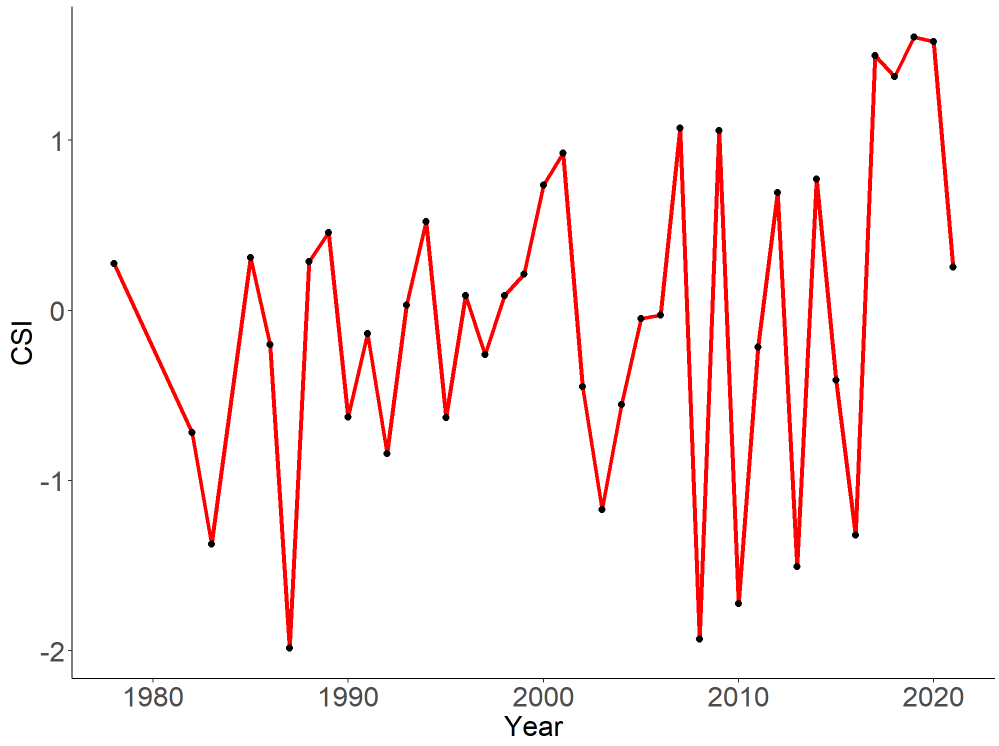


Figure 9. Combined Standardised Index time series from CEMP parameters collected at Admiralty Bay, Cape Shirreff, Esperanza Station, Lions Rump and Stranger Point Station for Adelie, gentoo and chinstrap penguins, and fur seals in Subarea 48.1.

Figure 10. Combined Standardised Index time series from CEMP parameters collected at Laurie Island and Signy Island for Adelie, gentoo and chinstrap penguins in Subarea 48.2.

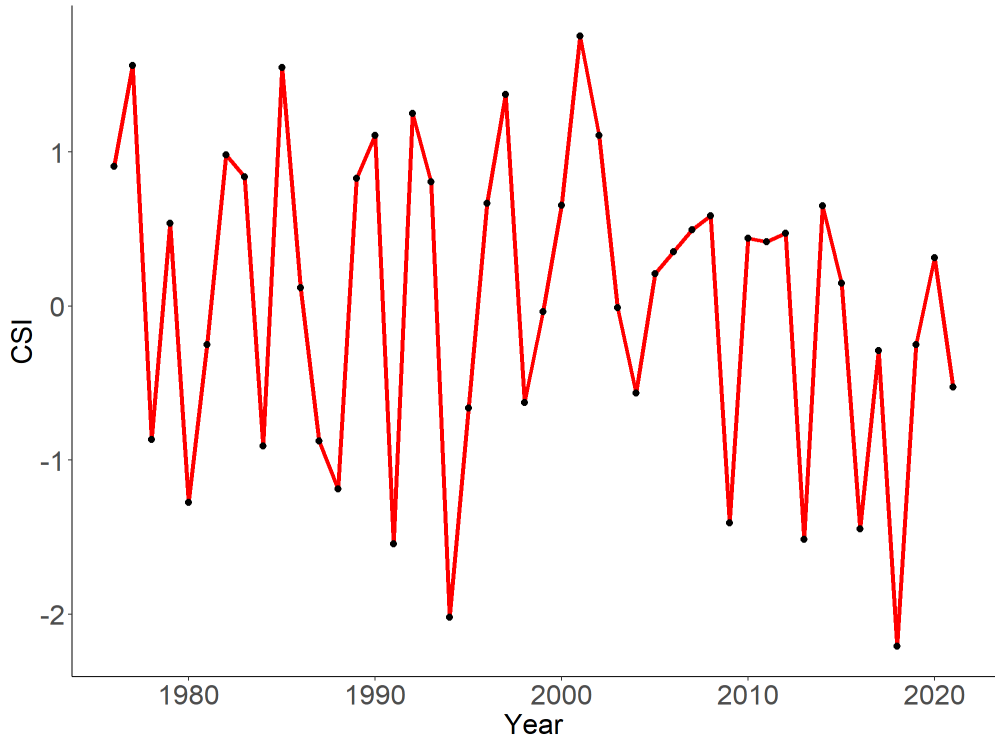


Figure 11. Combined Standardised Index time series from CEMP parameters collected at Bird Island and Maiviken for macaroni and gentoo penguins, southern black browed albatross, and fur seals in Subarea 48.3.

6. Stock status

Details on CCAMLR's approach to managing the krill fishery are given in this document.

7. Climate Change and environmental variability

A recent summary of the potential impacts of climate change on Southern Ocean fisheries (FAO 2018) highlights the following key points:

The Antarctic region is characterized by complex interaction of natural climate variability and anthropogenic climate change that produce high levels of variability in both physical and biological systems, including impacts on key fishery taxa such as Antarctic krill.

The impact of anthropogenic climate change in the short-term could be expected to be related to changes in sea ice and physical access to fishing grounds, whereas longer-term implications are likely to include changes in ecosystem productivity affecting target stocks.

There are no resident human populations or fishery-dependent livelihoods in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) Area, therefore climate change will have limited direct implications for regional food security. However, as an "under-exploited" fishery, there is potential for krill to play a role in global food security in the longer term.

The institutional and management approach taken by CCAMLR, including the ecosystem-based approach, the establishment of large marine protected areas, and scientific monitoring programmes, provides measures of resilience to climate change.

There is no formal evaluation of the impacts of climate Change and environmental variability available for this particular fishery.

References

Budzinski, E., P. Bykowski and D. Dutkiewicz. 1985. Possibilities of processing and marketing of products made from Antarctic krill. FAO Fish. Tech. Pap., 268. FAO, Rome: 46 pp.

Priddle, J., J.P. Croxall, I. Everson, R.B. Heywood, E.J. Murphy, P.A. Prince and C.B. Sear. 1988. Large-scale fluctuations in distribution and abundance of krill - a discussion of possible causes. In: Sahrhage, D. (Ed.). Antarctic Ocean and Resources Variability. Springer-Verlag, Berlin Heidelberg: 169-182.

Reid, K., J.P. Croxall, D.R. Briggs, and E.J. Murphy. 2005. Antarctic ecosystem monitoring: quantifying the response of ecosystem indicators to variability in Antarctic krill. ICES Journal of Marine Science, 62:366-373.

Trathan, P.N., J.L. Watkins, A.W.A. Murray, A.S. Brierley, I. Everson, C. Goss, J. Priddle, K. Reid, P. Ward, R. Hewitt, D. Demer, M. Naganobu, S. Kawaguchi, V. Sushin, S.M. Kasatkina, S. Hedley, S. Kim and T. Pauly. 2001. The CCAMLR-2000 Krill Synoptic Survey: a description of the rationale and design. CCAMLR Science, 8: 1-24.

Additional Resources

- Fishery Summary: pdf, html
- Management approach: pdf
- Species Description: pdf, html
- Fisheries Documents Browser

Appendix

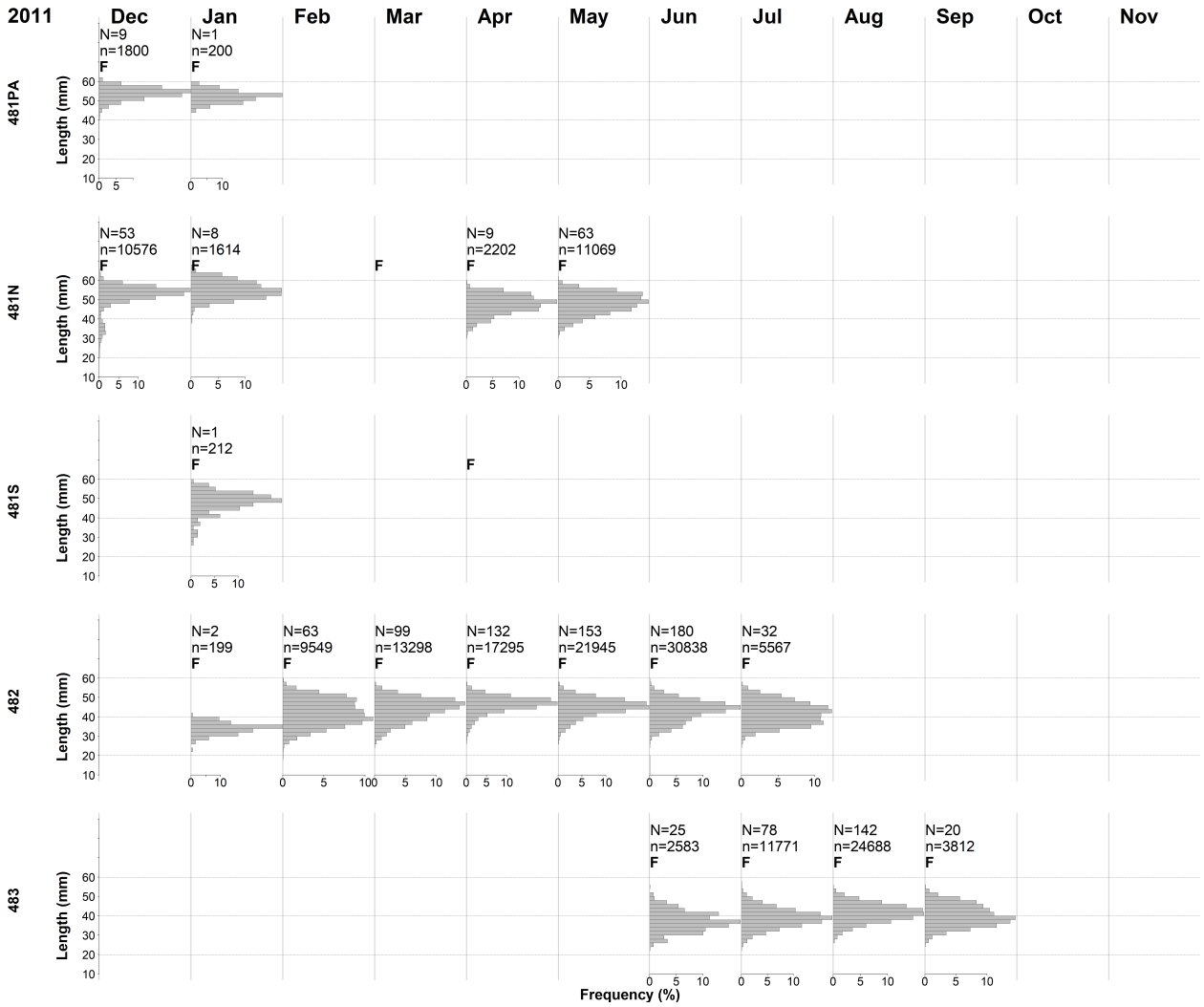


Figure A1. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2011. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

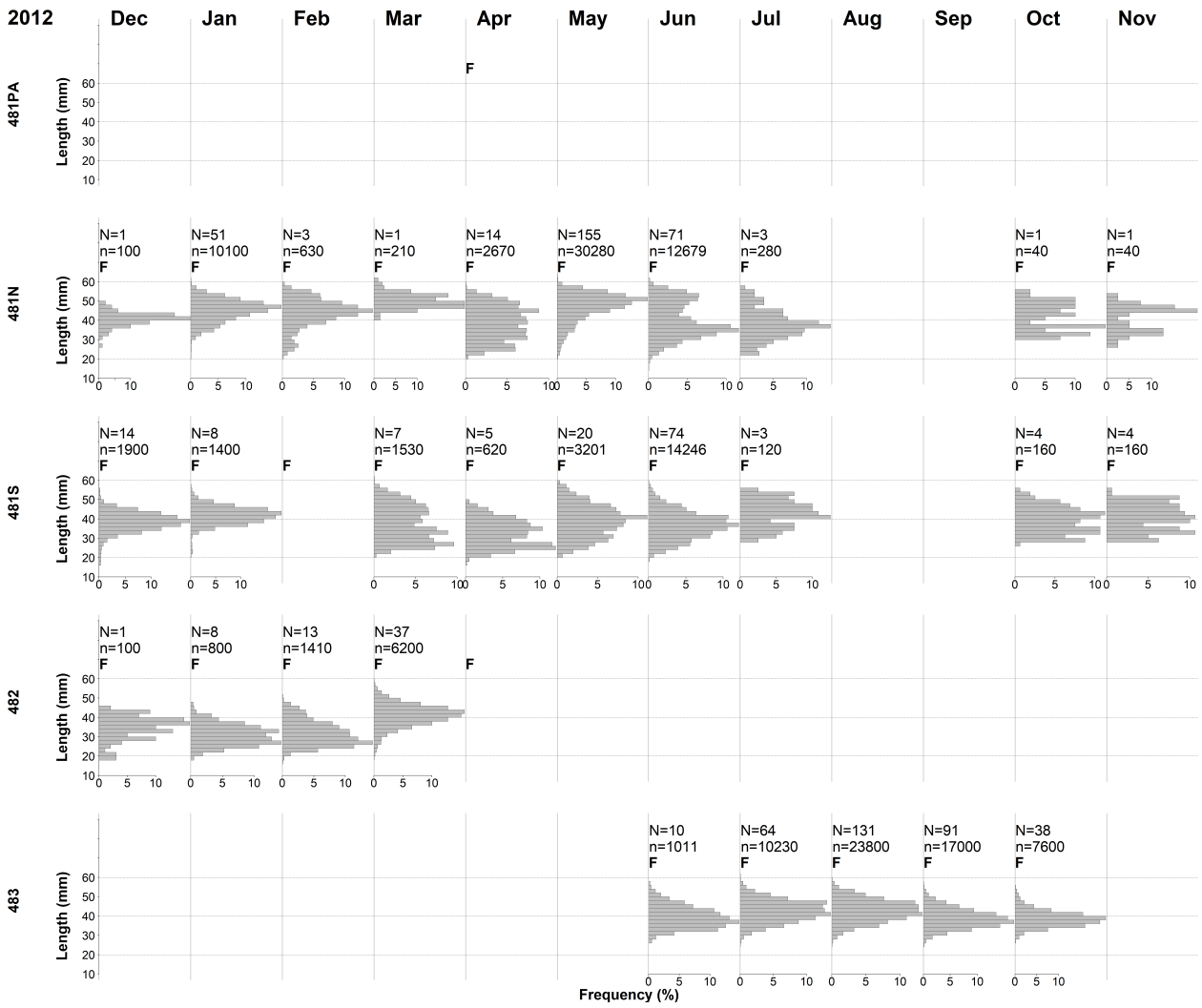


Figure A2. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2012. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

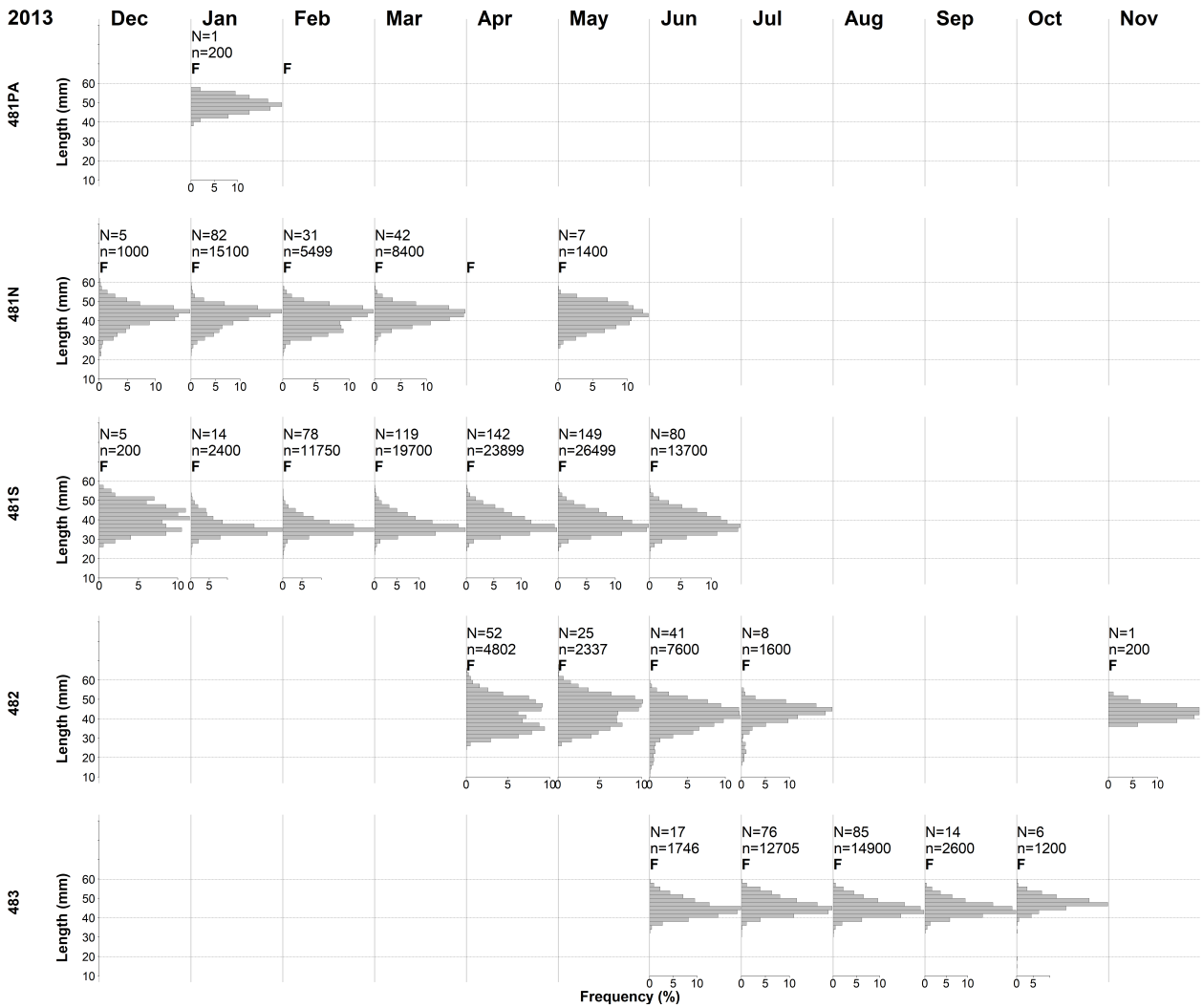


Figure A3. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2013. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

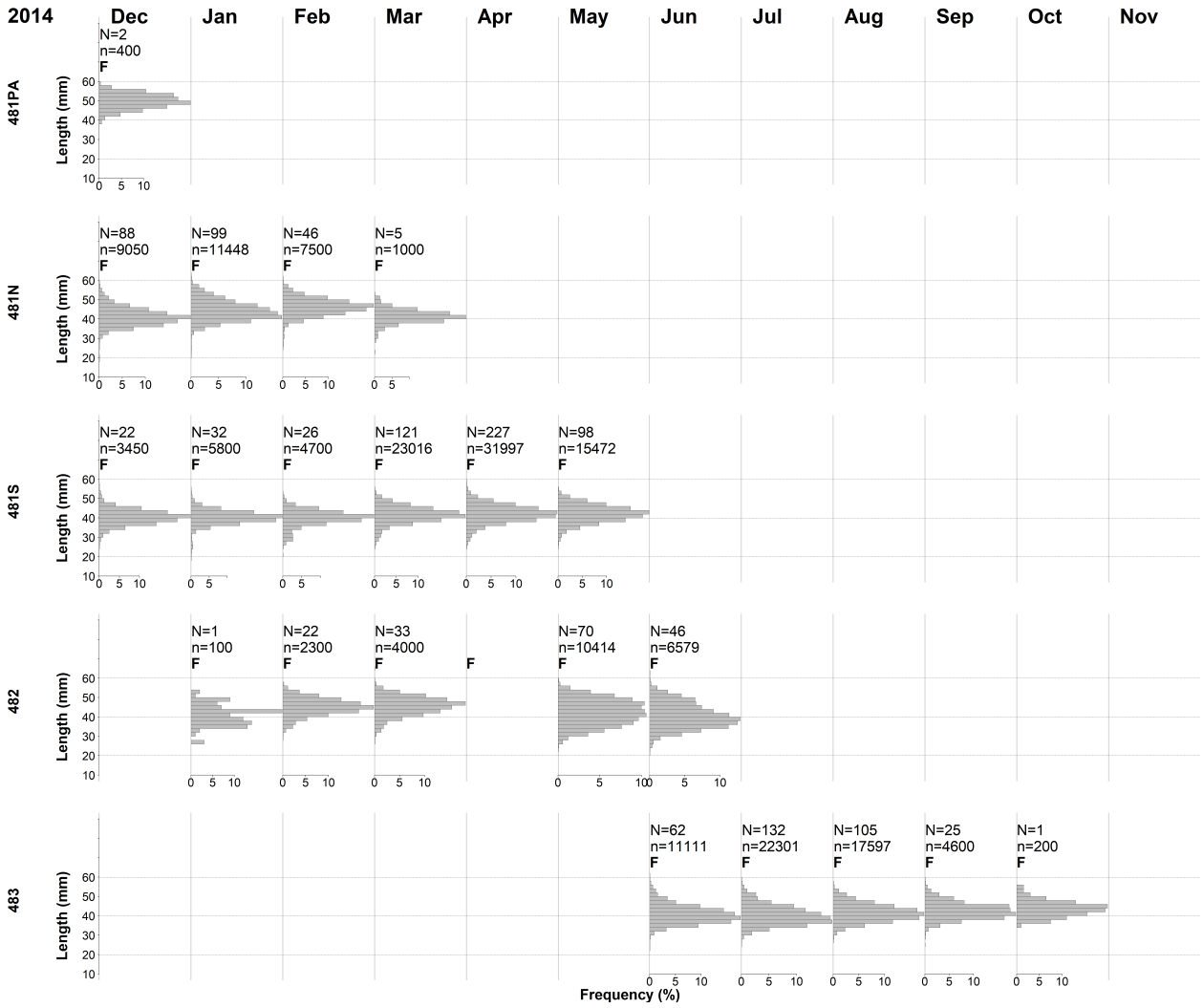


Figure A4. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2014. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

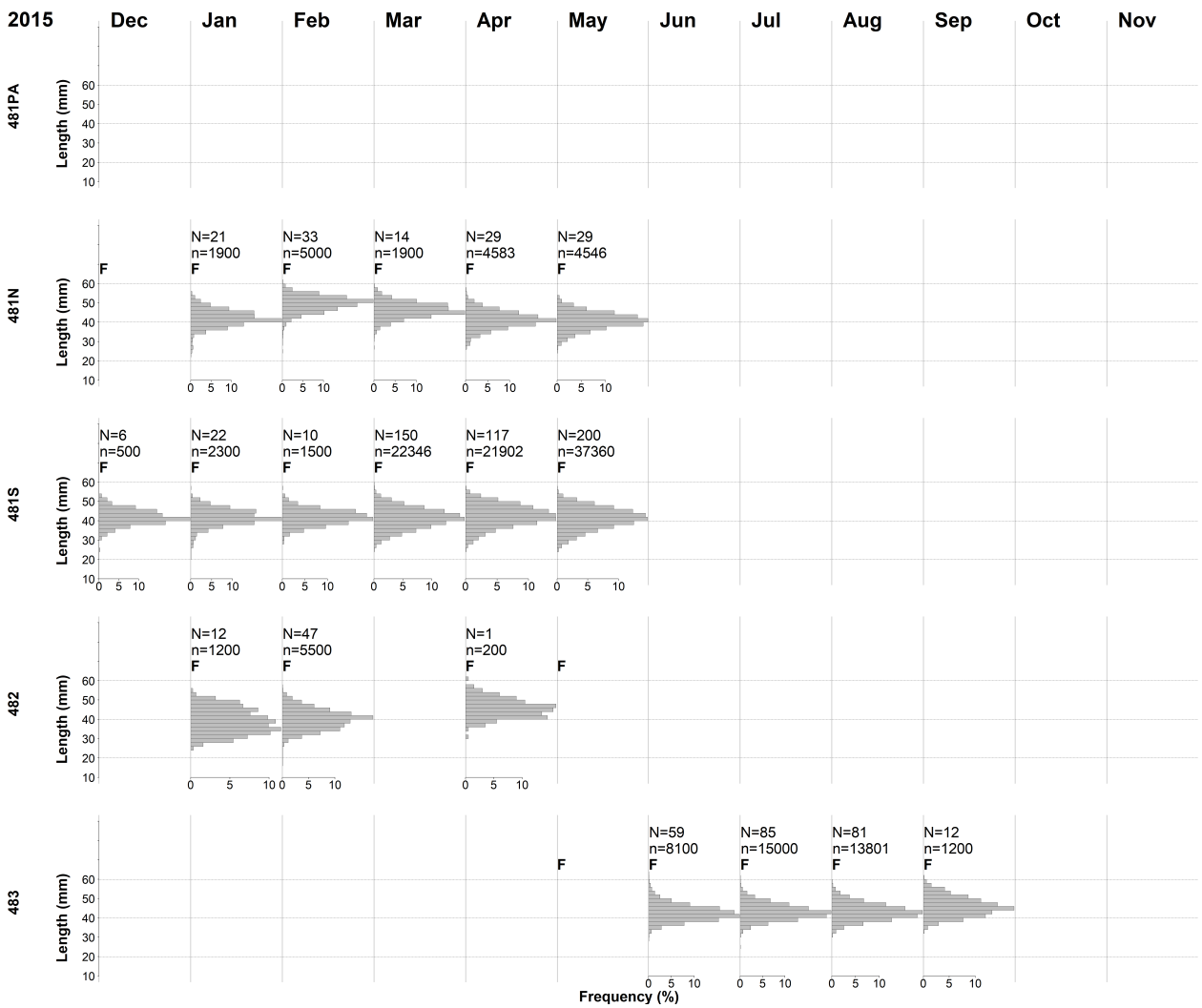


Figure A5. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2015. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

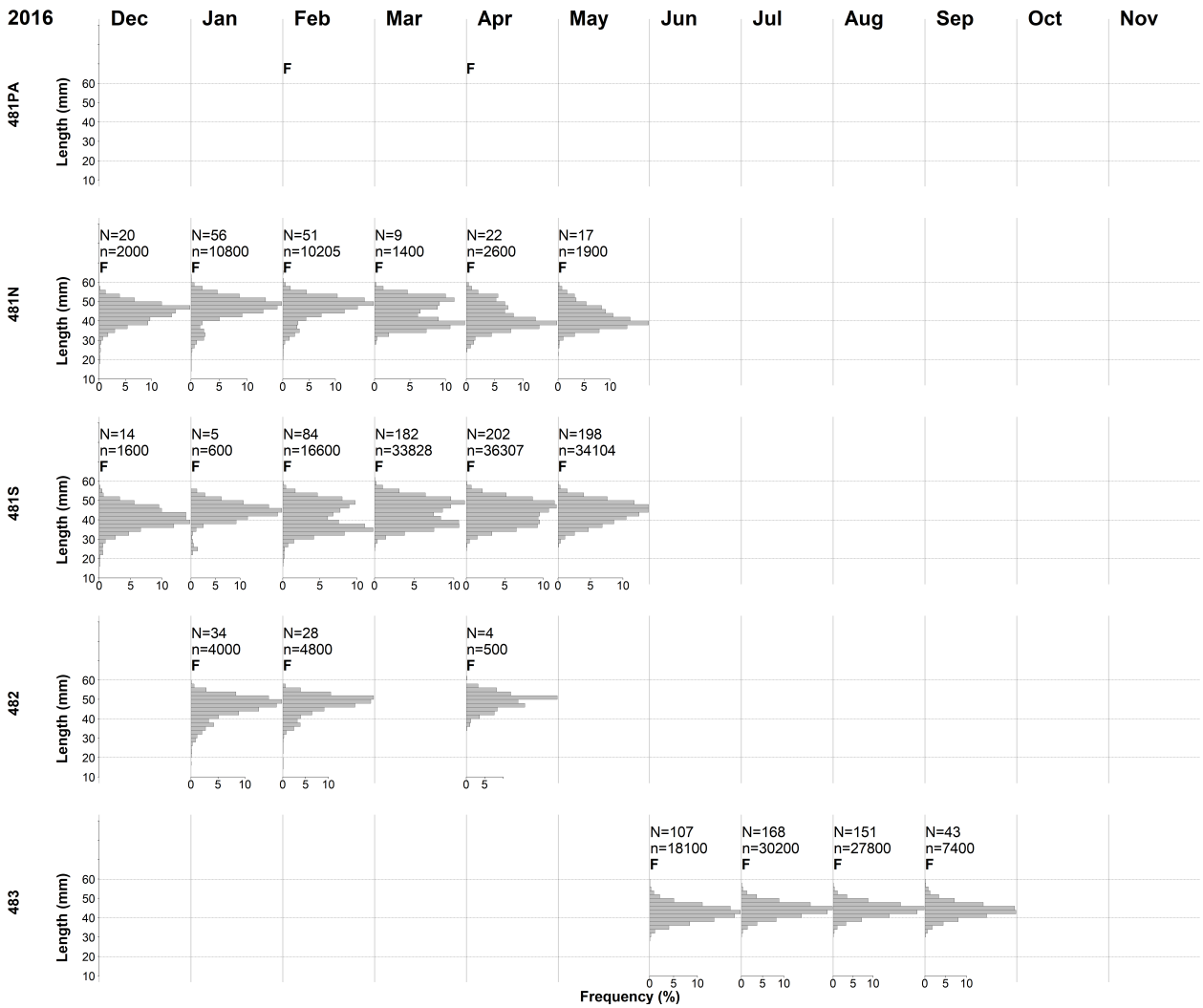


Figure A6. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2016. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

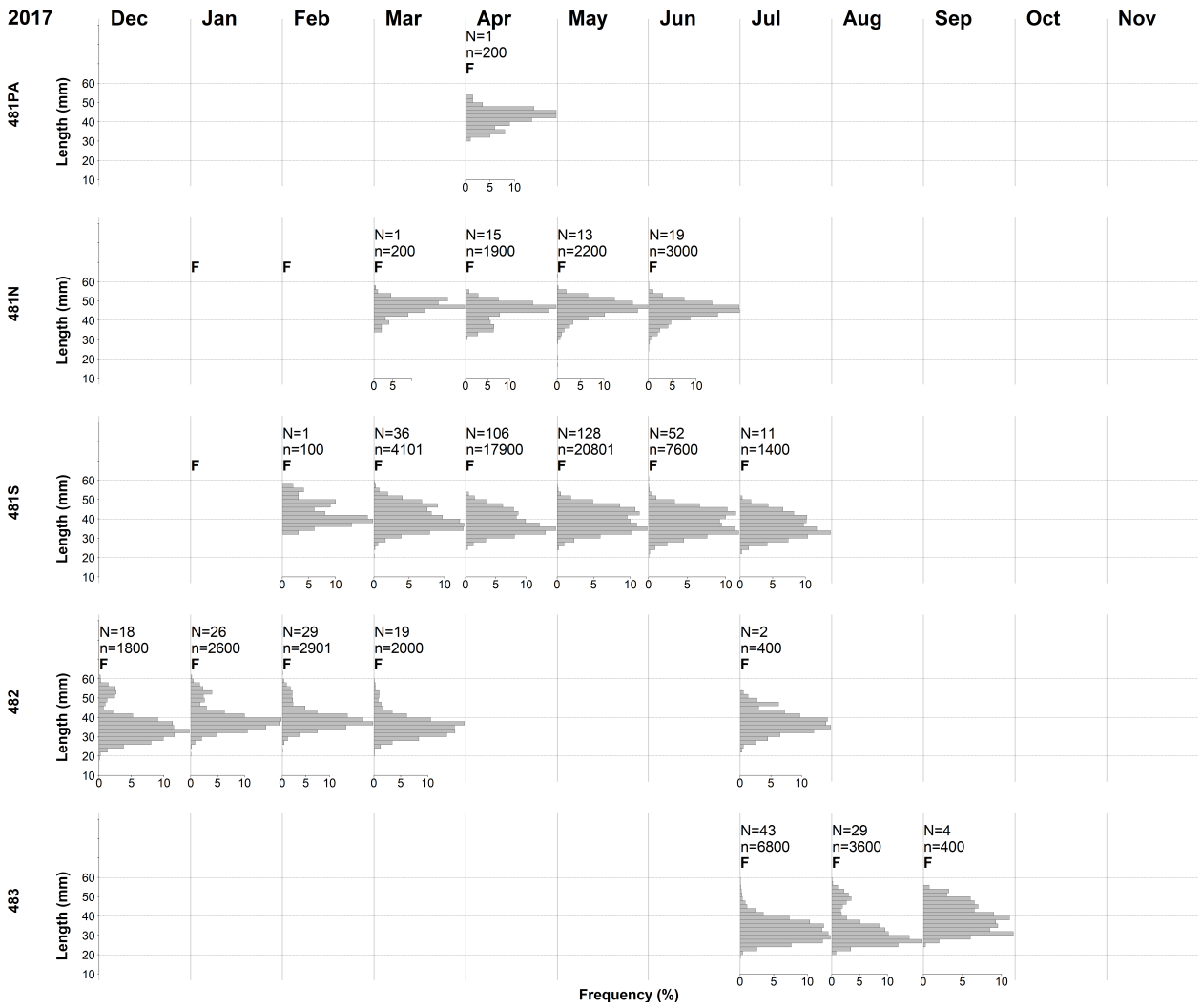


Figure A7. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2017. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

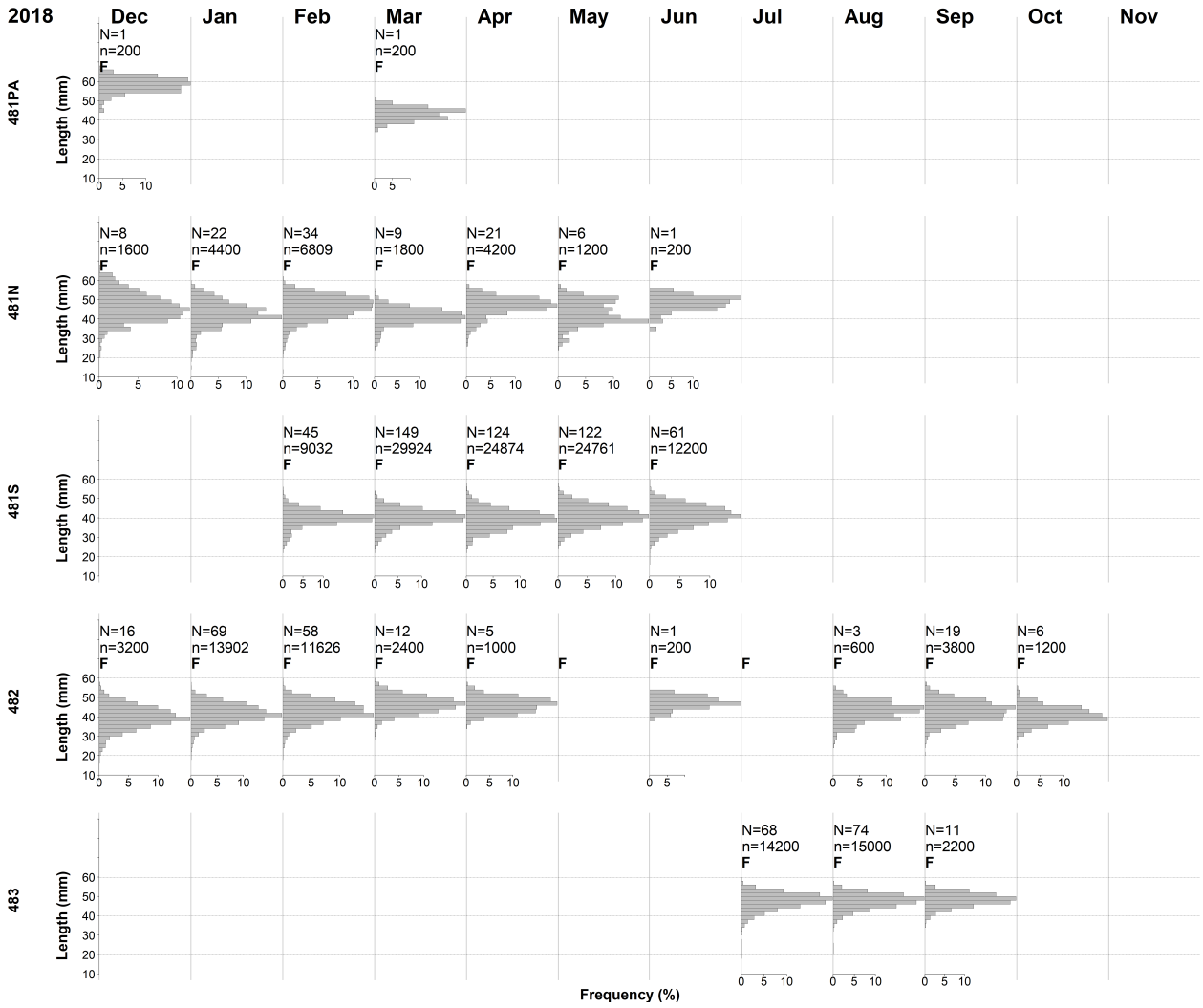


Figure A8. Monthly length frequency distributions for krill in Subareas 48.1 (including PA, N and S), 48.2 and 48.3 in 2018. The number of hauls from which krill were measured (N) and the number of individuals measured (n) in each month are provided; the months in which fishing occurred in a subarea are indicated by the letter F.

Table A1. Annual catch (tonnes) of krill from Small-Scale Management Units (SSMUs; see Fig. 4) in Area 48 reported since 1994. More than 95 percent of catches can be allocated to SSMUs based on haul by haul location reporting. A blank cell indicates that there was no fishing, a 0 indicates that fishing occurred but that there was a catch of less than 0.5 tonnes.

	Subarea 48.1								Subarea 48.2				Subarea 48.3		
Season	APPA	APW	APDPW	APDPE	APEI	APBSW	APBSE	APE	SOPA	SOW	SONE	SOSE	SGPA	SGW	SGE
1994	5	4	26564	722	17659	146			4	17806	103	1347	381	11	19906
1995	6256		13844	2646	15030	388			51	47509		1273	72	287	40461
1996	5828		37685	4191	12727	1331		25	10	2118	3		15	5191	22657
1997	806		23045	15354	9096	180	22			8	91			106	26601
1998	3340	2858	23888	17955	5766	1594			259	6151	304		14	3797	22722
1999	2593	3868	11382	10810	8880	41	925		605	45902	3429	12513			
2000	274	108	35166	19943	11412	7110	2972		3152	11150	1133	1496	6310	1984	11052
2001	5	683	24449	18218	4609	3600	759			1115	22	3861		10963	24768
2002	138	3	4853	1405	3914	330	57		53	51086	2941	893	2842	8889	28180
2003	47	58	29772	1504	961	336	16		547	16286	59	48	782	13966	51411
2004	349	248	5104	1467	6172	404	1900		299	47101	782	10	151	33168	22824
2005	9		5039	1966	38	44			52	70090	2033	87	22	307	48131
2006		40	41504	10133	2190	13375	23326			2893	185	33		8235	6665
2007	29	4	12154	2079	1184	502	19		10	64598	3413		6	3263	17468
2008			218	113	2251					88615	178	11		35277	22352
2009	1500		3327	1637	3883	635	20087	3049	1648	89066	875				0
2010	67	5999	17290	8797	1772	85514	34891		1279	48921	74	218			8834
2011	392	10	649	7975	15	59	115		490	111472	3836	196		2671	53130
2012	11	16949	20460	4901	73	28422	5007		43	28789	166			6197	50218
2013	83	13477	3801	7725	257	109155	18756		34	30539	4			3439	28782
2014	113	6712	19729	7374	676	49589	62245			69962	2492				75252
2015		36267	347	3131	5618	71007	37807		8	14282	2811				54354
2016	13	37789	10	5052	625	37137	73816			33848	436	17		218	71189
2017	60	18290	14846	2542		73842	39752	2		64307	4738			6441	12117
2018	12	22198	626	8673	511	75665	43992		2	132871	5006			11	23163
2019	0	206	1146	6999	1966	104643	40836			151157	11413	3			71799
2020	7	35031	938	25		27217	93862		3811	158569	16002			1044	114274
2021		8644	190	1117	73	87740	64008		2991	147663	58814	286			