Report on the feasibility of year round, regular research operations in ice-covered areas
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History

Revision	**Date**	**Modification**	**Author**
0.1	24.02.2015	First release	JJ Dañobeitia
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Diffusion list

AWI	Biebow, Nicole	Willmott Puig, Veronica		
CSIC-UTM	Ojeda, Miguel Angel	Dañobeitia, Juanjo		
DTU-Aqua	Thomsen, Helge Abildhauge	Gissel Nielsen, Torkel		
SPRS	Tannerfeldt, Magnus	Dahlback, Bjorn		
IMR	Nieuwejaar Per			
ISMAR	Bergamasco, Andrea	Vetrano, Anna		
OGS	Caburlotto, Andrea	Rebesco,Michelle		
IOPAN	Beszczynska-Möller, Agnieszka			
ESF	Campus, Paola	Azzolini, Roberto		
IFREMER	Valerie Mazauric			

1. General Introduction

The WP3 “Flagship initiative for polar access” is aiming at integrating the European Polar Research Vessel (PRV) fleet by establishing models for implementing a joint coordination of this fleet. It is pointing to find appropriate ways at optimizing the usage of the European Polar Research Vessels by:

- Determining the available capacities of PRV´s
- Comparing that with the scientific demand, in accordance with IASC (International Arctic Science Committee) and SCAR (Scientific Committee on Antarctic Research) for Research in the Polar Oceans.
- Establishing Models for optimization of this fleet by better coordination of the vessel's schedules and by harmonizing the deployment of ice-strengthened research vessels together with the heavy icebreakers

This Deliverable is interconnected with **Task 3.1** “Determination on the available capacities” for PRV´s access and Scientific Demand, which was completed by M16 (Deliverable 3.1), and with **Task 3.2** “Determination of the scientific demand for Polar Research Vessels” (PRV´s) which is underway.

Short summary on Deliverable 3.1

Based *on the scenario at* the beginning of 2014, we concluded that the perspective of the heavy Icebreakers from the European Polar Research fleet was solely two operative vessels: The PRV Oden (Sweden) and the PRV Polarstern (Germany). The PRV Oden is dedicated mostly for Arctic research since 2011, while the PRV Polarstern mostly spends her time in Antarctic waters. Polarstern is reaching the end of her lifetime, after 30 years of continuous operation, while Oden has still an estimated 15 years to go without a major refit. There are some progressing projects such as the Norwegian 100 m length PRV Kronprins Haakon, to be operational by mid-2017 and the replacement of Polarstern estimated to be operational in 2019. Moreover, recently NERC has announced the replacement of the RRS James Clark Ross and RRS Ernest Shackleton, by a multi-role polar research and logistics ship, operated by British Antarctic Survey (BAS) and estimated to be operational by autumn 2019. Even when considering the ongoing construction projects, the capacity and infrastructure of the European Polar fleet does not fulfil the needs of the European Polar Community.
A line of action already initiated by Norway and Germany, and lately by UK, is the planned construction of highly interoperable medium-size ships with research and cargo capacities - and finding mechanisms to share them. Furthermore, due the low possibility of new PRV's constructions, strategies for sharing existing European PRV capacities, as intended by the initiative ARICE (Arctic Research Icebreaker Consortium for Europe), should be supported in the European Union, since in the 2020 horizon only two heavy icebreakers will be available and most PRVs will overtake their lifetime.

Description of task 3.2 – **Determination of the scientific demand for Polar Research Vessels (PRV´s)** (M1-M16): This task will cover the following aspects:

- To determine the scientific demand in Europe for research and monitoring in the Polar Oceans,
- The icebreaking capacities needed and for the necessary equipment to carry out this work.

- To *elaborate* a short term (5 years) vision with identification of tasks that can be achieved with the present fleets.

2. Meetings

The results of WP3 were shown and discussed at the 16th ERVO meeting held in Barcelona on 11th-12th June 2014. The meeting was chaired by CSIC-UTM and the number of attendees substantially increased from previous meetings, with 37 participants from 28 organizations of 16 European countries, plus an observer from Japan.

A WP3 meeting was also organized in Barcelona, 20th-21st January 2015, at the ***Centro Mediterráneo de Investigaciones Marinas y Ambientales - CSIC*** with the following working agenda:

Agenda

Tuesday 20th January 2015

- 9:15 – 9:30; Welcome / Logistics (J. Danobeitia)
- 9:30 – 9:45; Introduction to WP3 tasks (V. Willmott)
- 09:45 -11:00; D.3.2 Report on the feasibility of year round, regular research operations in ice-covered areas: Task 3.1 and Task 3.2 [month 16] (Lead beneficiary: CSIC) Brainstorming and discussion
- 11:00 – 11:30 Coffee break
- 11:30 – 13:00; Continue with D.3.2
- 13:00 – 13:45 Lunch break
- 13:45 – 15:00; D3.3 Identification of the high priority investigation areas equipment requirement: Task 3.2 [month 20] (Lead beneficiary: OGS) Brainstorming and discussion
- 15:00 - 15:30 Coffee Break
- 15:30 – 17:30; Continue with D.3.3

Wednesday 21st January 2015

- 9:00 – 10:30 D.3.4. Current and future European demand for PRV and foreseeable gaps in the capacity of the fleet: Task 3.1 and Task 3.2 [month 26] (Lead beneficiary: CNR) Brainstorming and discussion
- 10:30 – 11:00 Coffee break
- 11:00 – 12:00; Continue with D.3.4
- 12:00 – 12:30 Wrap-up. Outlook on future WP3 work

Meeting Participants

- Azzolini, Roberto (ESF)
- Bergamasco, Andrea (CNR, ISMAR)
- Beszczynska-Möller, Agnieszka (IOPAN)
- Campus, Paola (ESF)
- Danobeitia; Juan José (CSIC, UTM)
- Nieuwejaar, Per Wilhelm (IMR)
- Ojeda; Miguel Angel (CSIC, UTM)
- Rebesco, Michele (OGS)(*)
- Thomsen; Helge Abildhauge (DTU-Aqua)
- Torkel Gissel Nielsen (DTU-Aqua)
- Willmott Puig, Verónica (AWI)

Apologies, Last minute missed participants

- Biebow, Nicole (AWI)
- Dahlbäck, Bjorn (SPRS)
- Caburlotto, Andrea (OGS), (*) Replaced by Michele Rebesco

3. Polar code /New Polar Classes

The Polar code was already addressed within Deliverable 3.1, although many people suggested replacing the old Ice Class to the new adopted Polar Classes (**Table I**, based on WMO Sea Ice Nomenclature) that follows the international standards to support SOLAS requirements, which are related to the thickness and/or age of the ice (see **Table II**).

POLAR CLASS	GENERAL DESCRIPTION
PC 1	Year-round operation in all Polar waters
PC 2	Year-round operation in moderate multi-year ice conditions
PC 3	Year-round operation in second-year ice which may include multiyear ice inclusions
PC 4	Year-round operation in thick first-year ice which may include old ice inclusions
PC 5	Year-round operation in medium first-year ice which may include old ice inclusions
PC 6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC 7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

TABLE I - Polar classes and general description

Polar Ship Categories

• **Category A ship:** means a ship capable to operate at least in medium first-year ice which may include old ice inclusions in accordance with an ice class at least equivalent to those acceptable to the Organization.
• **Category B ship:** means a ship capable to operate in sea ice conditions other than those included in Category A with an ice class at least equivalent to those acceptable to the Organization.
• **Category C ship:** means any ship which is not a Category A or Category B ship.

The IMO polar guides

- Only ships with Polar Ship Certificate and a Polar Water Operation Manual, based on IACS Unified Requirements for Polar Class Ships, should operate in Polar Waters.
- Or comparable alternative standard of ice strengthening
- Ice description follows WMO sea ice nomenclature

Category	Ice Class	Limiting Ice Thickness (m)	Threshold ice Thickness for Low Speed Operation (m)	Code
A	PC1	Any ice		A1
	PC2	Any ice		A2
	PC3	Ice >3m	Any ice	A3
	PC4	3	3	A4
	PC5	1.2	3	A5
B[1]	PC6	0.7	2	B1
	PC7	0.7	1.2	B2
C[2]	1B	0.5		C1
	1C	0.3		C2
	1D	0.15		C3
	O/W	0.1		C4

TABLE II - Ice Categories and Polar Classes including ice thickness

4. Sea-ice variability in the Polar Regions

4.1. Arctic

After a study over 32 years (1979-2010) of Arctic sea ice using microwave radiometers satellite data, Parkinson & Cavalieri (2012) concluded that the sea-ice extent (the outer edge of the area covered with ice) and area trends vary widely by month depending on the region and season. These authors (op. cit.) determine that all the months show negative sea-ice extent trends with a minimum magnitude in May and a maximum magnitude in September, whereas the corresponding sea-ice area trends are smaller in magnitude and reach minimum and maximum values in March and September. The results of these 3 decades of observations show a remarkable decrease in the sea-ice area and the amount of multiyear ice (perennial) as illustrated in **Figure 1.**

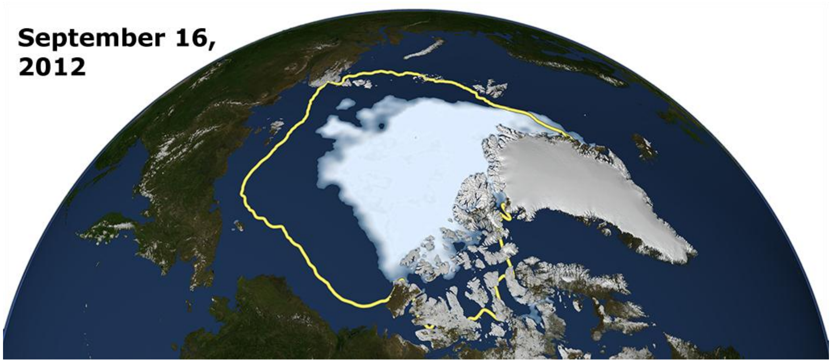


Figure 1- Minimum sea-ice extent. The yellow line indicates the average of the minimum sea-ice extent over last 30 years compared with the minimum sea-ice extent on September 16th 2012 (*https://ourchangingclimate.files.worldpress.com/2013/03/arctic*).

In September 2012 the average sea-ice extent fell below 3,5 million km^2 ±15%, which is more than half of what it was in 1980 (**Figure 2 and Figure 3**) with a decrease trending towards 2015. The last six years, 2007-2012, have the six lowest minimum extents since satellite observations began in 1979. In March 2012 the sea-ice extent reached a maximum value of 15.24 million km2, 4% below the 1979-2000 average. This was the highest maximum in 9 years (Perovich et al., 2012).

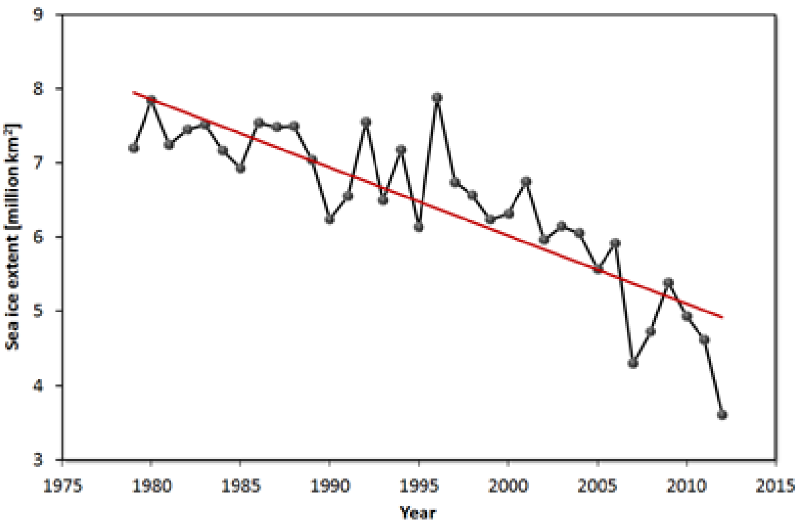


Figure 2- Variation of sea ice extent versus year

This shows the complexity of the ice cover variability through time and the importance of Polar Research studies year around using modern and well equipped PRV´s (PC1 to PC3)

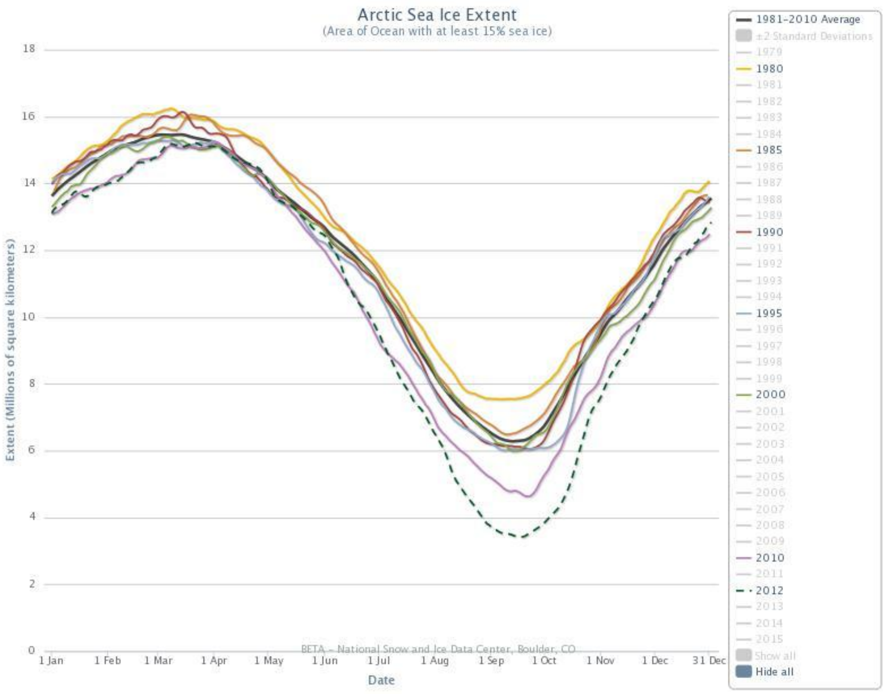


Figure 3 - Variation curves of sea-ice extent over a period of 32 years (1980-2012), plotted every 5 years (After NSIDC, *http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/*)

In terms of areas for year-round research, the thicker/older sea ice is located north-north east of Greenland and Canada as shown in this recent ice extension image from NSDC (**Figure 4**)

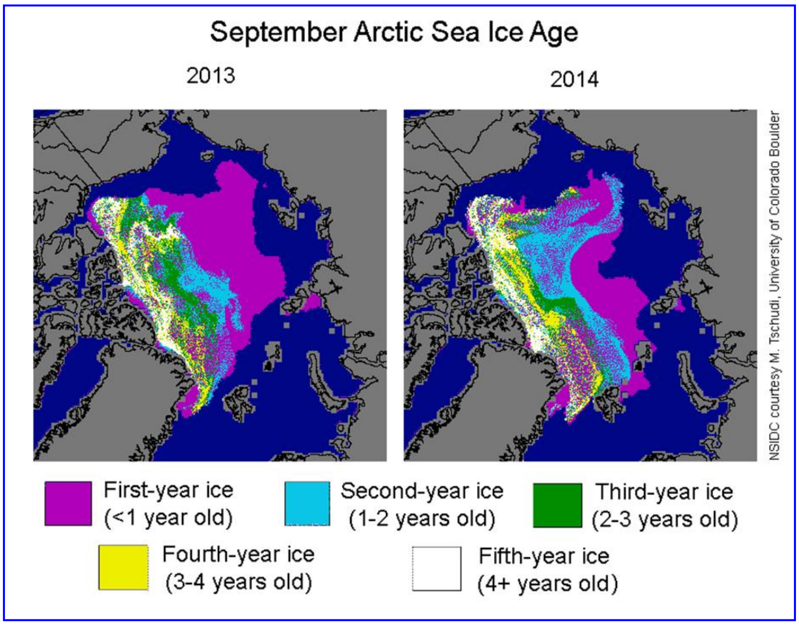


Figure 4 - Variability of sea-ice ages between September 2013 and 2014 (After NSDC, 2015)

4.2. Antarctic

In contrast with the dramatic decreasing sea-ice extent in the Arctic area, something more complex is happening in Antarctica (**Figure 5**). A NASA study shows that from 1978 to 2010 (Parkinson, C. L. and Cavalieri, D. J, 2012) the total extent of sea ice in the Southern Ocean surrounding Antarctica grew at an average rate by roughly 17.000 km² ± 15% every year, with some indications that this rate of increase has recently accelerated.

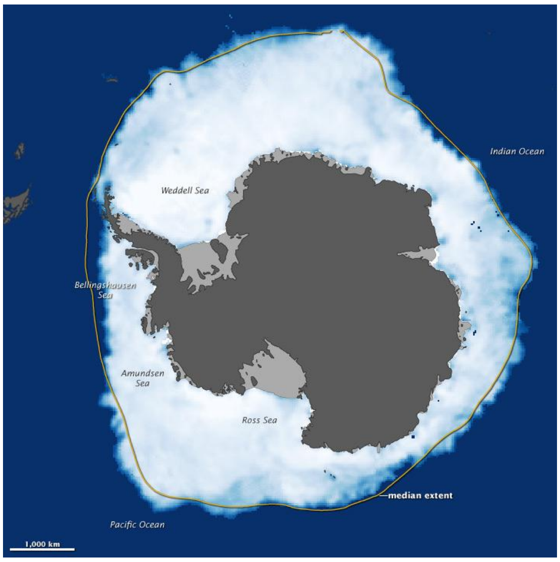


Figure 5 - The average sea-ice extent in September from 1979 to 2000 is marked by the yellow line. (After NASA/Goddard Space Flight Centre Scientific Visualization Studio)

The minimum average Antarctic sea-ice extent measured in February 2013 was about 3,6 million km^2± 15%, whereas in 1980 was around 2, 9 million km^2. This represents an increase of almost 25% with an increase trending 2015 (**Figure 6**). A smaller tendency is observed in winter time, September, from 1980 to 2013, with an increase of roughly 3%.

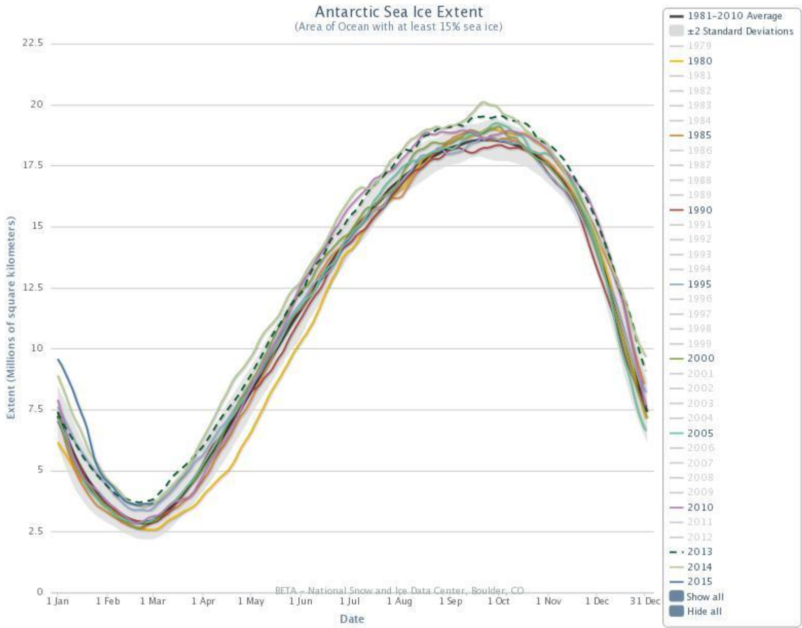


Figure 6 - Variation curves of sea-ice extent over a period of 35 years (1980-2015), plotted every 5 years (After NSDC, http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/)

5 PRVs capacity for year-round research

We have reduced the PRV compilation table of report D3.1 (*Determination of available capacities, 2014*) to include those PRVs which operate at least in first-year sea-ice (according to the new PRV classification, between PC1-PC5, see Table III on page 16).

On the full capacity of year-round operations, Europe is limited to three PRVs, the German Polarstern, the Swedish Oden and the Russian Akademik Fedorov. Worldwide only a few more are available, like the Healy and Polar Sea from USA, the Louis S. St. Laurent and Amundsen from Canada and the Shirase II from Japan. From all those PRVs, only the Polarstern is exclusively dedicated to science.

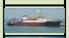
Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Research Equipment	Operating area		Major Refit	Supply Station
EUROPE	A	PC1 to PC3	Polarstern		Germany	118	1982	AWI	100 A5	100/100	Antarctic	Arctic	2002	Yes
			Oden		Sweden	108	1988	SMA	DNV-Polar 20	60/100		Arctic		Yes
			Akademik Federov		Russia	141	1987	AARI	KM * ULA [2]A2	50/100	Antarctic	Arctic		Yes
WORLDWIDE	A	PC1 to PC3	Healy		USA	128	1997	USACGC	**PC2**	60/100	Antarctic	Arctic		Yes
			Polar Sea		USA	122	1978	USACGC	**PC2**	25/100	Antarctic	Arctic		Yes
			Louis S. St-Laurent		Canada	120	1969	CCG	A4	60/100		Arctic	decom m. 2017	No
			Amundsen		Canada	98	1979	CCG	100 A3	50/100		Arctic	2003	No
			Shirase II		Japan	138	2008	Ministry of Defence & JARE	**PC3**	50/100	Antarctic	Arctic		Yes
			Sikuliaq		USA	80	2014	U. of Alaska UNOLS	**PC5**	100/100		Arctic		
EUROPE	A	PC4 to PC5	James Clark Ross		UK	99	1990	BAS	Lloyds IAS	100/100	Antarctic	Arctic		No
			Akade. Tryoshnikov		Russia	134	2011	AARI	**PC4-PC5**	50/100	Antarctic	Arctic		Yes
WORLDWIDE	A	PC4 to PC5	Xue Long		China	167	1993	CAA	CCS B1	50/100	Antarctic	Artic	2013	Yes
			N.I B. Palmer		USA	94	1992	USAP	A2	100/100	Antarctic			Yes
			Agulhas II,		Souht Africa	134	2012	SANAP	**PC5**	60/100	Antarctic			Yes
			Araon		South Korea	110	2009	KOPRI	**PC5**	100/100	Antarctic	Arctic		Yes
			Aurora Australis		Australia	95	1989	P & O / ADD	A1	60/100	Antarctic		2013	Yes
			Almirante Irizar		Argentina	121	1978	Argentina Navy	**PC5**	60/100	Antarctic		underway	Yes

<table>
<tr><th colspan="2">POLAR RESEARCH VESSELS</th><th rowspan="2">IACS</th><th rowspan="2"></th></tr>
<tr><th>World</th><th>Europe</th></tr>
<tr><td>Healy, Polar Sea, L. S. St. Laurent, Amundsen, Shirase II</td><td>Polarstern, Oden, Akademik Fedorov</td><td>PC1 PC2 PC3</td><td rowspan="2">Year-Round navigation in Polar Waters</td></tr>
<tr><td>Xue Long, N. B.Palmer, Agulhas II, Araon, Aurora Australis, Alm. Irizar</td><td>J. Clark Ross Akademik Tryoshnikov</td><td>PC4 PC5</td></tr>
<tr><td rowspan="3">Winter navigation in Sub-Polar waters</td><td>IA Super</td><td>PC6 PC7</td><td>Summer Navigation in Polar waters</td></tr>
<tr><td>IA</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>IB IC</td></tr>
<tr><td></td><td>FSICR Finnish-Swedish Ice Class Rules</td></tr>
</table>

TABLE IV -Summary of PRV Ice-Classes for year-round polar operations

The PRVs compilation list is extended to those PRV ice-classified between PC4-PC5 (Table II). When restricted to European PRVs, the list includes James Clark Ross from UK, and the Russian Akademik Tryoshnikov. Worldwide the list is extended with the new Sikuliaq (USA) and Nathaniel B. Palmer (USA), Xue Long (China), Agulhas II (South Africa), Araon (Korea), Aurora Australis (Australia) and Almirante Irizar (Argentina). This justifies that, in order to provide a response to societal demands it is necessary to significantly increase the international cooperation for the use of these expensive platforms.

The scenario is however quite different for the PRVs in categories B and C, those with ice-class that can only operate with an ice thickness of less than 70 cm. In this segment, European vessels are clearly featured, along with a comprehensive and well-endowed oceanographic instrumentation.

Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Research Equipment	Operating area		Major Refit	Supply Station
EUROPE	B	PC6 to PC7	**Aranda**		Finland	59,2	1989	Finnish Env. Insti.	1A Super	100/100		Artic		No
			Helmer Hanssen		Norway	64	1988	University of Tromso	Dnv 1A	100/100		Artic	1992	No
			Lance		Norway	61	1978	Norwegin Polar Ins.	Dnv 1A	100/100	Antarctic	Artic		No
			Maria S Merian		Germany	95	2005	IOW_Warne munde	PC 7	100/100		Artic		No
			Sanna		Greenland	32,3	2012	GINR	Ice 1A	100/100		Artic		No
			Italica		Italy	130	1981	DIAMAR	Ice 1A	/100	Antarctic			Yes
WORLD	B		**L. M. Gould**		USA	70,2	1997	USAP	ABS A1	50/100	Antarctic			Yes
EUROPE	C	ICE CLASSIFIED	**Arni Fridriksson**		Iceland	69,9	2000	MRI	1B	100/100		Artic		No
			Dana		Denmark	78	1981	DTU Aqua	1C	100/100		Artic	1992	No
			Ernest Shackleton		UK	80	1995	BAS	DNV; ICE05	25/100	Antarctic		2001	Yes
			G.O. Sars		Norway	77,5	2003	UiB	Ice 1C	100/100	Antarctic	Artic		No
			Hesperides		Spain	82,5	1991	Spain Navy/UTM	Ice 1C	100/100	Antarctic	Artic		Yes
			OGS-Explora		Italy	73	1973	OGS -Trieste	1c	100/100	Antarctic	Artic		No
WORLD	C		**Almi. Maximiniano**		Brasil	93,4	1974	Brasil Navy	Ice 1C	100/100	Antarctic			Yes
			Oscar Viel		Chile	90	1969	Chile Navy	Ice 1C	25/100	Antarctic			Yes
			Sagar Kanya		India	100	1983	NACAOR		100/100	Antarctic	Artic		
			Tangaroa		New Zealand	70	1991	NIWA	Ice 1C	100/100	Antarctic			

To conclude, we graphically show an overview of the European PRVs Polarstern and Oden operational areas, in summer and winter time at both Poles in **figures 7 and 8** respectively.

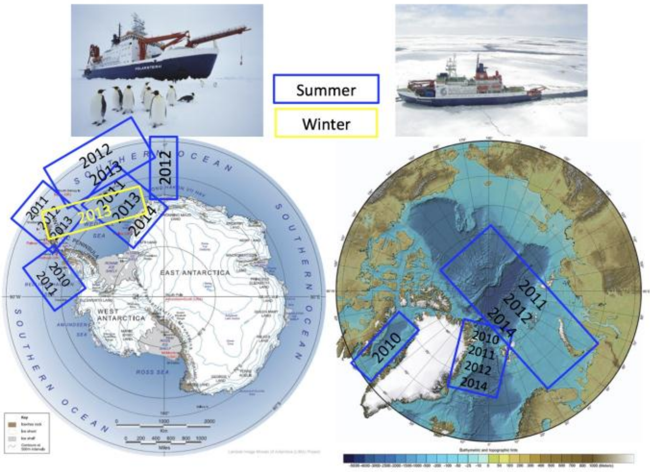


Figure 7 – PRV Polarstern operational areas from the last 5 years in the Arctic and Antarctic Polar regions

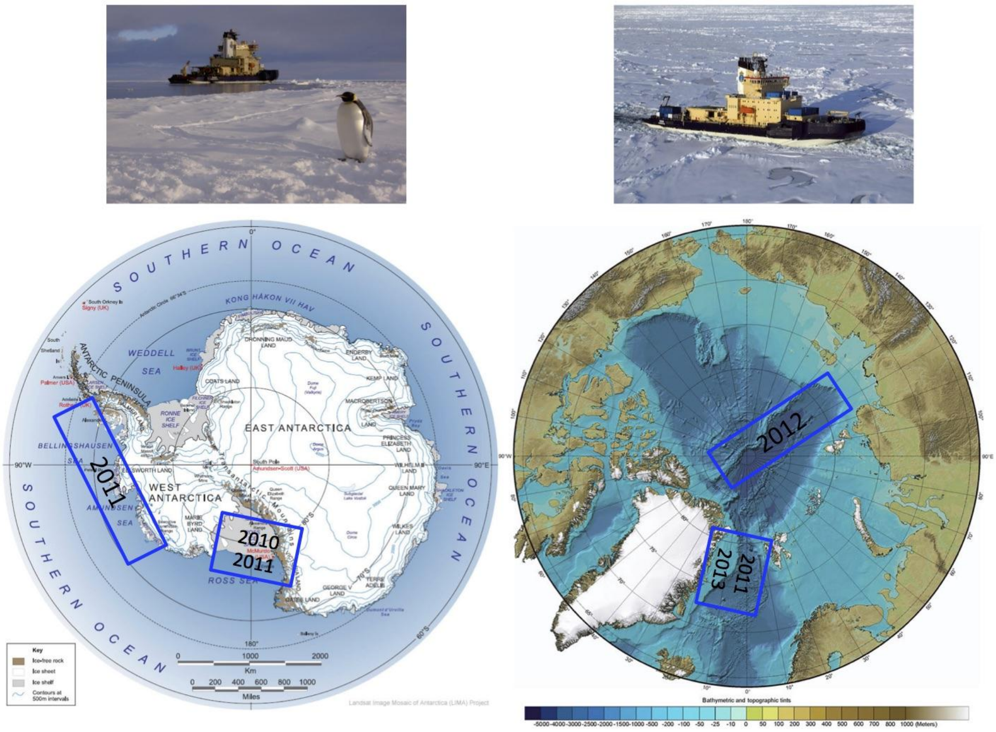


Figure 8 - PRV Oden operational areas from the last 5 years at Arctic and Antarctic Polar regions

This confirms that in summer time PC1-PC3 PRVs like Polarstern and Oden are capable to reach almost any place covered with multi-year ice. Oden has even been chartered (2006-2011) by the US National Science Foundation (NSF) to break an ice channel into the American McMurdo Research Station on the Ross Sea, Antarctica.

Concerning the world wide PRVs fleet, **Figure 9** displays year round operations in the Arctic and Antarctic Polar Regions.

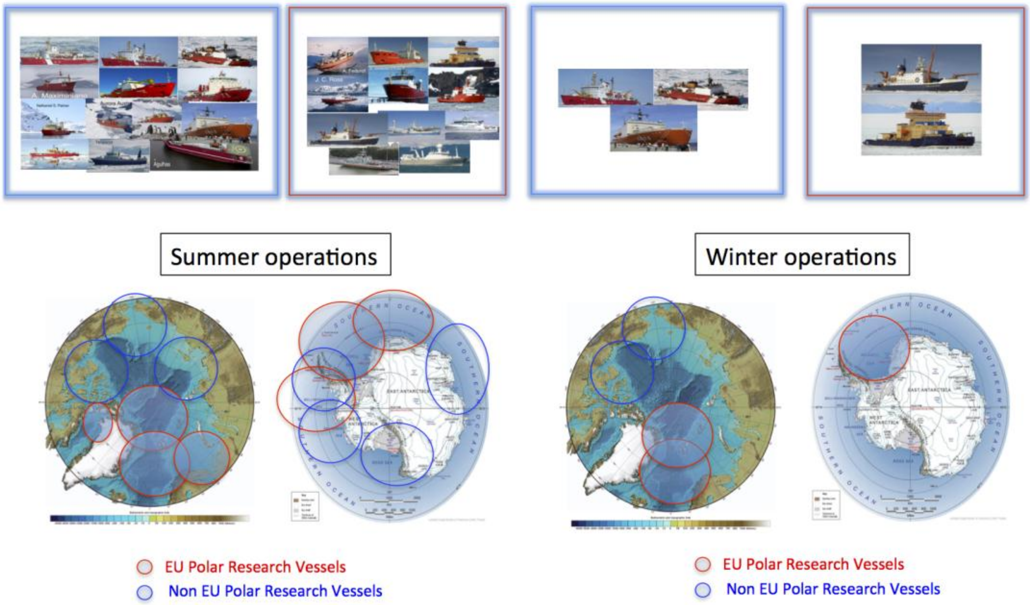


Figure 9 – Worldwide PRVs operational areas from the last 5 years in the Arctic and Antarctic Polar regions

Finally, we briefly list the Arctic and Antarctic regions where PRVs have conducted research in the past five years, which indicates a prioritization for some regions, and also the lack of appropriate infrastructure to reach other areas.

Areas:

Marine Antarctic Areas
Drake Passage & Antarctic Peninsula
Weddell Sea
Ross Sea
Amundsen Sea/Bellingshausen Sea
South Indian Ocean

Marine Arctic Areas
Bering + Chukchi Sea
Pacific Arctic Ocean
Atlantic Arctic Ocean
Barents Sea
Norwegian Sea + Fram Strait

6 Conclusions

Analysis of the European polar research fleet with ice classification able to work in thin to medium ice sheet shows a good coverage, mostly in autumn and summer time, at both poles in terms of research and cargo capacities These are vessels within the new polar categories B and C. Research has mostly been limited to marginal ice zone areas that are accessible with the current icebreaking capabilities. However, the situation is quite different in terms of year-round European capacity, having only two PRV´s (Polarstern and Oden); an analogue scenario applies for worldwide PRV´s, even though it is more extensive in the Arctic because of the greater ice breaking capability of the Polar Class icebreakers such as USCGC Healy as shown in **Figure 9**. So, little research can be done during the polar winter or in areas with thick ice cover year-round, especially in Antarctica. **Fig. 10** shows data estimates based on models of average sea-ice coverage and thickness as well as the annual sea ice primary production for the Antarctica margins. Areas difficult or impossible to access are shown in dark blue in the upper left figure (e.g.,> 70% coverage of ice and top ice thickness 1 m). However, many of these areas are critical for research, biological or physical oceanographic (**Fig. 11**), and are essential to provide an overview of the role of Antarctica in a variety of global processes.

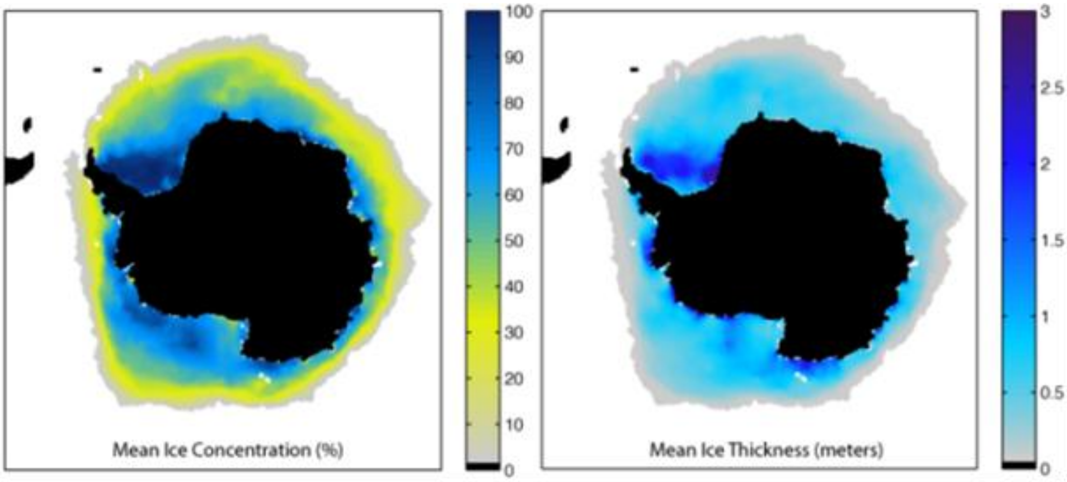


Figure 10 – Mean sea-ice concentration from satellite data (left) and Ice thickness (right), this is model-generated and validated matching to ASPECT ice and snow thickness observations (Worby et al. 2008).

Year-round access using a capable vessel from which to measure, observe, and describe and understand ecosystem structures and functions, physical and biogeochemical linkages, and the impact of physical drivers is needed to adequately understand ongoing changes in polar ecosystems (*US Polar Research Vessel Science Missions and Requirements – February 2012*)

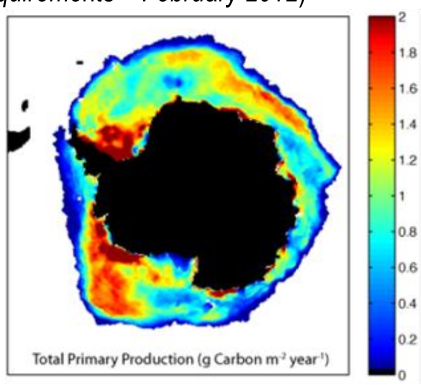


Figure 11 – Displays modelled annual sea ice primary production from sea ice algae (Saenz, 2011).

Ice breakers should allow access to ice sheet and ice shelf marginal areas during most months of the year. In addition, experimentation with polar marine organisms is carried out almost exclusively on board ships and in their natural habitats since they are difficult to keep alive in laboratories or during transport to shore facilities.

The difficulties to study remote areas in winter with the current European PRV capacity have been described in this report. There are some ongoing actions taken from Germany, Norway and UK, with new PRVS´s and/or the replacement of others. Even with these new projects, it still is difficult to get access to them for a wider polar research community, which can only be achieved through a strong European collaboration and some kind of transnational access, as the successful one launched in **EUROFLEETS** projects.

7 References

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- **Some web pages:**

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http://svs.gsfc.nasa.gov/
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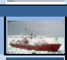
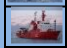
TABLE III - General characteristics of Polar Research Vessels, Heavy Icebreakers (updated from D3.1 using the new Polar Classes)

Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Research Equipment	Operating area	Major Refit	Supply Station
EUROPE	A	PC1 to PC3	**Polarstern**		Germany	118	1982	AWI	100 A5	100/100	Antarctic Arctic	2002	Yes
			Oden		Sweden	108	1988	SMA	DNV-Polar 20	60/100	Arctic		Yes
			Akademik Federov		Russia	141	1987	AARI	KM * ULA [2]A2	50/100	Antarctic Arctic		Yes
WORLDWIDE	A	PC1 to PC3	**Healy**		USA	128	1997	USACGC	PC2	60/100	Antarctic Arctic		Yes
			Polar Sea		USA	122	1978	USACGC	PC2	25/100	Antarctic Arctic		Yes
			Louis S. St-Laurent		Canada	120	1969	CCG	A4	60/100	Arctic	decom m. 2017	No
			Amundsen		Canada	98	1979	CCG	100 A3	50/100	Arctic	2003	No
			Shirase II		Japan	138	2008	Ministry of Defence & JARE	PC3	50/100	Antarctic Arctic		Yes
			Sikuliaq		USA	80	2014	U. of Alaska UNOLS	PC5	100/100	Arctic		
EUROPE	A	PC4 to PC5	**James Clark Ross**		UK	99	1990	BAS	Lloyds IAS	100/100	Antarctic Arctic		No
			Akade. Tryoshnikov		Russia	134	2011	AARI	PC4-PC5	50/100	Antarctic Arctic		Yes
WORLDWIDE	A	PC4 to PC5	**Xue Long**		China	167	1993	CAA	CCS B1	50/100	Antarctic Artic	2013	Yes
			N.I B. Palmer		USA	94	1992	USAP	A2	100/100	Antarctic		Yes
			Agulhas II,		Souht Africa	134	2012	SANAP	PC5	60/100	Antarctic		Yes
			Araon		South Korea	110	2009	KOPRI	PC5	100/100	Antarctic Arctic		Yes
			Aurora Australis		Australia	95	1989	P & O / ADD	A1	60/100	Antarctic	2013	Yes
			Almirante Irizar		Argentina	121	1978	Argentina Navy	PC5	60/100	Antarctic	underwa y	Yes
Region	Polar Code Category	IACS Class	Ship Name	Picture	Country	Length	Built year	Operator	Ice Class	Research Equipment	Operating area	Major Refit	Supply Station
EUROPE	B	PC6 to PC7	**Aranda**		Finland	59,2	1989	Finnish Env. Insti.	1A Super	100/100	Artic		No
			Helmer Hanssen		Norway	64	1988	University of Tromso	Dnv 1A	100/100	Artic	1992	No
			Lance		Norway	61	1978	Norwegin Polar Ins.	Dnv 1A	100/100	Antarctic Artic		No
			Maria S Merian		Germany	95	2005	IOW_Warne munde	PC 7	100/100	Artic		No
			Sanna		Greenland	32,3	2012	GINR	Ice 1A	100/100	Artic		No
			Italica		Italy	130	1981	DIAMAR	Ice 1A	/100	Antarctic		Yes
WORLDWIDE	B	PC6 to PC7	**L. M. Gould**		USA	70,2	1997	USAP	ABS A1	50/100	Antarctic		Yes
EUROPE	C	ICE CLASSIFIED	**Arni Fridriksson**		Iceland	69,9	2000	MRI	1B	100/100	Artic		No
			Dana		Denmark	78	1981	DTU Aqua	1C	100/100	Artic	1992	No
			Ernest Shackleton		UK	80	1995	BAS	DNV; ICE05	25/100	Antarctic	2001	Yes
			G.O. Sars		Norway	77,5	2003	UiB	Ice 1C	100/100	Antarctic Artic		No
			Hesperides		Spain	82,5	1991	Spain Navy/UTM	Ice 1C	100/100	Antarctic Artic		Yes
			OGS-Explora		Italy	73	1973	OGS -Trieste	1c	100/100	Antarctic Artic		No
WORLDWIDE	C	ICE CLASSIFIED	**Almi. Maximiniano**		Brasil	93,4	1974	Brasil Navy	Ice 1C	100/100	Antarctic		Yes
			Oscar Viel		Chile	90	1969	Chile Navy	Ice 1C	25/100	Antarctic		Yes
			Sagar Kanya		India	100	1983	NACAOR		100/100	Antarctic Artic		
			Tangaroa		New Zealand	70	1991	NIWA	Ice 1C	100/100	Antarctic		