South Georgia and South Sandwich Islands Marine Protected Area

RESEARCH AND MONITORING PLAN

South Georgia and South Sandwich Islands MPA

Research and Monitoring Plan

Introduction

The South Georgia and South Sandwich Islands MPA was designated in 2012, with additional provisions implemented in 2013, and further enhanced measures announced in 2018 following the first 5-year MPA review. The need for a Research and Monitoring Plan (RMP) was originally identified when the MPA was first designated (e.g. Trathan et al. 2014), and during the 2018 MPA review process this need was highlighted as a priority.

The South Georgia and South Sandwich Islands region has been a focus for scientific research since the earliest Discovery Investigations in 1925, and the marine ecosystem is relatively well-studied in comparison to some other parts of the Southern Ocean. Long-term research and monitoring of demersal fish stocks, the krill-based ecosystem, marine predators, oceanography, and benthic habitats provide the foundation for management of sustainable fisheries in the region, and informed the development of MPA management provisions and spatial zonation.

Regular scientific research cruises within the SGSSI MPA have included annual surveys to estimate the abundance and biomass of krill, as well as benthic, oceanographic and biogeochemical research undertaken by the UK and other national operators. Data on fisheries, by-catch, and fisheries-ecosystem interactions are collected from commercial fishing vessels, and a survey of demersal fish stocks is undertaken every two years. Stock assessments for the three exploited finfish species have further developed and matured since the designation of the MPA. Biological data on target and non-target species, collected annually on all fishing vessels, allows sustainable management of exploited fish species as well as monitoring of effects of the fishery on the ecosystem. Monitoring of predator populations and demography, breeding success and diet, tracking studies, and surveys of marine debris, are routinely undertaken at several sites around South Georgia, including Bird Island, King Edward Point (KEP) and Maiviken, and by using fishing vessels as research platforms. Fisheries research undertaken at KEP informs the sustainable management of commercial fishing activities around the island.

However, understanding remains limited in some key areas, such as the causes and ecological responses to inter- and intra-annual environmental variability; climate change response, including ecological responses to increasing temperatures, local freshening from glacial melt and ocean acidification; regional biomass and movement of krill; the rates of cetacean recovery and the consequences for other ecosystem components; the spatial habitat utilisation of some land-based marine predators, especially during winter; shelf slope and abyssal benthic communities and habitats; and the reproductive characteristics and migration patterns of Antarctic toothfish across the SGSSI and wider Scotia-Weddell Sea regions. There is also a marked difference in research effort and in understanding between South Georgia and the much less frequently visited South Sandwich Islands. Few scientific research cruises have visited the waters around the South Sandwich Islands; landings on the islands are rare, and there are currently only limited tracking studies from SSI predator colonies.

The SGSSI MPA RMP is designed to be a framework through which any interested scientists and stakeholders are encouraged to collect, access and analyse data, including relevant baseline data

and indicators. Data collected and analysed under this plan can be used as a basis to evaluate the effectiveness of the MPA in relation to its conservation and management objectives, to consider whether the boundaries of the MPA continue to encompass the features associated with specific MPA objectives, and to further understanding of the ecosystems and resources that the MPA protects. It is also important to continue evaluating threats to biodiversity, including from climate change, fishing and invasive species, as well as the impacts of tourism and scientific activities.

The RMP aims to guide scientific activities that will:

- contribute to an increased understanding of the SGSSI marine ecosystem
- assess the nature and extent of change
- assess specific threats to biodiversity
- provide information to evaluate the effectiveness of the MPA
- inform the development of enhanced and responsive management as required

These activities include ongoing monitoring, as well as specific research to address questions related to the MPA objectives and to improve knowledge and understanding of the SGSSI marine ecosystem.

Organisation of the plan

The RMP is organised on the basis of research and monitoring themes aligned with the objectives of the MPA and its specific management zones (see Annex 1). Under each theme, the RMP identifies current and required monitoring activities that will provide information on the status of key features protected by the MPA, particularly in terms of monitoring environmental change and the impact of human activities. The RMP also identifies research that could provide additional information and understanding of key features. Specific management zones or geographic locations are identified for each activity, and an indication of the status of current activities, or level of priority for future activities, is given where relevant. Specific research projects currently underway or planned are also highlighted.

The list of research and monitoring activities outlined in the plan is not intended to be exhaustive. Further research is likely to be developed (and may be added to the plan as appropriate), or relevant data may become available from other sources. Recognising the constraints of funding and capacity for research and monitoring activities, there is no expectation that all of the activities set out in the plan will be completed before the next MPA review. Rather, the RMP aims to provide a framework under which relevant research can be identified and planned according to available resources, acknowledging that not all questions will be addressed. Some activities have been assigned a ‘high priority’, if corresponding to an urgent data gap or immediate threat. However, other activities should not be viewed as ‘low priority’ in comparison, and are not listed in any particular order of priority.

Research and monitoring themes

The following tables identify monitoring activities, research needs and additional projects of interest under 10 themes:

1 – Physical oceanography and biogeochemistry
2 – Pelagic ecosystems – lower trophic levels
3 – Predators – ecology and demography
4 – Benthic ecosystems – species and habitats
5 – Harvested species – fish
6 – Harvested species – krill
7 – Impact of fisheries – bycatch and vulnerable benthic habitats
8 – Impact of fisheries – interaction with higher predators
9 – Climate change and variability
10 – Other human impacts

RESEARCH THEME 1	Physical oceanography and biogeochemistry		
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. ➢ Increase the resilience of the marine environment to the effects of climate change		
MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
Polar Ocean Ecosystem Times Series Western Core Box (POETS-WCB) Survey - vertical CTD profiles and continuous underway data	WCB survey area (NW shelf of South Georgia)	Annual surveys since 1996.	High
Scotia Sea Open-Ocean Biological Laboratories (SCOOBIES) – deep water moorings; long-term observations of biogeochemical cycles, carbon flux and sequestration	SW and NW of South Georgia	2006 - present	
Monitor physical and environmental changes to pelagic habitats, including those related to ocean circulation, sea ice, variations and trends in primary production (seasonal climatologies)	All MPA regions.		
RESEARCH NEEDS	**Zone/location**		**Priority**
High-resolution, regional ocean modelling, e.g. NEMO, to examine detailed oceanographic flows and water mass properties.	South Sandwich Islands.		High
Understanding of connectivity with upstream and downstream regions.	Wider Scotia Sea region; possible connections with sub-Antarctic islands to the east.		
Development of sustained monitoring strategies to improve oceanographic model performance	Wider Scotia Sea region.		
RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**	
Developing high-resolution hydrodynamic models of the shelf regions around South Georgia and the South Orkney Islands	South Georgia shelf	Oceanographic Models for the Scotia Sea (2015-2017)	
Determine mechanisms of carbon drawdown in the SGSSI region.	All MPA regions.	COMICS (Controls over Ocean Mesopelagic Carbon Storage) (2017-2021)	
Understanding of Southern Ocean impact on climate change via uptake and storage of heat and carbon.	Northern Weddell/Scotia Sea.	ORCHESTRA (Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports) (2016-2021)	

RESEARCH THEME 2	Pelagic ecosystems – lower trophic levels		
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. ➢ Increase the resilience of the marine environment to the effects of climate change		
MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
(POETS-WCB) Survey – acoustic survey with associated net (krill length frequency) and oceanographic sampling. Provides a time series of inter-annual mesoscale distribution and abundance of macro-zooplankton and micro-nekton, and an understanding of their physical environment.	WCB survey area (NW shelf of South Georgia)	Annual surveys since 1996.	High
Scotia Sea Open-Ocean Biological Laboratories (SCOOBIES) – deep water moorings; net sampling of zooplankton at mooring stations.	SW and NW of South Georgia	2006 - present	High
CCAMLR International Synoptic Krill Survey in Area 48 (2019) – surveys undertaken by *RRS Discovery, RV Kronprins Haakon* and *FV Cabo de Hornos.*	South Georgia and South Sandwich Islands transects.	Surveys undertaken in Jan-Feb 2019.	High
Continuous Plankton Recorder	South Georgia, and SG to Falklands	2005-2015	
RESEARCH NEEDS	**Zone/location**		**Priority**
(*see also* ***Research Theme 6****: Fisheries – krill, and* ***Research Theme 8****: Impact of fisheries – interaction with higher predators*)			
Estimates of regional krill biomass and flux, including models of population recruitment and mortality.	South Georgia and South Sandwich Islands		High
Aggregation, retention and dispersal of krill in relation to fished areas and predator foraging areas	South Georgia and South Sandwich Islands		High
Standardised methodology for comparison of long-term krill density observations in the Southern Ocean.	Wider Scotia Sea region.		
Modelling of pelagic foodwebs and zooplankton community structure, to understand differences between regions and possible responses to environmental change.	All MPA regions.		
Habitat modelling to determine the environmental drivers of variability and long-term change in the abundance and distribution of krill at the regional scale	All MPA regions.		
Projections of future pelagic ecosystem states, including change in krill availability and growth potential.	Wider Scotia Sea region.		
Understanding of how the interaction of large-scale physical and biological processes determines the response of ocean ecosystems to change.	All MPA regions.		
Improved understanding of life cycles and distribution of myctophids	All MPA regions.		
Extent of resource overlap between coexisting mesopelagic fish species in the same region.	All MPA regions.		
RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**	
Use of hydrographic models to investigate krill flux	Wider Scotia Sea region.	MMAK (Modelling Movement of Antarctic Krill) (2017-2018)	
Development of methods to allow rapid (near real-time), automated estimation of krill density from acoustic data collected by fishing vessels.	Krill fishery areas	Rapid-Krill (2018-2021)	
Quantifying abundance and distribution of krill and assessing predator distribution during winter in the fishery area.	Krill fishery areas	Resolving ecosystem effects of the South Georgia winter krill fishery - DPLUS149 (2021-2024)	

RESEARCH THEME 3	Higher predators – ecology and demography
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. • To conserve and protect mammalian and avian krill dependent predators, such as penguins and fur seals during the key part of the breeding season *(Seasonal closure of the krill fishery)* • To conserve and protect the inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions *(South Georgia & Clerke Rocks NTZs)* • To conserve and protect a key foraging area for black-browed albatross, Antarctic fur seals and baleen whales *(Shag Rocks NTZ)* • To conserve and protect the inshore foraging grounds of marine predators *(South Sandwich Islands NTZs)* • To conserve and protect the pelagic ecosystem and dependent predators in the area around each of the South Sandwich Islands, particularly the highly abundant chinstrap and Adelie penguins *(South Sandwich Islands Pelagic Closed Area)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
(*see also **Research Theme 8**: Fisheries – interaction with higher predators*)			
Wandering, black-browed and grey-headed albatross – demography; breeding success; rates of population change	Bird Island (selected colonies)	Annual (1958 -)	High
Wandering albatross – counts of active nests and chicks	Albatross & Prion Islands	Annual (1999 -)	
Black-browed and grey-headed albatross – diet; chick weights	Bird Island	Annual (1989 -)	
Light-mantled sooty albatross – rates of population change; breeding success	Bird Island (study area)	Annual (2000 -)	
Southern and northern giant petrel – rates of population change; breeding success	Bird Island (study areas) Albatross & Prion Islands Discovery, Greene & Maiviken	Annual (2000 -) . Annual (2005 -) . Annual (2014 -)	
Macaroni and gentoo penguins – arrival times/weights; colony counts; fledging counts/weights	Bird Island	Annual (1982 -)	
Macaroni penguins - diet	Bird Island	Annual (1989 -)	
Macaroni penguins – weight on entrance/exit to colony	Bird Island	Annual (2008 -)	
Gentoo penguins – colony counts; fledging counts & weights	Maiviken	Annual (2009 -)	
Gentoo, macaroni and king penguins – phenology monitored using remote cameras	Various locations at Bird Island, South Georgia, SSI		
Fur seals – counts of males/females	Bird Island (Special Study Beach) Maiviken	Annual (2001 -) . Annual (2009 -)	
Fur seals – pups born/survival rates; pup weight; female foraging attendance; diet analysis (scats)	Bird Island (Special Study Beach)	Annual (1984 -)	
Fur seals – diet analysis (scats); pup weight	Maiviken, Thatcher Peninsula	Annual (2008 -)	

RESEARCH NEEDS	**Zone/location**	**Priority**
(*see also **Research Theme 8**: Fisheries – interaction with higher predators*)		
Foraging distances and habitat use of species within and outside the MPA, factors influencing key foraging areas, and	All MPA regions	High

level of protection offered by current closed areas and seasonal fisheries closure.		
Winter tracking and diet studies (SG gentoo and macaroni, SSI chinstrap); overlap with fisheries	South Georgia, South Sandwich Islands	High
Population monitoring and breeding distribution (all species) in locations other than at Bird Island	Mainland (esp. SE) South Georgia, South Sandwich Islands	High
Effects of habitat / foraging preferences of higher predators on resource use and community structure.	All MPA regions	
Distribution at sea (all species), tracked from locations other than Bird Island	Mainland South Georgia (esp. SE), Cooper Island, Annenkov Island; SSI	
Effects of winter sea ice on predator distribution at SSI	South Sandwich Islands	
Breeding season foraging distribution of white-chinned petrels	South Georgia (and wider region to the north, e.g. Patagonian Shelf)	High
Recovery and metapopulation dynamics of white-chinned petrels and other burrowing species following eradication of rodents and reindeer.	Mainland South Georgia	
Development of methods to survey/better understand distribution and abundance of inconspicuous species, e.g. diving petrels, prions, storm petrels	Mainland South Georgia	
Penguin phenology and survivorship (e.g. using remote cameras); consideration of multiple effects across different life-stages on survival rates	Any accessible colonies	
Penguin diet analysis (e.g. using faecal DNA)	Any accessible colonies	
Population estimate for Antarctic fur seals	South Georgia	High
Monitoring of fur seal numbers other than at Bird Island	South Georgia	
High resolution winter tracking data (all seal species – Weddell, elephant and leopard seals)	All MPA regions	
Dispersal of juvenile Antarctic fur seals	Wider Scotia Sea region	
Spatial overlap and potential competition between Antarctic fur seals and macaroni penguins	South Georgia	
Population abundance estimates and distribution for cetacean species within the MPA	All MPA regions and wider region.	High
Tracking data for humpback and southern right whales	All MPA regions and wider region.	High
Timing of cetacean migrations	All MPA regions and wider region.	
Recovery of southern right whales and humpback whales; krill consumption estimates for all cetacean species; competition as major krill consumers with other krill-eating predators, and effects on food webs.	All MPA regions and wider region.	

RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**
White-chinned petrel tracking	Tracking from Bird Island	White-chinned Petrel Tracking (2015)
Grey-headed albatross juvenile tracking	Tracking from Bird Island	Grey-headed albatross juvenile tracking (2018-20)
Comparison between colonies of population trends and breeding success of wandering albatross	Bay of Isles and Bird Island	C. Rackete MSc
Seabird sentinels: mapping bycatch risk of wandering albatrosses using bird-borne radar detection	Tracking from Bird Island	Bycatch risk of wandering albatross using radar detection (2019-21)
Gentoo penguin tracking during winter	Winter roosts at Cumberland Bay and Barff Peninsula	Gentoo Penguin Tracking
Chinstrap penguin tracking during summer	South Sandwich Islands	University of Oxford, 2019/20

Identification of marine Important Bird and Biodiversity Areas and Key Biodiversity Areas	All MPA regions and wider region	BirdLife International marine IBA e-Atlas
South Georgia Right Whale project and Humpback Whale tracking	All MPA regions	South Georgia Right Whale Project (2018-2020)
Recovering cetacean assessment	All MPA regions	Blue Belt cruise DY99 (2019)
Identification of Important Marine Mammal Areas and Key Biodiversity Areas	All MPA regions and wider region	IUCN Marine Mammal Protected Areas Task Force (2016-2021)
UAV airborne surveys to establish multi-species baseline datasets for marine predator population counts.	South Georgia	Initiating monitoring support for the SGSSI MPA Research and Monitoring Plan - DPLUS109 (2020-2023)
Using satellite imagery to count wandering albatrosses on South Georgia	South Georgia	Monitoring albatrosses using very high resolution satellites and citizen science - DPLUS132 (2021-2022)
Tracking grey-headed albatrosses and white-chinned petrels to characterize overlap of birds with fishing fleets, identify high-risk areas, and address impacts of bycatch	South Georgia	Spatial segregation and bycatch risk of seabirds at South Georgia - DPLUS120 (2021-2023)

RESEARCH THEME 4	Benthic ecosystems – species and habitats
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. ➢ Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent marine ecosystems ➢ protect the benthic marine organisms from the destructive effects of bottom trawling • To conserve and protect vulnerable and sensitive marine fauna, and provide refugia for adult and juvenile toothfish *(Benthic Closed Areas)* • To conserve and protect sensitive and unknown benthic fauna of seamounts and calderas *(Benthic Closed Areas)* • To conserve and protect spawning grounds of fish species including mackerel icefish *(South Georgia & Clerke Rocks NTZs)* • To conserve and protect the serpulid reef *(Clerke Rocks NTZ)* • To conserve and protect the principal recruitment area for juvenile Patagonian toothfish and spawning grounds of mackerel icefish *(Shag Rocks NTZ)* • To conserve and protect the spawning ground of fish species and all benthic habitats shallower than 700 m and deeper than 2250 m *(South Sandwich Islands NTZs)* • To conserve and protect a unique biogeographical feature which could potentially contain rare or unique habitats and biodiversity including hydrothermal communities *(South Sandwich Trench NTZ)* • To conserve and protect a unique biogeographical feature which include seamounts, deep trenches and a large area of the South Sandwich Fracture Zone and Herdman Bank - regions of high hydrothermal and tectonic activity *(NTZ South of 60°S)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
(*see also **Research Theme 7**: Impact of fisheries – bycatch and vulnerable benthic habitats*)			

RESEARCH NEEDS	**Zone/location**	**Priority**
(*see also **Research Theme 7**: Impact of fisheries – bycatch and vulnerable benthic habitats*)		
Identification of existing samples to better taxonomic resolution.	All MPA regions (little knowledge of biodiversity in slope ecosystems and very little for the deep sea). South Sandwich Islands; SSI seamounts.	High
Document change and recovery of disturbed benthic areas paired with open sites	Benthic Closed Areas and comparative locations	High
Improved understanding of how environmental variables correspond to the spatial scale of benthic sampling	All MPA regions	
Assess spatial and temporal patterns of functional diversity	All MPA regions	
Identify indicator species with differing vulnerability to threats and environmental variables	All MPA regions	
Identify the presence of 'biodiversity hotspots' and correlate these with physical landscape clusters	All MPA regions	
Improved understanding of diversity and habitats in the hadal zone	South Sandwich Trench	
Investigate distribution & diversity of chemosynthetic ecosystems	East Scotia Ridge	
Further investigate methane seeps, including quantification & effects of methane	Methane seeps on South Georgia shelf	
Investigate the extent of benthic-pelagic coupling and identify priority regions	All MPA regions	

Investigate the occurrence of Ecologically and Biologically Significant Areas (EBSAs)	All MPA regions	
RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**
Benthic surveys using 'Blue Belt' deep water camera system	South Georgia BCAs South Sandwich Islands	2018 trial survey 2019 benthic survey - DY99
BAS Shallow Underwater Camera System surveys	South Georgia shelf	JR620b (2012) JR287 (2013) JR304 (2014) JR16003 (2016)
Polarstern (Alfred Wegener Institute) survey – hydrothermal vents and cold seeps	South Georgia (southern shelf) and South Sandwich Islands	PS119 (2016)
Improving understanding of ecological and geological processes in the South Sandwich Trench.	South Sandwich Trench	HOT: Hadal zones of our Overseas Territories - DPLUS093 (2019-2021)
Sub-Antarctic deep-sea biodiversity and genetic connectivity	South Georgia, South Sandwich Islands and wider Southern Ocean	Integrating genetic approaches into sub-Antarctic deep sea research and management - DPLUS089 (2019-2022)

RESEARCH THEME 5	Harvested species – fish
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. ➢ Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems. • To conserve and protect vulnerable and sensitive marine fauna, and provide refugia for adult and juvenile toothfish *(Benthic Closed Areas)* • To conserve and protect spawning grounds of fish species including mackerel icefish *(South Georgia & Clerke Rocks NTZs)* • To conserve and protect the principal recruitment area for juvenile Patagonian toothfish and spawning grounds of mackerel icefish *(Shag Rocks NTZ)* • To conserve and protect the spawning ground of fish species and all benthic habitats shallower than 700 m and deeper than 2250 m *(South Sandwich Islands NTZs)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
Catch and effort data reported by toothfish and icefish fishing vessels	All fished areas	All fishing operations	High
Observers on toothfish and icefish fishing vessels collect data for stock assessments (fish length, weight, tagging) and report on vessel operations. Observers also report on bycatch, incidental mortality and other interactions e.g. depredation (see Research Themes 10 and 11) (CCAMLR Scheme of International Scientific Observation and additional requirements under GSGSSI licensing)	All fished areas	All fishing operations	High
South Georgia Groundfish Survey – abundance and length composition of juvenile toothfish to provide an index of recruitment; estimates of standing stock of mackerel icefish; density of other demersal fish species and non-target species.	South Georgia and Shag Rocks shelves	Biennial (approx.) since early 1980s	High
Icefish diet from samples from Groundfish survey (links to krill monitoring)	South Georgia and Shag Rocks shelves		
Sampling of icefish adult population and larval distribution and abundance.	Bays around King Edward Point		
(Additional monitoring activities undertaken in support of toothfish and icefish fishery management as part of King Edward Point science programme)			

RESEARCH NEEDS	**Zone/location**	**Priority**
Effects of fishing, environmental variability and climate change on marine living resources, in comparison with other, fished areas.	All MPA regions	
Toothfish tagging and movement analysis, including estimates of post-tagging mortality	Fished areas	High
Connectivity and reproduction of *D. mawsoni* populations in the South Atlantic sector	Wider South Atlantic sector / Weddell Sea region	High
Specific role of the South Sandwich Islands in *D. mawsoni* lifecycle	South Sandwich Islands	
Distribution of spawning and nursery grounds for *D. eleginoides*	South Georgia shelf	
High resolution oceanographic modelling – toothfish retention and transport	Wider South Atlantic sector / Weddell Sea region	
(Additional research activities undertaken in support of toothfish fishery management as part of King Edward Point science programme)		

RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**

Development of a *D. mawsoni* population hypothesis for Area 48	Area 48	CCAMLR Workshop (WS-DmPH, February 2018)

RESEARCH THEME 6	Harvested species – krill
MPA Objective(s)	➢ Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems. • To conserve and protect mammalian and avian krill dependent predators, such as penguins and fur seals during the key part of the breeding season *(Seasonal closure of the krill fishery)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
(*see also **Research Theme 2**: Pelagic ecosystems – lower tropic levels*)			
Krill distribution and abundance time series (BAS POETS-WCB)	South Georgia	Annual (1996-)	High
Catch and effort data reported by krill fishing vessels	All fished areas	All fishing operations	High
Data collected by observers on krill fishing vessels (CCAMLR Scheme of International Scientific Observation and additional requirements under GSGSSI licensing)	All fished areas	All fishing operations	High
Potential use of krill fishing vessels for in-season (winter) biomass estimation using acoustic transects	Fished areas		High
(Additional monitoring activities undertaken in support of krill fishery management as part of King Edward Point science programme)			

RESEARCH NEEDS	**Zone/location**	**Priority**
(*see also **Research Theme 2**: Pelagic ecosystems – lower tropic levels*)		
Development of the CCAMLR Risk Assessment framework for krill fishery management within the South Atlantic sector	CCAMLR Area 48	High
Effects of fishing, environmental variability and climate change on krill abundance and distribution, in comparison with other, fished areas.	All MPA regions	
Relationship between krill availability to the fishery and their relative abundance in predator diets	All MPA regions	
(Additional research activities undertaken in support of krill fishery management as part of King Edward Point science programme)		

RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**
Predator monitoring (*see also **Research Theme 2**: Higher predators – ecology and demography* and ***Research Theme 8**: Impact of fisheries – interaction with higher predators)*	South Georgia	Bird Island (1989-2019) Maiviken (2008-2019)
Quantifying abundance and distribution of krill and assessing predator distribution during winter in the fishery area.	Krill fishery areas	Resolving ecosystem effects of the South Georgia winter krill fishery - DPLUS149 (2021-2024)
Estimates of krill distribution and abundance	South Sandwich Islands	Blue Belt cruise DY99 (2019)
Development of methods to allow rapid (near real-time), automated estimation of krill density from acoustic data collected by fishing vessels.	Fished areas	Rapid-Krill (2018-2021)
Refinement of Risk Assessment for the krill fishery	CCAMLR Area 48	Developing the risk assessment framework for the Antarctic krill fishery - DPLUS072 (2018-2020)

RESEARCH THEME 7	Impact of fisheries – bycatch and vulnerable benthic habitats
MPA Objective(s)	➢ Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems. ➢ Protect benthic fauna from destructive effects of bottom trawling • To conserve and protect vulnerable and sensitive marine fauna, and provide refugia for adult and juvenile toothfish *(Benthic Closed Areas)* • To conserve and protect spawning grounds of fish species including mackerel icefish *(South Georgia & Clerke Rocks NTZs)* • To conserve and protect the serpulid reef *(Clerke Rocks NTZ*) • To conserve and protect the principal recruitment area for juvenile Patagonian toothfish and spawning grounds of mackerel icefish *(Shag Rocks NTZ)* • To conserve and protect the spawning ground of fish species and all benthic habitats shallower than 700 m and deeper than 2250 m *(South Sandwich Islands NTZs)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
Data collected by observers on all toothfish fishing vessels (CCAMLR Scheme of International Scientific Observation and additional requirements under GSGSSI licensing)	All fished areas	All fishing operations	High
South Georgia Groundfish Survey – estimates of standing stock and age structure of mackerel icefish (and other demersal fish species)	South Georgia and Shag Rocks shelves	Biennial (approx.) since early 1980s	High

RESEARCH NEEDS	**Zone/location**	**Priority**
Effectiveness of Benthic Closed Areas for protection and recovery of benthic species and habitats	Benthic Closed Areas	High
Overlap of high diversity groundfish hauls with other biodiversity hotspots	South Georgia shelf/slope	
Vulnerability of *Raja georgiana* and *Bathyraja meridionalis* to the longline fishery	South Georgia	
Grenadier status and assessment – species ID, age structure over time, population (size/sex) structure, depth distribution patterns	South Georgia	
Evaluation of juvenile fish bycatch in the krill fishery	All fished areas	
Biological and life history parameters for benthic bycatch species; improved identification of benthic bycatch	All fished areas	
Improve spatial understanding of past fishery impact/footprint, using e.g. movement sensors to determine longline swept area.	Historic fished areas	
Understanding of benthic footprint of longline fisheries	All fished areas	
Representativeness of benthic assemblages in longline bycatch	All fished areas	

RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**
Blue Belt deep water camera deployed on Pharos (2018) and Discovery (2019) – biodiversity and impacts of fishing	Benthic Closed Areas; South Sandwich Islands	DY99

RESEARCH THEME 8	Impact of fisheries – interaction with higher predators
MPA Objective(s)	➢ Conserve marine biodiversity, habitats and critical ecosystem function. ➢ Ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems. • To conserve and protect mammalian and avian krill dependent predators, such as penguins and fur seals during the key part of the breeding season *(Seasonal closure of the krill fishery)* • To conserve and protect the inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions *(South Georgia & Clerke Rocks NTZs)* • To conserve and protect a key foraging area for black-browed albatross, Antarctic fur seals and baleen whales *(Shag Rocks NTZ)* • To conserve and protect the inshore foraging grounds of marine predators *(South Sandwich Islands NTZs)* • To conserve and protect the pelagic ecosystem and dependent predators in the area around each of the South Sandwich Islands, particularly the highly abundant chinstrap and Adelie penguins *(South Sandwich Islands Pelagic Closed Area)*

MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
(*see also **Research Theme 2**: Higher predators – ecology and demography*)			
Data collected by observers on all fishing vessels – bycatch and incidental mortality; seabird and marine mammal observations (CCAMLR Scheme of International Scientific Observation and additional requirements under GSGSSI licensing)	All fished areas	All fishing operations	High
Monitoring of albatross nests for hooks and debris associated with fishing	Bird Island	1992 onwards	High
Bird strikes reported from fishing vessels	All MPA regions	2017 onwards	

RESEARCH NEEDS	**Zone/location**	**Priority**
(*see also **Research Theme 2**: Higher predators – ecology and demography*)		
Behaviour of seabirds interacting with the toothfish fishery, and effectiveness of mitigation measures.	All fished areas in SGSSI	High
Effects of IUU fishing in the high seas and within other national jurisdictions on species breeding at SGSSI; extent and causes of seabird mortality outside the MPA.	Wider South Atlantic region beyond the MPA, and including relevant RFMOs	High
White-chinned petrel population estimates and monitoring; tracking studies and spatial overlap with fishing activities.	Bird Island / Mainland South Georgia, and wider region to the north, e.g. Patagonian Shelf	High
Spatial and functional overlap (and potential effects of competition) between krill-dependent predators and the krill fishery;	Krill fishery areas	High
Development of the CCAMLR Risk Assessment framework for krill fishery management within the South Atlantic sector	CCAMLR Area 48	High
Tracking and diet studies of krill-dependent predators during winter.	SG & Clerke Rocks NTZ; Shag Rocks NTZ; SSI NTZ	High
Carry-over effects of winter fishing mortality on the availability of krill in the following summer, and effects on dependent species.	All MPA regions	High
Predator response to krill availability (e.g. density, swarm structure)	All MPA regions; South Georgia shelf	

Spatial distribution of krill consumption	All MPA regions; South Georgia shelf	
Effects of depredation on population ecology of killer whales	All MPA regions	
Adaptive behaviour of depredating killer whales and consequences for fishery management.	All MPA regions	
Identify the demographic traits (e.g. adult/juvenile survival, breeding frequency & success) that are most sensitive to environmental variation, and determine how life-history strategies affect responses to change.		
Understand how the recovery of previously exploited marine mammals has affected food webs; competition of major krill consumers with other krill-eating predators and with the krill fishery.		

RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**
White-chinned petrel tracking (from Bird Island)	Bird Island; all MPA regions	White-chinned Petrel Tracking (2015)
Gentoo penguin tracking during winter (from winter roosts at Cumberland Bay and Barff Peninsula)	South Georgia	Gentoo Penguin Tracking
Chinstrap penguin tracking during summer	South Sandwich Islands	University of Oxford, 2019/20
Using bird-borne radar to quantify interactions of tracked wandering albatrosses with legal and illegal fishing vessels.	All MPA regions and wider South Atlantic	Seabird sentinels: mapping potential bycatch risk using bird-borne radar - DPLUS092 (2019-2021)
Tracking grey-headed albatrosses and white-chinned petrels to characterize overlap of birds with fishing fleets, identify high-risk areas, and address impacts of bycatch	South Georgia; toothfish fishery areas	Spatial segregation and bycatch risk of seabirds at South Georgia - DPLUS120 (2021-2023)
Quantifying abundance and distribution of krill and assessing predator distribution during winter in the fishery area.	Krill fishery areas	Resolving ecosystem effects of the South Georgia winter krill fishery - DPLUS149 (2021-2024)
Development of bird-strike reporting systems for vessels operating in the SGSSI Maritime Zone.	All MPA regions	What goes thump at night: managing bird strike in South Georgia – DPLUS143 (2021-2024)

RESEARCH THEME 9	Climate change
MPA Objective(s)	➢ Increase the resilience of the marine environment to the effects of climate change

MONITORING ACTIVITIES	Zone/location	Status/frequency	Priority
Predator population and breeding success (see also ***Research Theme 2****: Higher predators – ecology and demography*)	South Georgia (further locations needed)	(see Theme 2)	High
Krill distribution and abundance time series (BAS POETS-WCB)	South Georgia	Annual (1996-)	High
SCOOBIES – deep water moorings; long-term observations of biogeochemical cycles, carbon flux and sequestration	SW and NW of South Georgia	2006 - present	High
Temperature loggers on longlines	Toothfish fishing areas		

RESEARCH NEEDS	Zone/location	Priority
Potential effects of climate change on primary production and zooplankton growth potential	Scotia Sea region	High
Potential effects of climate change and ocean acidification on the habitat, distribution and abundance of krill	Scotia Sea region	High
Biogeochemical importance of krill in carbon sequestration	Scotia Sea region	High
Changes to oceanographic currents as a result of warming	Scotia Sea region	High
Predator responses (e.g. breeding success) to changing environmental conditions	South Georgia and South Sandwich Islands	High
Implications of climate change effects on fish larval dispersal	Scotia Sea region	
Projections of future ecosystem states	Southern Ocean	
Methods for evaluating climate change impacts in parallel with improved regional climate projections	Southern Ocean/global	
Impacts of glacial retreat and sea level rise, e.g. increased nutrient input	South Georgia	

RELEVANT PROJECTS/ACTIVITIES	Zone/location	Project
Marine Ecosystem Assessment of the Southern Ocean (MEASO)	Southern Ocean	MEASO
Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) - climate interactions, implications for ecosystem dynamics, impacts on biogeochemical cycles, and development of sustainable management procedures.	Southern Ocean	ICED
Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate	Southern Ocean	IPCC SROCC

RESEARCH THEME 10	Other human impacts		
MPA Objective(s)	➢ Manage other human activities including shipping, tourism and scientific research, to minimize impacts on the marine environment ➢ Prevent the introduction of non-native marine species		
MONITORING ACTIVITIES	**Zone/location**	**Status/frequency**	**Priority**
Man-made debris found in bird nests/colonies	Bird Island	1992 -	
Man-made debris found on beaches	Bird Island	1992 -	
Entanglements	Bird Island Grytviken	1992 - 2008 -	
Bird strikes reported from stations, fishing vessels, and tourism post-visit reports	All MPA regions		
RESEARCH NEEDS	**Zone/location**		**Priority**
Monitoring of marine plastics using standardised or comparable sampling and extraction techniques; potential involvement of commercial fishing vessels in data collection			
Further monitoring and re-examination of settlement plates to detect non-native species; existing and new locations (and other potential approaches, e.g. eDNA)	Cumberland Bay, and other locations e.g. Stromness Bay, Bay of Isles		
Understanding of biosecurity risks posed by shipping, including from increased vessel numbers.			
Investigate relative risk of potential threats from different human activities			
RELEVANT PROJECTS/ACTIVITIES	**Zone/location**	**Project**	
Microplastics in the marine environment and foodwebs	South Georgia	BAS collaborations with Universities of Hull & Siena	
Development of bird-strike reporting systems for vessels operating in the SGSSI Maritime Zone.	All MPA regions	What goes thump at night: managing bird strike in South Georgia – DPLUS143 (2021-2024)	

Annex 1 – MPA objectives

The overarching purpose of the SGSSI MPA is the conservation of marine biodiversity. The South Georgia and South Sandwich Islands Marine Protected Areas Order (2019) identifies the principal conservation objectives for the SGSSI MPA, as well as specific objectives relating to particular geographic areas or management zones.

Principal conservation objectives for the SGSSI MPA

(a) conserve marine biodiversity, habitats and critical ecosystem function;

(b) ensure that fisheries are managed sustainably, with minimal impact on associated and dependent ecosystems;

(c) manage other human activities including shipping and scientific research, to minimise environmental impacts on the marine environment;

(d) protect the benthic marine organisms from the destructive effects of bottom trawling;

(e) facilitate recovery of previously over-exploited marine species;

(f) increase the resilience of the marine environment to the effects of climate change; and

(g) prevent the introduction of non-native marine species.

Conservation objectives for Benthic Closed Areas

Area	**Conservation objectives** To conserve & protect:
West Shag Benthic Closed Area	The vulnerable marine fauna identified in this location; provides refugia for toothfish.
West Gully Benthic Closed Area	The vulnerable marine fauna in this area and protect juvenile toothfish, which are abundant in this area.
Northern Benthic Closed Area	The vulnerable marine fauna identified in this location; provides refugia for toothfish.
Eastern Benthic Closed Area	The vulnerable marine fauna identified in this area (particularly gorgonians).
Southern Seamounts Benthic Closed Area A	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
Southern Seamounts Benthic Closed Area B	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
North Georgia Rise Benthic Closed Area	The potentially sensitive (but largely unknown) benthic fauna of this area; provides refugia for adult toothfish.
North East Georgia Rise Benthic Closed Area	The potentially sensitive (but largely unknown) benthic fauna of this area; provides refugia for adult toothfish.
Protector Shoals Benthic Closed Area	The potentially sensitive (but largely unknown) benthic fauna; provides refugia for adult toothfish.
Kemp Seamount & Calderas Benthic Closed Area	The potentially sensitive (largely unknown) benthic fauna of this seamount and caldera. Protects different chemosynthetic habitats, including white smoker vent fields.

Conservation objectives for Closed Season

Closed season	**Conservation objectives** To conserve and protect:
Seasonal closure of the fishery for Antarctic krill (Oct-Apr)	Mammalian and avian krill dependent predators, such as penguins and fur seals during the key part of the breeding season.

Conservation objectives for No-take Zones

Zone	**Conservation objectives** To conserve & protect:
South Georgia No-take Zone	The shallow marine environment around South Georgia including: 1. the spawning grounds of many fish species, including mackerel icefish; 2. the inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions.
Clerke Rocks No-take Zone	The shallow marine environment to the SE of South Georgia including: 1. the spawning grounds of many fish species, including mackerel icefish; 2. the inshore foraging areas of marine predators such as gentoo penguins, cormorants, petrels and prions; 3. the serpulid reef at approximately 55°00'S, 34°31'W.
Shag Rocks No-take Zone	The shallow marine environment of the Shag Rocks shelf incorporating: 1. the principal recruitment area for juvenile Patagonian toothfish; 2. spawning grounds of mackerel icefish; 3. a key foraging area for black-browed albatross, Antarctic fur seals and baleen whales.
South Sandwich Islands No-take Zones	The shallow marine environment around each of the South Sandwich Islands including: 1. the inshore foraging grounds of marine predators; 2. the spawning grounds of fish species; 3. all benthic habitats shallower than 700 m and deeper than 2250 m.
South Sandwich Trench No-take Zone	A unique biogeographical feature which could potentially contain rare or unique habitats and biodiversity including hydrothermal communities.
No-Take Zone south of 60° South	A unique biogeographical feature which include seamounts, deep trenches and a large area of the South Sandwich Fracture Zone and Herdman Bank - regions of high hydrothermal and tectonic activity.

Conservation objectives for Pelagic Closed Area

Area	**Conservation objectives** To conserve & protect:
South Sandwich Islands Pelagic Closed Area	The pelagic ecosystem and dependent predators in the area around each of the South Sandwich Islands, particularly the highly abundant chinstrap and Adelie penguins.