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A CITES risk assessment for the common minke whale (*Balaenoptera acutorostrata*)

Opinion of the Panel on Alien organisms and trade in endangered species (CITES) of the Norwegian Scientific Committee for Food and Environment

Report from the Norwegian Scientific Committee for Food and Environment (VKM) 2019:
A CITES risk assessment for the common minke whale (*Balaenoptera acutorostrata*)

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A CITES risk assessment for the common minke whale (*Balaenoptera acutorostrata*)

Authors of the opinion

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Competence of VKM experts

Persons working for VKM, either as appointed members of the Committee or as external experts, do this by virtue of their scientific expertise, not as representatives for their employers or third party interests. The Civil Services Act instructions on legal competence apply for all work prepared by VKM.

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Summary

Key words: *Balaenoptera acutorostrata*, CITES, common minke whale, Non-Detriment Finding, Norwegian Scientific Committee for Food and Environment, Norwegian Environment Agency, VKM

Background: After centuries of overexploitation of whales globally the international whaling commission (IWC) decided to introduce a moratorium on commercial harvest of all whale species in 1982. Consequently, the minke whale was listed in CITES Appendix I under the order listing of *Cetacea* spp. in 1986. The species' current IUCN Red List status is Least Concern.

Norway has objected to the moratorium by the International Whaling Commission and whaling is carried out on an annual basis. Furthermore, Norway holds a reservation against the CITES Appendix I-listing and chooses to regulate trade in minke whale products as if the species was a CITES Appendix II listed species. Under the CITES protocol an annual risk assessment (a non-detriment finding (NDF)) is required prior to issuing export permits. The NDF should be used to conclude if trade could be detrimental to the survival of the species.

Methods: VKM has reviewed available data and estimates on the current population status and trends for minke whales in the waters managed for whaling by Norway. The survey methods that make the basis for abundance estimates that guides the determination of harvest quotas as well as catch practises and management procedures have been scrutinized. The report also reviews what is assumed to be the most important threats to the population of common minke whale. Further, available statistics on quotas, catches and international trade are presented. Altogether, the information is used for an assessment of the feasibility of predicting future minke whale populations in a changing Atlantic environment.

Results: Predictability of minke whale population trends is complicated by the fact that the species is a relatively long-lived, slowly reproducing, highly migratory and to a large extent invisible to surveys. Moreover, there are fundamental knowledge gaps pertaining to the minke whale's migration patterns, wintering grounds, mating behaviour, mortality factors and the structuring of breeding stocks. Rapid environmental changes in the Arctic further add unpredictability due to distributional shifts and ecosystem level instability.

Thus, estimates and assumptions that inform the management procedure include numerous uncertainties of various types. The appointed expert group have to the best of their ability investigated how the current management procedures compensate for uncertainties and data gaps, but have not been able to reach a full comprehension.

In the report, uncertainties have been divided into three types:

I) Uncertainties inherent in survey and monitoring methods II) uncertainties stemming from fundamental data gaps in the population biology of minke whales and III) uncertainties stemming from environmental changes.

A simulation model illustrating the vulnerability to assumptions in a wider parameter space than considered in the stationary models most commonly found in the literature is presented in Appendix I of the report. Several data gaps must be filled in order to confidently evaluate the potential effect of continued hunting. Particularly knowledge pertaining to bycatch, other hidden causes of non-age specific mortalities and population structure. The model also suggests that disproportionate catch of females (70% on average) might have a very strong reducing and destabilizing effect.

Conclusion: Estimates over the past 20 years indicate that the minke whale population has been relatively stable, and while there are fundamental data gaps and uncertainties related to the long-term persistence of this population, the export of minke whale harvested by Norway **does not appear to have been detrimental thus far.**

Whether or not VKM will be able to **continue to find no detriment** for the export of the common minke whale from the Northeast Atlantic will rely on to what extent clarifications can be made regarding factors contributing to the current uncertainty.

Sammendrag på norsk

Nøkkelord: *Balaenoptera acutorostrata*, CITES, Miljødirektoratet, VKM, Non-Detriment Finding, Vågehval

Bakgrunn: Etter århundrer med overutnyttelse av verdens hvalbestander ble det innført moratorium på hvalfangst i 1982 ved Den internasjonale hvalfangstkommisjonen (IWC). Det førte til at vågehvalen ble inkludert i CITES Appendiks I, som en del av orden *Cetacea* spp. i 1986. Vågehvalen er klassifisert som Livskraftig (LC, Least Concern) av Verdens naturvernunions (IUCN) rødliste for truede arter.

Norge har reservert seg mot moratoriet til Hvalfangstkommisjonen og utsteder en årlig kvote for hvalfangst. I tillegg har Norge reservert seg mot CITES Appendiks I-klassifiseringen, og har i stedet valgt å regulere handel med vågehvalprodukter som om de skulle komme fra en art regulert under CITES Appendiks II. I henhold til CITES-protokollen innebærer det at det kreves en årlig risikoanalyse for arten, en såkalt "non-detrimental finding" (NDF), for å utstede eksporttillatelser. En NDF skal konkludere hvorvidt handel kan være til skade for artens evne til å overleve.

De norske fangstkvotene for vågehval settes årlig av Nærings- og fiskeridepartementet, etter råd fra Havforskningsinstituttet.

Metode: VKM har gjennomgått tilgjengelige data om biologien og bestandsutviklingen til vågehval i havområdene som Norge forvalter for hvalfangst. VKM har undersøkt metodene som benyttes for å observere hval og som danner grunnlaget for bestandsestimater, og som igjen benyttes til å sette kvoter. Rapporten inneholder også en oppsummering av de viktigste kjente truslene mot artens levedyktighet. Videre beskriver den historiske og nåværende praksis for forvaltning og statistikk på kvoter, fangst og internasjonal handel. Den samlede informasjonen brukes til å vurdere mulighetene for å forutse fremtiden til vågehvalbestanden i Atlanterhavet, hvor miljøet er i rask endring.

Resultater: At vågehvalen er en art som lever relativt lenge, har lav reproduksjonsrate, migrerer over store avstander, og i tillegg er svært vanskelig å observere, gjør det komplisert å forutse den fremtidige bestandsutviklingen. Det er i tillegg store kunnskapshull angående hvalens grunnleggende økologi, som migrasjonsmønster, vinterhabitat, genetisk strukturering i paringsområdene, samt om trusler og dødelighetsfaktorer. Videre bidrar miljøendringene i Arktis til endringer i utbredelsesområder og til mindre stabilitet i de marine økosystemene som vågehvalen er en del av. Dette fører til mer uforutsigbarhet, og bidrar til at estimater og antagelser som ligger til grunn for forvaltningen av vågehval nødvendigvis er forbundet med flere usikkerhetsmomenter. Prosjektgruppen har, etter beste evne, utforsket hvordan nåværende forvaltningsprosedyrer kompenserer for usikkerheter og kunnskapshull, men har ikke klart å danne seg et helhetlig bilde.

Usikkerhetene som omtales er delt i tre kategorier:

I) Usikkerheter i overvåkningspraksis og metoder som inkluderes i eksisterende statistisk rammeverk, II) usikkerheter som bunner i grunnleggende kunnskapshull vedrørende vågehvalens populasjonsbiologi og, III) usikkerhet vedrørende miljøendringer.

En simuleringsmodell som illustrerer sårbarheten for ulike antakelser over et større parameterrom enn vi ser i modellene som er presentert i vitenskapelig litteratur, finnes i rapportens Appendiks I. Flere av de tidligere nevnte kunnskapshullene må tettes før det er mulig å gjøre en sikker evaluering av videre jakt. Det gjelder for eksempel kunnskapshull som er relatert til bifangst og andre skjulte dødelighetsfaktorer, og kunnskapshull om populasjonsstruktur. Modellen indikerer også at den uforholdsmessig store andelen av fangsten som utgjøres av hunner (gjennomsnitt 70 %), kan komme til å ha en reduserende og destabiliserende effekt på bestanden.

Konklusjon: Bestandsestimater gjennom de siste 20 årene indikerer at vågehvalbestanden har vært relativt stabil. Til tross for grunnleggende hull i datagrunnlaget og usikkerhet relatert til langtids overlevelse, ser det ikke ut til at norsk eksport av vågehval hittil har vært ødeleggende.

Hvorvidt VKM vil kunne konkludere med at eksport ikke er ødeleggende i årene som kommer (finne no detriment) vil avhenge av i hvilken grad faktorene som bidrar til nåværende usikkerhet blir klarlagt.

Abbreviations and/or glossary

Abbreviations

IWC – International Whaling Commission

IWCSC- International Whaling Commission Science Committee

RMP – Revised Management Procedure

IMR – Institute of Marine Research in Norway

NEA - The Norwegian Environment Agency

VKM - Norwegian Scientific Committee for Food and Environment

NDF - Non-detriment finding

PAM - Passive Acoustic Monitoring

NMP - New Management Procedure

CPUE - Catch Per Unit Effort

CLA - Catch Limit Algorithm

NMDR - Norwegian Minke Whale DNA Registry

Background as provided by the Norwegian Environment Agency

The Norwegian Environment Agency (NEA) requests the Norwegian Scientific Committee for Food and Environment (VKM) to prepare a CITES risk assessment (non-detriment finding) for the common minke whale (*Balaenoptera acutorostrata*).

The common minke whale is included in CITES Appendix I, meaning that international commercial trade in this species is prohibited. Norway holds a reservation against the Appendix I-listing of minke whale and may therefore export minke whale products commercially*. Norway chooses to regulate trade in minke whale products as a CITES Appendix II listed species. Consequently, it is possible to obtain an export permit and trade internationally in Norwegian minke whale products, given that a CITES risk assessment (non-detriment finding, NDF) has been prepared in line with Article III of the Convention.

Norway sets annual quotas for harvesting minke whales from the populations in the Northeastern Atlantic and the areas surrounding Jan Mayen Island. Because a share of the minke whale products is exported, a risk assessment is required. The risk assessment will form the scientific basis for processing export permit applications related to minke whale products.

*Only to non-Parties of CITES and other CITES Parties who similarly hold a reservation against the listing of minke whale in Appendix I.

Terms of reference as provided by the Norwegian Environment Agency

The NEA requests VKM to prepare a risk assessment (CITES NDF) for the Norwegian minke whale export.
The following template should be used for the assessment:

1. Description
    a. Names, distribution, life history, habitat, role in the ecosystem
2. Populations and trends: globally/regionally (from the area in which Norway conducts its harvest)
3. Threats and conservation status: globally/regionally
4. Management in Norway and globally:
    a. Historical perspective
    b. Present day management and harvest quotas
    c. Licenses and harvest control
    d. Assessment of legal/illegal harvesting and bycatch
5. Population surveillance and monitoring
6. Trade
7. Regulation/legislation
8. Assessment of data quality
9. Conclusions
10. References

1 Methodology and data

1.1 CITES and Non-detriment findings (NDF)

The convention on International Trade in Endangered Species of Fauna and Flora (CITES) was established in 1975 to ensure that trade in wildlife species is managed sustainably (Rosser and Haywood, 2002). CITES aims to regulate international trade in wildlife products through international cooperation between its currently 183 member states (parties). Under CITES, species are listed in two main Appendices, I and II, depending on the level of protection they require. Appendix I is for species that are threatened with extinction. For these species, international commercial trade is prohibited. Appendix II lists species that are not necessarily threatened with extinction, but that may become so unless trade is closely controlled. International trade in Appendix II species may be authorized by the granting of an export or re-export certificate. No import permit is necessary for such species under CITES, however, many parties (including Norway and the EU) have stricter regulations and require import permits also for Appendix II species. Furthermore, CITES includes an Appendix III, where species are listed at the request of a party that already regulates trade in the species and need the cooperation of other countries in order to prevent unsustainable or illegal exploitation (for more information about how CITES works see: https://www.cites.org/eng/app/index.php)

A non-detriment finding (NDF) (as outlined in Res. Conf. 16.7 (Rev. CoP17)) by a Scientific Authority is required before an export permit or a certificate for an introduction from the sea may be granted for a specimen of an Appendix II species. Parties may also enforce stricter domestic CITES legislation, for example by requiring import permits for Appendix II species. NDFs are scientific assessments of whether trade is going to be detrimental to species survival in the wild or threaten their role in their ecosystem. The NDF is a risk assessment, where the species vulnerability is considered in relation to how well it is managed. Factors that are considered when carrying out a NDF are the biological characteristics of the species and its global/national status such as distribution, population size and trends and threats, as well as harvest management and control, and conservation measures. A NDF conclusion is either positive (trade is not going to be detrimental to the species in question) or negative (trade may be detrimental to the species), or may in some cases be inconclusive, for example in situations when there is very little information available or when data quality is poor.

NDFs are prepared through reviewing peer-reviewed literature, CITES-meeting documents, national/international status reviews and reports as well as personal communication with species experts (Rosser and Haywood, 2002).

1.2 Literature search and selection

The Web of Science (https://clarivate.com/products/web-of-science/) was used as a starting point for literature collection through VKM and the University of Oslo using the same search words and selection criteria. The following search terms where used "common minke whale", "minke whale", "balaenoptera acutorostrata" to conduct the initial searches. Abstracts where then screened to find articles about the *Balaenoptera acutorostrata* subspecies of the North Atlantic. More specifically, all articles on genetics, ecology and behaviour were selected for further analysis.

For the parts of the report containing general information about the common minke whale (e.g. part 1 of this report), the project group found information on the website of the North Atlantic Marine Mammal Commission (NAMMCO) (https://nammco.no/topics/common-minke-whale/) and the website of the IUCN Red List (https://www.iucnredlist.org/searchquery=minke%20whale&searchType=species).

A substantial amount of information relating to minke whale management is published in reports issued by the International Whaling Commission (https://iwc.int/home) and NAMMCO.

2 Assessment

2.1 Description

Names: *Balaenoptera acutorostrata* (Lacépède 1804)

Synonyms: NA

Common name: Minke whale

Norwegian names: Vågehval, minkehval, minke

Taxonomic notes: Minke whales are currently considered as two species (Rice, 1998): the cosmopolitan common minke whale (*B. acutorostrata)* and the Antarctic minke whale (*B. bonaerensis*), which is mostly confined to the Southern hemisphere.

The common minke whale is further divided into three sub-species (Quintela et al., 2014):

- the North Atlantic (*B.a. acutorostrata)*
- the North Pacific (*B.a. scammoni*)
- dwarf common minke whale (B.a. unnamed subspecies), probably southern hemisphere (Acevedo et al., 2010)

This NDF is concerned with the North Atlantic common minke whale *B. a. acutorostrata* population of the northeast Atlantic.

Characteristics

The common minke whale is the smallest species of the rorqual family with a length of 8-10 m and a weight of about 8 tonnes. They are black or dark grey dorsally and white on the ventral side. A transverse white band on the flippers is characteristic for the species in the northern Hemisphere. The dorsal fin is curved and located two-thirds back along the body. Males and females are very similar in appearance, and while females are somewhat larger than males they cannot be sexed by sight at a distance (NAMMCO website; Pers. Comm. N. Øien)

Habitat and distribution

The common minke whale is a cosmopolitan species found in all oceans and nearly all latitudes (Cooke, 2018). The species occurs in both coastal and offshore waters, and diet varies according to availability (Cooke, 2018). The summer feeding grounds of common minke whales are well-known, and include the North, Norwegian and Barents Seas, and the coastal waters of Iceland, east and west Greenland, Newfoundland and Labrador (Horwood, 1989).

Like other baleen whales, the species undertakes seasonal migrations, but very little is known about their southbound winter migration. The use of satellite telemetry has proved to be difficult for common minke whales, with tags stopping transmission after a short time (Vikingson, 2015). In one of the very few studies of minke whale migration, Vikingsson and Heide-Jørgensen (2015) presented data from the tracking of three minke whales that set off from Icelandic waters in autumn. The three whales headed south, following an offshore route in the middle of the Atlantic. Contact was lost with two of the whales, but the third whale was tracked for 100 days, and by that time, it had passed the Azores. This represent the longest tracking record for a common minke whale, both in terms of distance (3,700 km) and time (100 days), and provides an indication of migration route (Vikingson and Heide-Jørgensen, 2015).

Passive acoustic monitoring (PAM) based on recordings of minke whale's vocal signals enables surveillance of remote areas over extended time periods regardless of weather conditions. This has provided new insights about migration timing and a possible migration corridor along the North American continental shelf, indicating that minke whale breeding grounds extend eastwards from the Caribbean to at least the Mid-Atlantic ridge (Risch et al., 2014). The same method applied on minke whales in the North Sea supported the data from sightings regarding absence of whales during winter months (Risch et al., 2019) and could with an extended study area potentially be applied to shed light on migration routes and winter habitats.

Recently, observations of minke whale in areas of the Canadian Hudson Bay Region (Hidgeon and Ferguson, 2010) and an increase in takes in the northern communities of West Greenland suggest a distributional shift northward in summer and winter (NAMMCO, 2012 cited in NAMMCO). This is corroborated by recent Norwegian surveys (Solvang et al., 2015) suggesting a distributional shift to the north, and is also consistent with findings from Icelandic waters (Vikingsson and Heide-Jørgensen, 2015).

Life history

Common minke whales reach sexual maturity between the ages of 5 and 7 years old, with most females becoming pregnant every year (NAMMCO website). Mating occurs in late winter and the gestation period is approximately 10 months, with calves born predominantly in winter. The locations of breeding and calving grounds are unknown and information about mating behaviour is lacking. Kavanagh et al. (2018) reported minke whale calf sightings in the Northeast Atlantic during winter, which raise the possibility that not all pregnant females migrate to low latitudes in order to calf, or that warmer winters are shifting calving grounds.

Minke whales are generally considered solitary in the North Atlantic, but there is evidence of sexual segregation during summer, with the larger females reaching further towards higher latitudes than smaller males (Horwood, 1989). Several studies demonstrate a large gender bias towards females in the catch from the northernmost areas (e.g. Andersen et al., 2003; Anderwald et al., 2011; Quintela et al., 2014).

Role in the ecosystem

Common minke whales feed on a wide range of prey species, including herring (*Clupea harengus*), capelin (*Mallotus villosus*) and cod (*Gadus morhua*), as well as various makrozooplankton such as krill (order *Euphausiacea;* e.g. Haug et al., 1996). Feeding habits appear to be opportunistic and vary with season, year to year and location (e.g. Haug et al., 1995; 1996; 2002). For example, Haug et al. (1995) analysed the stomach content of northeast Atlantic minke whales caught during summer 1992 and autumn 1993. They found that for a particular summer in the Spitsbergen and Bear Island areas (the northernmost study areas) capelin was the dominating prey species, whereas the following summer and autumn more krill was consumed. This pattern was consistent with an increase in krill and a decrease in capelin availability in these areas from 1992 to 1993. In other regions, such as the southern coastal areas, herring was a dominant food item both in 1992 and 1993 (Haug et al., 1995). Analysis of the forestomach content of 210 minke whales sampled in the years 2000-2004 (Windsland et al., 2008) and diet studies of minke whales in Icelandic waters (e.g. Sigurjónsson et al., 2000), showed differentiation in diet composition between areas.

Bogstad et al. (2015) suggests that competition occurs between minke whales and other predators with similar diets, like cod, harp seal (*Pagophilus groenlandicus*) and possibly sea birds, in the Barents Sea. Occasionally, minke whales are subject to predation by killer whales (*Orcinus orca*) (Ford et al., 2005; Samarra et al., 2018).

Sighting data (2002–2014) showed a large degree of overlap between minke whales and other migratory baleen whales, dolphins and killer whales in the summer foraging habitats in the waters around the Svalbard Archipelago (Storrie et al. 2018).

Genetic structuring

Analyses of mitochondrial DNA (mtDNA) data indicate that the common and Antarctic minke whales diverged approximately 5 million years ago (Pastene et al., 2007). However, several individuals of Antarctic minke whale and hybrids have been captured in the Northeast Atlantic since 1996 (Glover et al.; 2010, Glover et al., 2013). It has been suggested that Antarctic minke whales undertake temporary migrations out of its native distribution in search of better feeding opportunities in response to ecological changes (Glover et al., 2013; Malde et al., 2017).

Three mtDNA lineages have been identified, but there is no geographical pattern detected in genetic variation in the Northeast Atlantic (Quintela et al., 2014). A study of genetic variation in 16 microsatellite markers for ca 300 samples, ranging the years 1982-1998, indicated the existence of four genetically differentiated sub-populations: (1) West Greenland, (2) Central North Atlantic-East Greenland-Jan Mayen area, (3) Northeast Atlantic (Svalbard, the Barents Sea and north- western Norway), and (4) North Sea (Andersen et al., 2003). The authors attributed the genetic differentiation observed to ecological variability among feeding grounds. However, Quintela et al. (2014) analysed 10 biparentally inherited markers in almost 3,000 individuals sampled between 2004 and 2011 in the five Norwegian managing areas (ES, EB, EW, EN CM, see Figure 2.2-1) and revealed no clustering into groups. This was also the case when dividing samples by age classes.

As the geographic locations of the minke whale's mating and breeding grounds are unknown, information about the number, sizes and potential structuring of the breeding populations is lacking. Conclusions about the genetic structure of the minke whale breeding populations would require that sampling is undertaken on breeding grounds.

2.2 Populations and trends

Global population trend: Unknown (Cooke, 2018 for the IUCN Red List Assessment).

Regional population trend: Assumed stable (based on table 2.2-1)

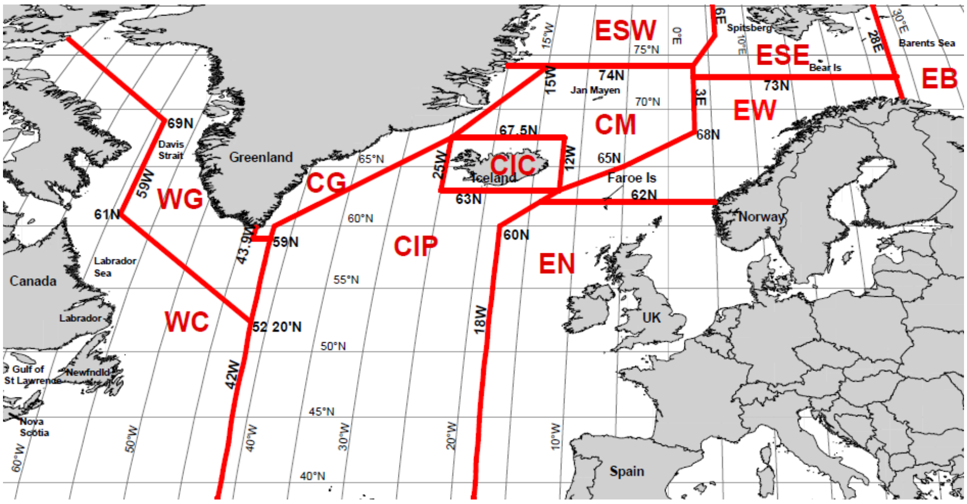

Figure 2.2-1 Map of area structure used for minke whale management in the North Atlantic. The management region is divided into 11 sub-areas. The rationale for the position of the sub-area boundaries is given in annual reports of the International Whaling Commission 1993 (p194), 2004 (p12-13), and 2009 (p138). Norway manages the regions: EN, EW, EB, ES, CM. Note that ES is divided into ESW and ESE on Figure 2.2-1.

2.2.1 Trends in abundance in the Norwegian survey areas

The abundance estimates are based on sighting surveys along line transects in five areas in the North, Norwegian and Barents Sea, and areas around Svalbard and Jan Mayen (Figure 2.2-1). Each area is surveyed once over a six-year survey period and the result from each area is combined to estimate the total population size (Solvang et al., 2015). The methodology for surveying minke whale abundance in the Northeast Atlantic is described in more detail in section 2.5 of this report.

The current survey cycle (2014-2019) for estimating minke whale abundance in the Northeast Atlantic was initiated in 2014. The 2014 survey was dedicated to the Svalbard area (management area ESW and ESE, Figure 2.2-1), whereas the 2015 survey covered the Norwegian Sea (management area EW, Figure 2.2-1). The Jan Mayen (management area CM, Figure 2.2-1) area was surveyed in 2016, and the Barents Sea (management area EB, Figure 2.2-1) in 2017.

Over the four years 2014-2017, 21,8139 km was covered in a total search area of 2,969,039 km^2. From these efforts a total of 747 sightings were recorded varying between 39 and 314 annual observations (see table 2.2.1-1).

The results of the surveys conducted between 2014 and 2017 indicate considerable changes in distribution of minke whales in the Northeast Atlantic compared to previous survey cycles. For example, based on the 2014-survey, the abundance of minke whales in the Svalbard area (ES) shows a considerable decrease (45%) compared to the 2008-survey, and the lowest number since 1995 (Solvang et al., 2018). Furthermore, the most recent estimate from the Norwegian Sea indicate a decrease in abundance, with the current estimate being the lowest over two survey cycles (Solvang et al., 2018). In contrast, the 2016-survey of the Jan Mayen area resulted in the largest estimate of minke whale abundance since these surveys started (Solvang et al., 2018).

The results from previous survey cycles and abundance estimates per area are presented in Table 2.2.1-2. The abundance estimates for the Jan Mayen area and the Eastern areas (Barents, Norwegian and North Sea) are given in Table 2.2.1-2. The population estimate for the total survey area and period between 2014 and 2019 will be presented at the International Whaling Commission Scientific Committee’s annual meeting in 2020.

Table 2.2.1-1 Sighting numbers and estimated abundance per area for the survey cycles 2002-2007, 2008-2013, 2014-2019 (preliminary results from this cycle)

Small management area	Survey cycle	Number of whale sightings	Estimated abundance	Reference
CM	2002-2007	135	27,864	Bøthun et al.,2009
EB	2002-2007	165	29,907	-
EN	2002-2007	39	6,476	-
ES	2002-2007	188	20,190	-
EW	2002-2007	314	52,594	-
CM	2008-2013	52	10,991	Solvang et al., 2015
EB	2008-2013	436	34,125	-
EN	2008-2013	56	6,891	-
ES	2008-2013	238	27,389	-
EW	2008-2013	123	21,217	-
CM	2014-2019	318	57,443	Solvang et al.,2018
EB	2014-2019	295	65,362	-
EN	2014-2019	-	-	-
ES	2014-2019	130	13,062	-
EW	2014-2019	62	13,926	-

Table 2.2.1-2 Abundance estimates for the Jan Mayen area and the Eastern areas (Barents, Norwegian and North Sea) from Solvang et al., 2015.

Year	Jan Mayen	Eastern	Total	Reference
1989	2,650 (CV 0.484)	64,730 (CV 0.192)	67,380 (CV 0.190)	Schweder et al., 1997
1995	6,174 (CV 0.357)	112,125 (CV 0.104)	118,299 (CV0.103)	Schweder et al., 1997
1996-2001	26,718 (CV 0.14)	80,487 (CV 0.15)	107,205 (CV 0.13)	Skaug et al., 2004
2002-2007	26,739 (CV 0.39)	81,401 (CV 0.15 0.23)	108,140 (CV 0.23)	Bøthun et al., 2009
2008-2013	10,991 (CV 0.26)	89,623 (CV 0.12)	100,615 (CV 0.11)	Solvang et al., 2015

2.2.2 Additional surveys of minke whale abundance and trends

In addition to the 6-year survey cycles described above, several other initiatives for estimating cetacean abundance and trends are carried out on a regular basis.

North Atlantic Sightings Surveys (NASS)
The North Atlantic Sightings Surveys (NASS) are a series of internationally coordinated cetacean surveys. The survey area encompasses much of the northern north Atlantic between Norway and North America. Surveys were carried out in 1987, 1989, 1995, 2001, 2007 and 2015, with the aim of obtaining quantitative information on the abundance and distribution of all cetaceans in the survey area. Large ships are used to cover the offshore areas whereas some coastal areas are covered by aircraft. Five countries, Faroes, Greenland, Iceland, Norway and Spain, participated in the initial surveys in 1987 and 1989. After 1995, Norway initiated the 6-year rotation survey approach, thus a smaller area was covered by Norway in the surveys from 2001 and onwards (https://nammco.no/topics/abundance-surveys-counting-whales/#1502888669916-d4b2cdad-05c2).

Results seem to be published gradually in NAMMCO Scientific Publications, effectively an open-access, peer-reviewed journal run by NAMMCO. There is a significant delay between surveys and publications, as the surveys of 1987, 1989, 1995, and 2001 were published in NAMMCO Scientific Publications Volume 7, which was available online between 2009 and 2013. More recent survey results will be available in NAMMCO Scientific Publications Volume 11 (https://septentrio.uit.no/index.php/NAMMCOSP/announcement/view/57).

SCANS
SCANS are large-scale multinational ship and aerial surveys for cetaceans in European Atlantic waters, originally initiated in 1994 to obtain information about levels of bycatch in harbour porpoises (Hammond et al., 2017). The motivation for the more recent SCANS surveys is to gather abundance and distribution data on cetacean species, including minke whales. The SCANS surveys have been carried out in the North Sea and adjacent waters (Hammond et al., 2017).

Hammond et al. (2007) present the results of the data-series from 1994, 2005/2007, 2016. They found no evidence for changes in minke whale abundance in the North Sea over this time-period (Hammond et al., 2017). The abundance estimate for 2016 in the North Sea was 8,900 (with a coefficient of variation of abundance and density CV= 0.24), which is within the range of previous estimates from SCANS surveys and Norwegian surveys (described above).

For the total survey area, the estimated abundance of 14,800 (CV 0.33) from 2016, was lower than that from the 2007-survey of 26,800 (CV=00.35; presented in Hammond et al. 2011). However, the authors note that this may be due to a lack of an estimate in Irish waters, and thus a direct comparison should not be made until estimates are available for equivalent areas (Hammond et al., 2017).

2.3 Threats and Conservation status: globally and regionally

Global IUCN red list status: Least Concern ver.3.1 (Cooke, 2018).

In 1982 the International Whaling Commission introduced a pause (moratorium) in commercial whaling of all whale species (order Cetacea spp.). The common minke whale was subsequently transferred from CITES Appendix II to I.

There is ongoing commercial whaling by Norway and Iceland (under objection and reservation to the moratorium by the International Whaling Commission). Subsistence hunts are carried out by Greenland.

There are several sources of human-induced mortality and population stressors for minke whales and other whale species in the North Atlantic:

Bycatch and fatal injuries from entanglement

The International Whaling Commission has estimated that at least 300,000 cetaceans are accidentally caught in fishing gear every year (https://iwc.int/bycatch). Entangled animals may drown or die slowly from cuts through skin and blubber causing infection, starvation and even amputation of fins or tail. There are very few reports of by-catch of minke whales in the reports of the International Council of the Exploration of the Sea (ICES) Working Group on By-catch of Protected Species (WGBYC) for the period 2008-2012 (ICES WGBYC 2010-2014). However, due to their small size, near-shore and shelf occurrence, and preference for commercially targeted fish species, minke whales might be vulnerable to entanglement, particularly in gill nets (Reeves et al., 2013), creel lines and ropes (Northridge et al 2010).

Injuries sustained from encounters with ropes can negatively impact minke whale behaviour, for example by affecting feeding abilities (Kot et al., 2009; 2012). A thorough review of minke whale records for southern parts of the eastern North Atlantic found evidence of net entanglement in the Azores, Canary Islands and Senegal (Reeves et al., 2013). In records from the North Atlantic US coastline between 1970 and 2009, the cause of death could be determined for 176 of 396 minke whale carcasses; 101 deaths (57%) were caused by entanglement in fishing gear (Van Der Hoop et al., 2012). This is consistent with a study on minke whale carcasses washed ashore in Scotland between 1990 and 2009 that found entanglement, mostly in creel lines, to account for about 50% of all mortalities of stranded whales (Northridge et al., 2010)

Ship strikes

Collisions with vessels mostly involve large whales, but accounted for 17 (10%) of 176 US East Coast minke whale mortalities reported by Van Der Hoop et al. (2012). The Large Whale Ship Strike Database of 292 records from 11 species of whale struck between 1975-2002 records 19 strikes of ships on minke whales. The frequency of ship strikes, both fatal and non-fatal are most likely underestimated (Risch et al., 2019).

Whale watching boats have reportedly affected minke whale feeding behaviour off the coast of Iceland (Christiansen et al., 2013). The whales responded to whale-watching boats by performing shorter dives and increased sinuous movement, thus reducing their foraging activity (Christiansen et al., 2013).

Anthropogenic noise

Minke whales have been suggested to react to sonar (Sivle et al., 2015) by prolonged diving and thus metabolic stress (Kvadsheim et al., 2017). Increased risk of mass strandings during use of naval sonar has been documented (Hohn et al., 2006; Parsons, 2017).

Non-sonar anthropogenic noise may negatively affect many whale species abilities to communicate acoustically (Risch et al., 2019). A study of communication masking from the combination of ambient noise and discrete vessels operating in the Stellwagen Bank National Marine Sanctuary found that minke whale signals experience masking levels of 80% or more (Cholewiak et al., 2018).

Habitat degradation

Marine debris (e.g. plastic) has become a pervasive problem with large impacts on marine life and more than 60% of cetacean species have already been shown to be adversely affected (Fossi et al., 2018). Microplastics can be ingested directly and potentially indirectly from prey species (krill and copepods) by whales and their accumulation may pose a health threat (e.g. Fossi et al., 2012; Germanov et al., 2018)

A recent study of minke whales from the Barents Sea found heavy metal contaminations below seafood safety limits (Maage et al., 2017). Persistent organic pollutants (POPs) have been suggested to cause endochrine disruption in North Atlantic pilot whales, and minke whales may be subject to similar effects (Hoydal, 2017).

Finally, the consequences of ocean acidification remain challenging to characterize (Thomas et al., 2015), but it is clearly an emerging threat to marine ecosystems, with reports of negative physiological effects on a wide range of calcareous organisms, from phytoplankton to shellfish to predators (Macko et al., 2018).

Climate change

From the year 2000, the sea surface temperature (SST) as estimated by the Norwegian Meteorological Services has shown annual temperature sums for the North Atlantic to be rapidly rising outside the range of the last century, and with no sign of stabilizing (Figure 2.3-1).

Numerous reviews concerning the possible impacts of climate change upon marine mammals predict that their distribution, prey preference and long-term recruitment will be affected (e.g. IWC, 1997; 2009; Laidre et al., 2008; MacLeod, 2009). Common minke whales seem to be extending their summer range northwards (e.g. Higdon and Ferguson, 2011; Solvang et al., 2015;), most likely as a response to changes in prey distribution due to a warming climate (Nøttestad et al., 2015).

Breeding success of Antarctic minke whale has been found to be negatively related to sea surface temperature anomalies (Leaper et al., 2006). Tynan and Russell (2008) assessed the impacts of a 2°C global warming on Southern Ocean cetaceans. Among projected changes were a decrease in the extent of sea ice and ice-edge habitat along the Antarctic continent and a poleward shift and shrinking of ocean fronts (e.g., the Antarctic Convergence), which may in turn affect the availability of krill (Reid and Croxall, 2001; Fraser and Hoffman, 2003; Trathan et al., 2003). Similar changes may potentially also apply to the North Atlantic.

Furthermore, ongoing decline of sea ice in the Arctic may lead to more ship traffic in areas currently used intensively by baleen whales (Thomas et al., 2015).

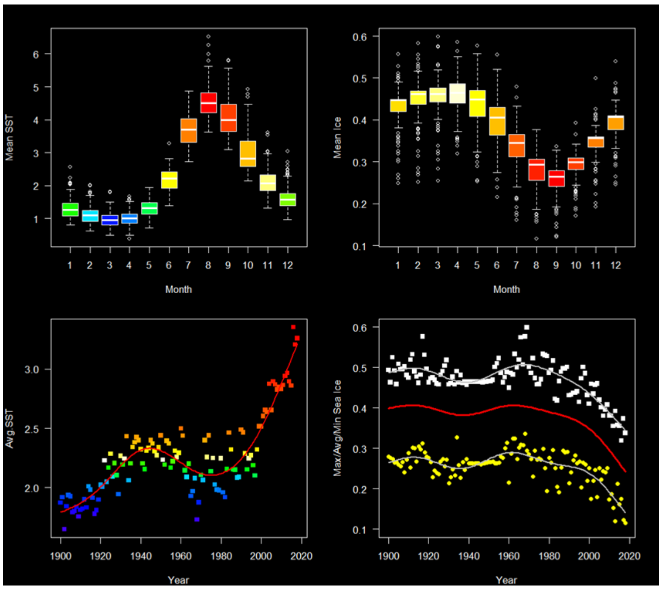

Figure 2.3-1 There is strong seasonality in Sea Surface Temperature (SST) (upper left and sea ice cover (upper right). There are very strong trends towards higher SSTs (lower left, colours are graded for readability) and less sea ice (lower right, with white showing maximum and yellow minimum values and red line the mean).

Sex biased mortality

There is a pronounced sex bias towards females in minke whale hunting (Andersen et al., 2003; Anderwald et al., 2011; Quintela et al., 2014). Catch data from Norway since 1993 shows that females, on average, makes up nearly 70% of the annual catch. This has consequences for the effective population size in terms of genetic diversity and because the population growth rates may be substantially lower in a population that is biased towards males.

2.4 Management in Norway and globally

2.4.1 Historical perspective

The modern Norwegian minke whaling probably started off western Norway around 1920. At that time, much experience had been gained from harpooning tunas and basking sharks, and from an earlier fishery for Northern bottlenose whales. The increasing interest for this fishery created a demand for regulation and onwards from the 1938 season, a licensing system was established. An important part of the system was compulsory logbooks and since that time, individual records of all whales caught have been collected (Christensen and Øien, 1990).

During the first years, the whaling was without regulations other than the need for a licence, but as the effort and number of whalers steadily increased, a summer closure between the 1st and 21st July was introduced in 1950 (Øien and Øritsland, 1987). In 1952, the summer closure was maintained while introducing six months whaling season from 15th of March to 14th of September. In the following years, regulations for geographical areas and time periods came in to effect. In the mid-1950s the Norwegian minke whaling reached its peak levels with annual total catches of nearly 4,500 individuals. The competition between the whalers probably caused expansion of the Norwegian minke whaling throughout the Northeast Atlantic to Jan Mayen, Iceland, the Denmark Strait and West Greenland during the 1960s (Christensen and Øien, 1990). The Norwegian minke whaling retreated to Norwegian waters as exclusive economic zones were introduced and expanded during the 1970s (Øien et al., 1987).

In 1975, the International Whaling Commission adopted the New Management Procedure (NMP) for commercial whaling (In Chairman's report of twenty-seventh meeting, London 1975, Report of the International Whaling Commission 27, 1977). The principle underlying NMP is that of maximum sustainable yield; the catch levels should be set to be sustainable and at the same time move the stock under consideration towards a maximum productivity. The necessary information for applying the NMP is the trend development, which at the time could be derived from catch statistics through catch per unit effort (CPUE) series. These have, however, many shortcomings due to the non-random distribution of whales as aggregations make the relationship between stock size and CPUE strictly non-linear, which hampers the detection of even serious declines in stock size (Cooke, 1995).

In 1982 the International Whaling Commission introduced a pause (termed the 'moratorium') in commercial whaling on all whale species, starting from the 1985/1986 Antarctic catching season. This decision was to be re-evaluated by 1990 at the latest. However, the moratorium has never since been lifted and is therefore the present Whaling Commission management of commercial whaling.

2.4.2 The development of a Revised Management Procedure (RMP).

After the moratorium decision, the International Whaling Commission's Scientific Committee was asked to develop a revised management procedure (RMP, see https://iwc.int/rmpbw). The procedure should be based on three key objectives: (i) stability of catch limits (desired by the whaling industry) (ii) acceptable risk that a stock will be depleted below some chosen level (risk of extinction not seriously increased by exploitation) (iii) making possible the highest continuing yield from the stock.

The catch limit algorithm (CLA) was developed to calculate catch limits that would meet the objectives stated above. The catch limit algorithm does not allow for catches from a stock estimated to be below 54% of its estimated pre-harvest population. The International Whaling Commission's Scientific Committee provides three tuning levels, of 0.60, 0.66, 0.72, i.e. the levels where the whale population stabilises despite harvest. The whaling Commission has chosen 0.72 as its recommended tuning level, meaning that quotas (if the moratorium was to be lifted) should be set at a level where the whale population stabilises at 72% of its carrying capacity to ensure that conservation objectives receive the highest weight.

The catch limit algorithm requires information on: A) estimates of the number of whales ('abundance estimates') taken at regular 6-year intervals (see 1.5 for description) and their associated statistical uncertainty, and B) estimates of numbers of past catches (allowing for the uncertainty in historic records) and numbers of present catches (assumed to be known reliably). See; IWC (1993), IWC (1994) and IWC (2012).

2.4.3 Present day management and harvest quotas in Norway

Norway is managing its minke whaling under objection to the moratorium and the CITES Appendix I listing. This whaling is therefore not regulated by the International Whaling Commission, but by national decisions. Institute of Marine Research (IMR) uses the Revised Management Procedure tuned to 0.60 for calculating minke whale harvest quotas. The abundance estimates used for setting hunting quotas have to be officially approved by the Scientific Committee of the International Whaling Commission.

The effects of quotas are assessed through age-structured simulation models and the quotas may be adjusted accordingly. Initially, the tuning level was set to 0.72 as agreed-upon by International Whaling Commission in 1993, but was then lowered to 0.66 in 2001, to 0.62 in 2002 and 0.60 in 2006. The current tuning level for quota calculation is set to 0.60, meaning that the population should stabilise at around 60% of its pre-catching level. The modification from the Revised Management Procedure is due to how the catch allowance is divided within the small management areas (see figure 2.2-1 for a map over small areas used for management purposes). In its original form, the RMP will result in a quota which will then be divided between a set of small areas. However, in Norway, management authorities have merged the quota for the small areas ES, EB and EW, thus the combined quota may be taken within any of these small areas. This decision is based on the notion that the IWC Scientific Committee has concluded that there is one single population within the E-area.

Based on the calculations described above, the Institute of Marine Research submits a quota proposition. The Ministry of Trade, Industry and Fisheries makes the final decision on quotas and the Norwegian Directorate of Fisheries is responsible for the practical regulations for the whaling. The regulations typically set the quotas, the conditions for participating in the whaling, the whaling period, reporting procedures, logbook keeping and inspector arrangements.

The most recent abundance estimate approved by the International Whaling Commission's Scientific Committee for the total area surveyed by Norway is 100,615 minke whales (see table 2.2-1). The quota for 2019 is set to 1,278 whales, which is 1.27% of the estimated population managed by Norway.

Appendix II lists the annual quotas and catches from 1994 to 2018 in the Eastern and Central management areas. Less than half of the annual quota is caught for most years. In Jan Mayen, the last catch was 1 individual in 2010 while the annual quota for this area has been 170 since 2016. From 2010 to 2015 it was 270. According to the Institute of Marine Research, the discrepancy between quota and catches can be explained by whaling effort, and Jan Mayen is not attractive due to its remoteness and rough weather.

Most hunting is done in summer habitats around the Svalbard Archipelago. Here, many mature females are foraging leading to a strong gender bias in the catches (see table in Appendix II for catch data statistics). In 2018, 454 whales were caught of which 102 were males, 348 females and 4 of unknown gender (lost animals). The pregnancy rate in the harvested population is known to be high and 131 of the females caught in 2018 were carrying fetuses. In an older study from the Barents Sea, as much as 94% of the mature females (length > 715 cm) investigated were pregnant (Christensen et al., 1981).

2.4.4 Licenses and harvest control

Traditionally, methods for controlling whether whaling is in accordance with the set conditions include logbooks, inspectors, observer programs and general data collection. Since 2001, an electronic automated computer system has been applied to monitor and collect data on the whaling activity onboard the vessels (NAMMCO, 2010). This system, named the Blue Box system, is equipped with an independent GPS and several sensors mounted different places onboard to register when a whale is shot and brought onboard. The system is calibrated for each individual vessel to be able for the developed software to collect the appropriate information from the data recorded. This generates a control, which can be directly compared with the logbook information and potentially reveal discrepancies.

2.4.5 Assessment of legal/illegal harvesting and bycatch

After the International Whaling Commission's Scientific Committee had developed the Revised Management Procedure, the Commission decided that an inspection and observation scheme had to be established before the moratorium eventually could be lifted. This scheme is known as the Revised Management Scheme (RMS). The aim of RMS has been to decide for a proper surveillance of whaling operations as well as monitoring the origin of whale products in the market. Discussions regarding what the RMS should comprise of and how it should be implemented were carried out for many years in the Commission. However, around 2008 this work was halted and the IWC confirmed their commitment to the moratorium on whaling.

The Norwegian minke whale DNA register was established in 1996 and contains genetic profiles for the majority of whales captured after 1997 (Glover et al., 2012). The DNA register function as a control system to detect any attempts at illegal trade in products derived from other stocks of minke whale or other whale species, under the cover of legal Norwegian harvest and trade of the Northeast Atlantic minke whale (Glover et al., 2012). All legally captured individuals are genotyped, and thus all legal whale products may be traced back to its original source based on the genetic profile in the DNA register. Any mis-match would suggest illegal harvest and trade (Glover et al., 2012). The Institute of Marine Research is responsible for the practicalities regarding the DNA register, from supplying the whaling boats with tissue collection kits to conducting the laboratory work and DNA analyses (Glover et al., 2012). The Norwegian Directorate of Fisheries owns and manages the DNA register. Permission to export minke whale meat will only be granted for cases where the receiving country has a system for taking DNA samples for comparison with the NMDR in place (https://lovdata.no/dokument/SF/forskrift/2001-06-29-799 -in Norwegian).

The Norwegian Directorate of Fisheries is responsible for issuing whaling permits and for overseeing that the commercial harvest of minke whale is conducted according to national regulations (Glover et al., 2012). For further information about the Norwegian minke whale

DNA register, see Glover et al. 2012. Palsbøll et al. (2006) tested whether meat purchased on the Norwegian market matched samples in the register, and their results confirmed that the meat was legally sourced. There is however an 8 to 12 weeks delay from the end of the hunting season (April to August or September) and the start of the DNA analyses (Glover et al., 2012). Whale meat is sold fresh upon landing, or as a frozen product, which may enter the market over several years. For meat that is sold as fresh or frozen within the 8 to 12 weeks delay, it may be available in the market before the DNA register is updated (Glover et al., 2012).

There is no surveillance program for bycatch of minke whales in Norwegian waters, and thus no available data on the levels of bycatch. One individual that died from entanglement in gillnets was reported by Norway in 2017 (IWC/67/Rep01 (2018), Annex J).

2.5 Population surveillance and monitoring

The Northeast Atlantic is split into survey regions coinciding with the five small areas used for the Revised Management Procedure (RMP) of the International Whaling Commission: CM, EB, EC, EN, ES (ESW and ESE) (see figure 2.2-1). The abundance estimates used as the basis for establishing the annual hunting quota are based on sighting surveys in these small areas (Solvang et al., 2017). Minke whale abundance estimates are obtained by conducting annual surveys over a six-year period, covering one small area each year (Solvang et al., 2015; Skaug et al., 2004). The results of such surveys are then combined to obtain one single abundance estimate for the total population (Øien and Schweder, 1996).

Studies have shown that northeastern minke whales are mostly solitary on their feeding grounds (Sigurjonsson et al., 1989). Whales are searched for by naked eye from two platforms (usually a barrel in the mast (A platform) and on the wheelhouse roof (B platform)), each manned with two observers working in teams during two-hour shifts. The platforms are visually and audibly separated to be independent. Primary searching speed is intended to be 10 knots and the surveys conducted in passing mode, and conditions for searching defined as visibility greater than 1 km and Beaufort Sea state of four or less. For each sighting, species, radial distance as estimated by eye, angle from the transect line as read from an angle board, school size and swimming direction are reported, and the units of observation are the tracks of observed surfacing. The selection criteria for sightings are that they must be recorded from platforms in primary search mode, the species confirmed, the initial sighting done before abeam, and with a confining radial distance $r \in [100m, 2000m]$. The sightings are then transferred to abundance estimates through a hazard probability model incorporating detection probability as a function of radial distance and the surfacing rate, which is determined from external dive time data collected by radio-tagging of 20 minke whales. Together with strip widths, this is then are used to obtain an abundance estimate by survey block. Bias correction of blockwise parameter estimates has been conducted through a simulation. The model incorporates spatial clustering of whales, measurement errors in distance and angle and errors that may arise from the matching process of tracks, and the additional variance, caused by non-synoptic coverage of the survey area, estimated combining available survey data (Bøthun et al., 2009).

In addition, the airplane-based North Atlantic Sightings Surveys (NASS) provide some abundance estimates from 1987 to 2007, covering a part of the North Atlantic. (https://nammco.no/topics/abundance-surveys-counting-whales/).

2.6 Trade

The CITES Appendix I listing of minke whales (with the exception of the population of West Greenland, which is included in Appendix II; https://www.cites.org/eng/app/reserve.ph), means that most countries will not import (or export) any products from minke whales. However, Norway, Japan, Iceland and Palau hold reservations against the Appendix I listing of *Balaenoptera acutorostrata* and Norway exports a proportion of its annual catch internationally. The Faroe Islands are not a member of CITES and can thus import whale meat from Norway. CITES trade reports for commercial trade (exporter reported quantity, CITES purpose code: T, commercial) from 2010 to 2017 (reports from 2018 were not available at the time of writing this report) are shown in table 2.6-1 below.

Table 2.6-1: Reported commercial exports (CITES purpose code T) from Norway (exporter reported quantities) in the period between 2010 and 2017. Note that results from 2018 were not available at the time of finalizing the report.

Year	Importer	Quantity (kg)
2010	Faroe Islands	1000
2011	Faroe Islands	468
2012	Japan	30
2012	Faroe Islands	500
2013	Faroe Islands	2000
2013	Japan	40,709
2014	Faroe Islands	1000
2014	Iceland	10,000
2014	Japan	96,341
2015	Faroe Islands	6000
2015	Iceland	20,000
2016	Faroe Islands	864
2016	Japan	199,000
2017	Faroe Islands	864
2017	Japan	214,765

2.7 Regulation/legislation

B. acutorostrata has been listed on Appendix I of CITES since 1986, under the order listing of Cetacea spp. The minke whale has been listed in Annex A of the EU Wildlife Trade Regulations, also under the order listing of Cetacea spp. since 1997.

In Norway, the law of resources of the sea (Havressurssloven) (https://lovdata.no/dokument/NL/lov/2008-06-06-37) deals with marine resources and includes several regulations in relation to whaling. It states the permitted quotas per year and management block, hunting methods, licencing, documentation, DNA sample taking and export.

2.8 Assessment of data quality

Table 2.2.1-1 presents the number of sightings of minke whales within each small management area in the northeast Atlantic for the survey cycles 2002-2007, 2008-2013 and 2014-2019. It also presents the abundance estimated based on the sightings.

The survey methods and calculations for estimating minke whale abundance have been developed and improved over several years and the abundance estimates are officially approved by the International Whaling Commission. However, for an external group (like VKM's minke whale NDF-project group) it was rather difficult to assess the procedures beyond the translation of raw data (i.e. sightings) to corresponding local abundance estimates.

The Institute of Marine Research kindly provided the project group with a collection of scripts, these were however not written for externals and it was difficult to align them and recreate calculations. The group has therefore not obtained sufficient insight into the procedures for translating local to global abundance estimates and into how these together with other modifying factors lead to quota estimates. Further, there is a lack in the understanding of how uncertainties and data gaps are accounted for in the simulations aiming at predicting population trajectories.

3 Uncertainties

The minke whale is among the most difficult whales to count effectively (Pike et al., 2009). This is due to its relatively small size and that it occurs single or in very small groups and surfaces only for a very short period of time (Pike et al., 2009).

Minke whale management is further complicated by the fact that the species is relatively long-lived, slowly reproducing and highly migratory. The estimates and assumptions that feed into the Revised Management Procedure all introduce various types of uncertainties. These range from well-recognized statistical properties inherent in monitoring of wild animals, to less well-quantified uncertainties stemming from biological knowledge gaps and dynamic environmental processes.

We have defined three main classes of uncertainties:

I) Uncertainties inherent in survey and monitoring methods that are recognized in existing model frameworks, II) uncertainties stemming from fundamental data gaps in the population biology of minke whales (e.g. migration patterns), and III) uncertainties stemming from changes in the environment such as climate change affecting habitat, prey and phenology, or changes in bycatch frequencies in the unknown, unmonitored, winter habitat of minke whales.

I) Uncertainties inherent in survey and monitoring methods that are recognized in existing model frameworks.

Type I uncertainties are addressed in current methodology by the IWC Scientific Committee. However, the methods, practices and estimates are difficult to access for persons not directly involved in management.

II) Uncertainty due to lack of data on basic biology

As highlighted in section 2.1 and data gaps, studies of common minke whales are generally restricted to the summer feeding ground, and the locations of the breeding grounds are not known.

If genetic differentiation of breeding populations exists, the relative proportions of these in the feeding grounds, where hunting takes place is currently impossible to assess. If some breeding populations are smaller than others, they are particularly vulnerable to harvesting under the Revised Management Procedure (Punt and Donovan, 2007). This point has been addressed by the continued revision of simulations incorporated in the RMP framework, but uncertainties remain in the absence of conclusive genetic data from the (so far unknown) breeding grounds.

Moreover, survey of a certain area is conducted only every sixth year, introducing a time lag between the population estimate and the current stock situation. Given the large confidence intervals in surveys that are prone to conflate local and global abundance due to their incomplete spatial coverage, detectability of population decline may be low and /or introduce a significantly delay between population events and management response.

There is no surveillance of minke whale bycatch other mortalities like ship strikes and sonar/seismic stress in Norwegian waters. In addition, bycatch or winter mortalities would be overlooked until they became visible in the summer catches or surveys.

It is uncertain how the overrepresentation of females in the annual catches may affect population structure.

III) Uncertainties stemming from environmental changes and changes in human impact

Type III uncertainties reflect the effect of climate change and changing human impact on the minke whales and their habitat due to this interacting with fisheries on minke whale prey species, and bycatch/ other removal such as ship strikes, seismic surveys, naval sonar, fishing gear entanglement and oceanic pollution.

The rate of environmental change in the Arctic is strongly suggested to be accelerating (Figure 3.1-1). And while one may suspect that the net effect of climate change, oceanic acidification, increased human activity and fisheries is not positive for the minke whale population (see also 2.3), the reality is that it is currently not known by how much and how quickly. The realities of sparse surveillance and large uncertainties compounded by spatial population shifts and uncertain population structures means that there may be a considerable lag between events and detection.

Thus, while most efforts of model evaluation have been directed at observational and process error, structural errors are likely to result in poorer management model performance (Punt and Donovan, 2007), and may arise from an environment-model mismatch when conditions change.

Appendix I presents a population simulation model aiming at investigating the system's vulnerability to assumptions in a wider parameter space. The results from the simulations suggest that the uncertainties inherent in current methods (Type I) can mask, or disallow incorporation of, the effects of knowledge gaps such as mortality due to bycatch, hidden population structure and the observed gender bias in catches (type II), even current quota system can reduce and destabilize minke whale population dynamics and reduce their odds of survival when the environment changes unpredictably (type III). In short, cascading effects can become destabilizing and cause larger population impacts than assumed in the Revised Management Procedure before any adjustment to the quotas could be made. The ability to rapidly detect changes in population status and to minimize the current knowledge gaps is thus critical to adequate management.

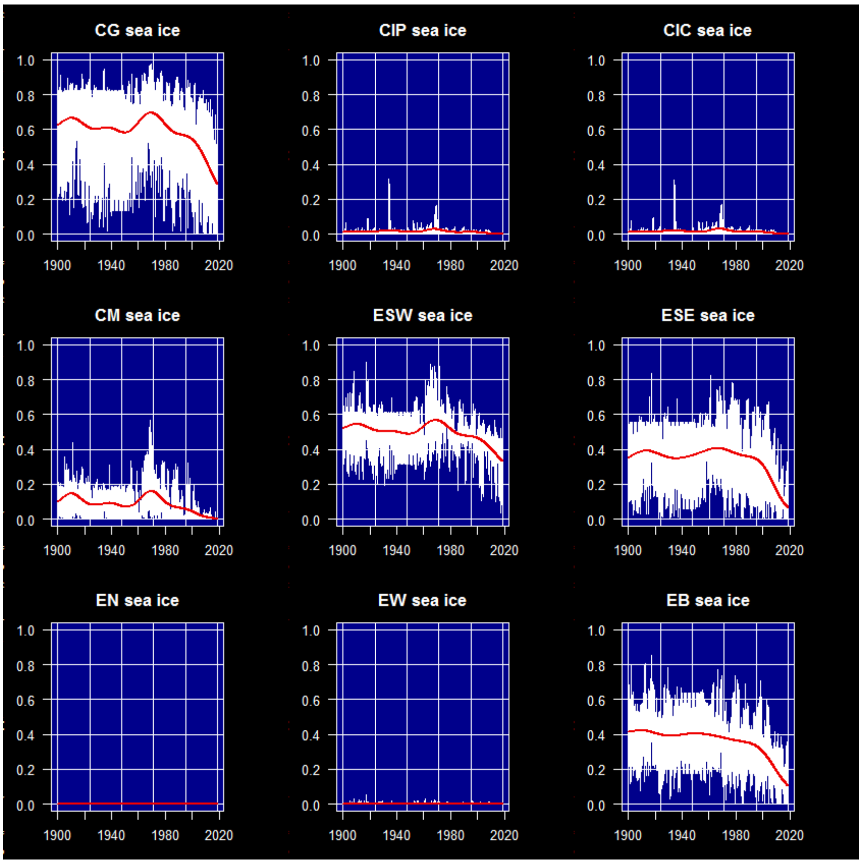

Figure 3.1-1 Mean sea ice cover in the different survey blocks shown on the map, demonstrating the spatial heterogeneity between the management areas as well as the accelerating overall trend towards loss of ice cover.

4 Conclusions (with answers to the terms of reference)

VKM adopted the **definition of detriment**, jf. Conf. 16.7 (Rev. CoP17), suggested by the U.S. Fish and Wildlife Service Division of Scientific Authority (https://www.fws.gov/international/pdf/archive/workshop-american-ginseng-cites-non-detriment-findings.pdf):

1. Harvest is not sustainable.
2. Harm to the status of the species in the wild.
3. Removal from the wild that results in habitat loss or destruction, or interference with recovery efforts for a species.

The export of any specimen of a species included in Appendix II require the prior grant and presentation of an export permit, that shall only be granted when the national Scientific Authority of has advised that such export will not be detrimental to the survival of that species (CITES Article IV).

Due to national reservations under CITES and International Whaling Commission (IWC), national harvest quotas in Norway is set annually by the Ministry of Trade, Industry and Fisheries, who base their decisions on advice from The North Atlantic Marine Mammal Commission (https://www.regjeringen.no/no/tema/mat-fiske-og-landbruk/fiskeri-og-havbruk/rad-1/kval-og-sel2/hvalfangst-etisk-og-barekraftig/id2505119/ and https://lovdata.no/dokument/LTI/forskrift/2013-12-13-1441). A review and update of the current NDF is recommended with new information on the population and/or with changes of the quota.

The current Norwegian harvesting quota for the common minke whale (*Balaenoptera acutorostrata*) of the northeast Atlantic constitutes a 1.27% of the estimated population size. Population estimates over the past 20 years indicate that the population has been relatively stable, and while there are fundamental data gaps and uncertainties related to the long-term persistence of this population, the export of minke whale harvested by Norway **does not appear to have been detrimental thus far.**

Whether or not VKM will be able to **continue to find no detriment** for the export of common minke whale from the Northeast Atlantic will depend on whether improvements are made in data collection and understanding of some of the factors contributing to the current uncertainty. Given the data gaps and the uncertainty related to factors such as the impact of climate change on population dynamics, a more conservative management approach could be considered for future whaling seasons. Furthermore, there is an urgent need for assessments of by-catch and ship strikes, in order to determine what additive mortality might be occurring. These improvements in monitoring needs to be made soon so that there is greater ability to react in real time and make changes in management to avoid adverse impacts (i.e., exacerbation of population declines) from harvest.

Finally, research directed towards filling the data gaps on basic biological parameters such as migration patterns, mating behaviour and structuring of breeding stocks is urgently needed. It is also unknown to what extent gender biased harvesting (in average >70 % females) since 1993 has affected the demographic structure of the population.

5 Data gaps

VKM identified the following data-gaps

- Lack of knowledge on breeding grounds and migratory patterns.
- Lack of knowledge on genetic structure of breeding populations.
- Lack of data of age and gender structure of populations.
- Lack of data on bycatch and other mortalities throughout the year.

In addition, VKMs project group did not manage to obtain information on:

- Whether and to what extent the Revised Management Procedure incorporates other human-induced excess mortality than hunting as required by the IWC RMP.
- Whether and to what extent the Revised Management Procedure incorporate environmental stochasticity as according to the RMP2 description.
- To what extent and how are the abundance estimates of the common minke whale will able to detect population declines and tell them apart from spatial shifts. Particularly if masked by slow declines in vital rates that make a population more vulnerable to extreme events.

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Appendix I

A.1.1 Population simulation model

A set of age-structured population models for panmictic or multiple populations of North Atlantic minke whale have been constructed and parameterized for survival, fecundity and other life history traits from the literature. While they display a number of relatively realistic dynamic behaviours, they are not intended to be improvements on current Institute of Marine Research (IMR) models with regards to predicting specific population trajectories. On the contrary, it is a complementary approach to address the vulnerability to assumptions in a wider parameter space.

In other words, this model can obviously not be accurately parameterized, simply because the knowledge of minke whale fundamental biology does not exist. We can, however, make some rough estimates based on general principles and the knowledge we do have, and use these as center points around which to explore parameter space. Non-stable combinations can be discarded as the population has obviously proven capable of existing indefinitely under the conditions hitherto experienced. The remainder of the plausible parameter space can then be examined for sensitivity to management procedures and conditions in the event that any given combination represents the true parameters.

The model is age-structured in discrete time on a monthly scale. When calf-bearing females are caught this reduces the number of one-month calves accordingly as it is assumed that newborns will not survive. Seasonality is introduced through annually repeating vectors modifying the probability of giving birth, background mortality from age and other causes, or being caught as bycatch or by whalers. Adding variance and trends to these vectors is used to simulate the effects of changing conditions following cyclical or long-term climate trends in a set of scenarios.

Model parameters are chosen so that the dynamics correspond to the assumed dynamics of an approximate carrying capacity K at which density regulation of reproduction equals background mortality rate, and a level 0.6K where annual recruitment is at maximum (see Figure 1.4-2 below). The tuning level and vital rates are set on the assumption that the IMR is right in that it is the optimal productivity point; the model stabilizes at any point above the allee threshold depending on conditions and implemented catch, but K is where it arrives at without perturbation, catch or prolonged adverse conditions. If one has a removal of individuals matched to maximum productivity at above 0.6K it moves to 0.6K, and if you have max outtake below max productivity the population declines further. But that is why the no-catch rule is implemented when the estimate has a p>0.5 of being at 0.54K, and the hunting algorithm works as a proportion of the estimates (for lack of better description of what they do), not a fixed number. The population estimate E is assumed to be corrected for the known skewness in gender distribution P_f among caught animals E_0 so that $E=0.5E_0P_f^{-1}$

according to the Revised Management Procedure (https://iwc.int/rmpbw#ann26). Thus, the model is fairly optimistic, and assumes no error in implementation of current management.

In many respects the approach is very similar to the robustness tests described for the Revised Management Procedure in Punt and Donovan (2007), except for that where some parameters like bycatch were varied over a continuous scale from 0 to somewhat above background (age-based) mortality, and environmental "disasters" were kept a lot less impactful that in Punt and Donovan (being implemented as a stochastic impact on recruitment rather than a linear decrease in conditions coupled with dramatic mortalities), age at maturity was not manipulated.

Each model run consists of one hunted and one non-hunted population subject to the same climate conditions but otherwise run separately (see Figures A.1.4-3-A.1.4-7 for example). At intervals *I* an estimate *E* is extracted as a Poisson draw of the mean annual population with or without a bias *B* and used as the basis for hunting quotas for the rest of the time interval.

The algorithm governing the outtake is adaptive and allowed a learning period of 1K time steps before each simulation begins to mimic intelligent management aiming to regulate the population at tuning level. If the estimate *E* is below the no-catch threshold of 0.54K used by IMR (Øien 2019 pers. comm) the quotas are set to zero for the whole interval.

After running the hunting algorithm learning period, 1K steps of relatively benign climate conditions are performed to weed out parameter combinations that do not produce stable dynamics, moving gradually into a regime of 1K steps of increasingly strong perturbations and/or negative trends. The "climate conditions" vector is a resampled series of the monthly mean sea surface temperature (SST) data (with seasonality intact so Januaries are drawn only from Januaries etc.) superimposed on means with trends and/or sine function fluctuations with decreasing periodicity and increasing variance to mimic climate conditions of increasing variance on multiple time scales. The time series is then feature scaled to a 0-1 range to enter the model as a consistent effect parameter. As shown in figure A.1.4-1, scenario 1 represents cyclic perturbations around a stationary mean (i.e. no trend), scenario 2 represents perturbations of increasing variance and frequency, and scenario 3 represent increasing perturbations like in the former but with a mean trend, thus in principle representing the most likely realistic situation.

The model is then run for 10K random permutations of parameters to check for the effect of management parameters and sensitivities inherent under the different assumptions.

Results

The models demonstrate, unsurprisingly, that long-lived mammal populations with limited reproduction are susceptible to even moderate increases in annual mortality. If we measure by mean population density in the hunted population as a proportion of that of the control population the last 360 time steps (i.e. 30 "years") of the simulation runs, then the results are surprisingly resilient to the exact value of the time interval between estimates.

The by far most important parameters influencing how the hunted population survives relative to the control population are the amount of bycatch (Bc; constrained up to about the same levels as background mortality as found in the studies referred to in "threats" or less), and the proportion of females caught (PFC; constrained to between 0.45 and 0.9, covering the skewed sex ratio reported for annual catches but assuming bycatch is not gender specific). The amount of bias in population estimates unsurprisingly also plays a role, particularly when the percentage of females caught is high. The effects were illustrated by generalized additive models using the variable parameters as non-parametric spline functions constrained to unimodality as predictor variables and the population mean and variances for the hunted and control populations as responses. See figures A.1.4-6 and A.1.4-7.

Conclusion

Data gaps need to be filled to ascertain the effects of continued hunting, in particular with regards to bycatch, other hidden causes of non-age specific mortalities and population structure. The spatial distribution of hunting efforts that result in the current disproportionate catch of females has a very strong reducing and destabilizing effect.

A.1.2 Software

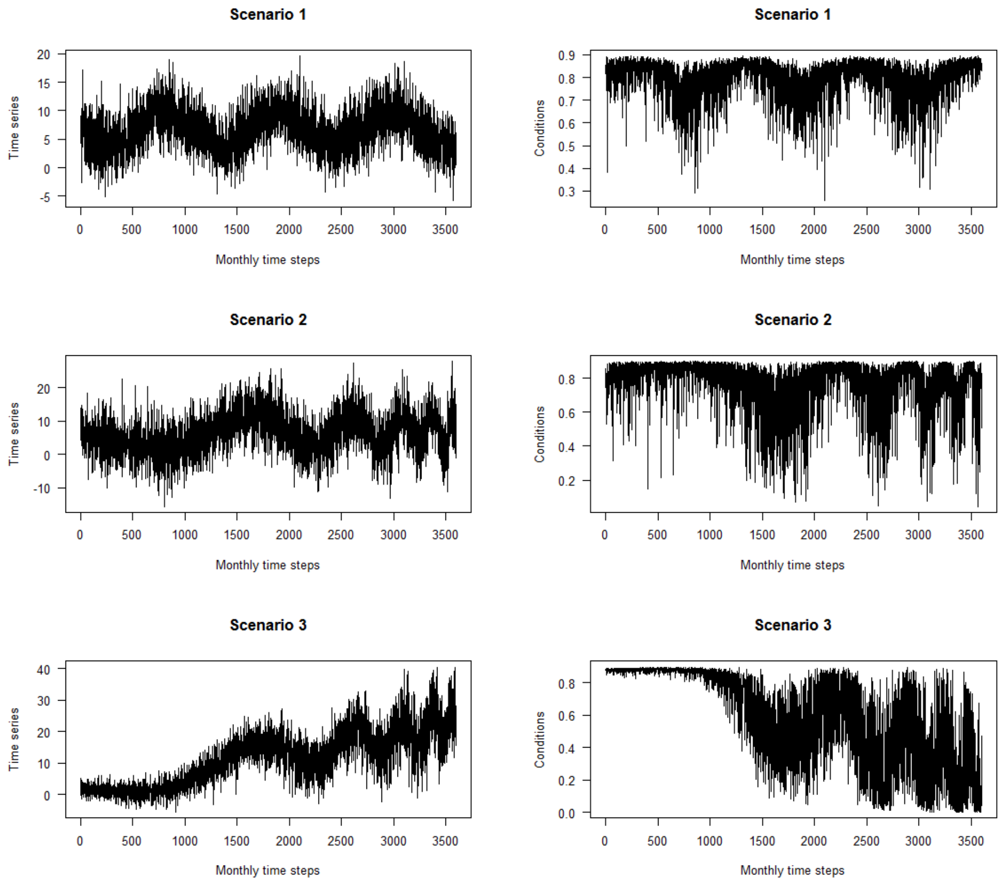
The software R 3.5.2 was used for analysis, with the packages chron, RColorBrewer, lattice, chron, RColorBrewer, ncdf4, mgcv, nlme, lattice, ggplot2, rgbif, dismo, rgdal, maptools, devtools, raster, sp, sf, spatialEco, fasterize, rasterVis, oce, smoothr, lwgeom, rgeos, and rmapshaper.

A.1.3 Temperature and sea ice data

Sea surface temperature and sea ice data were taken as monthly gridded reanalysis data from the ERA5 dataset from the Copernicus Climate Change Service (https://climate.copernicus.eu/climate-reanalysis) and ERA20C (before 1979) from the European Centre for Medium Range Weather Forecast (www.ecmwf.int), subsetted and aggregated to monthly values by the Norwegian Meteorological Institute, and temperatures converted to degrees Centigrade. The data covers the period January 1900-December 2018. Horizontal resolution for ERA5 is approximately 31km, while for ERA20C it is approximately 125km.

A.1.4 Figures

Figure A.1.4-1 Examples of the three different climate scenarios with the raw resampled sea



surface temperature (SST) data to the left and the climate conditions vector to the right.

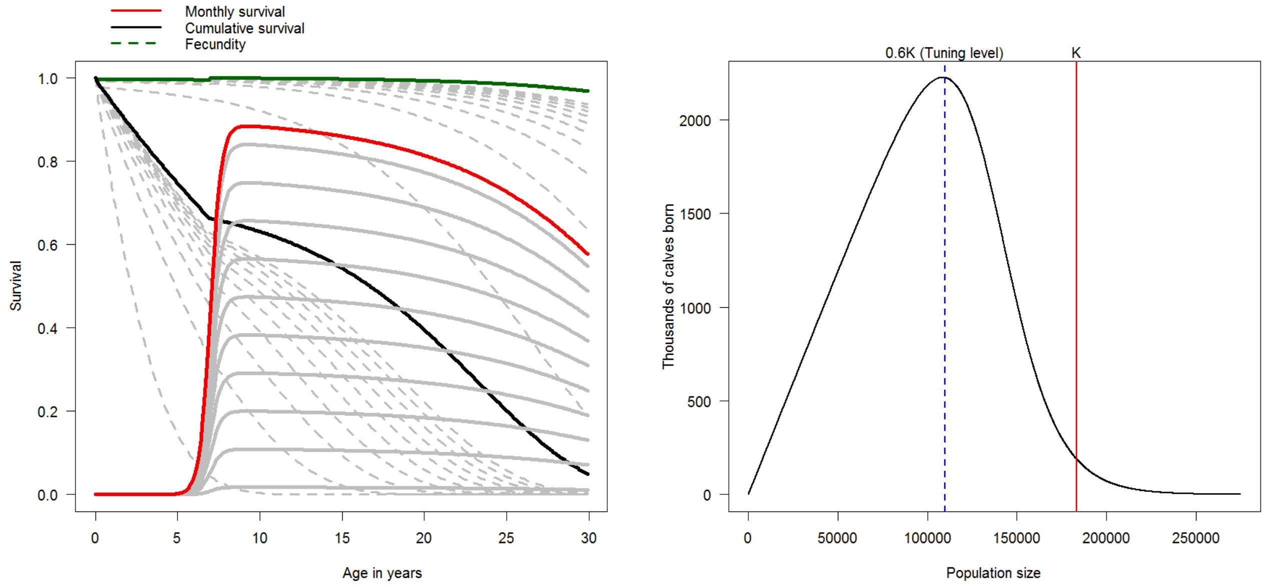


Figure A.1.4-2 Vital rates for the model population. Left panel: Optimal monthly mortality rate (red line), cumulative mortality rate (black line), and annual fertility rate (green line). Examples of sub-optimal conditions indicated as grey lines. Right panel: Population dynamics emerging from the vital rate parameters used. The population is stable at the carrying capacity K for the North Atlantic minke whale population, and at optimal productivity at tuning level 0.6K.

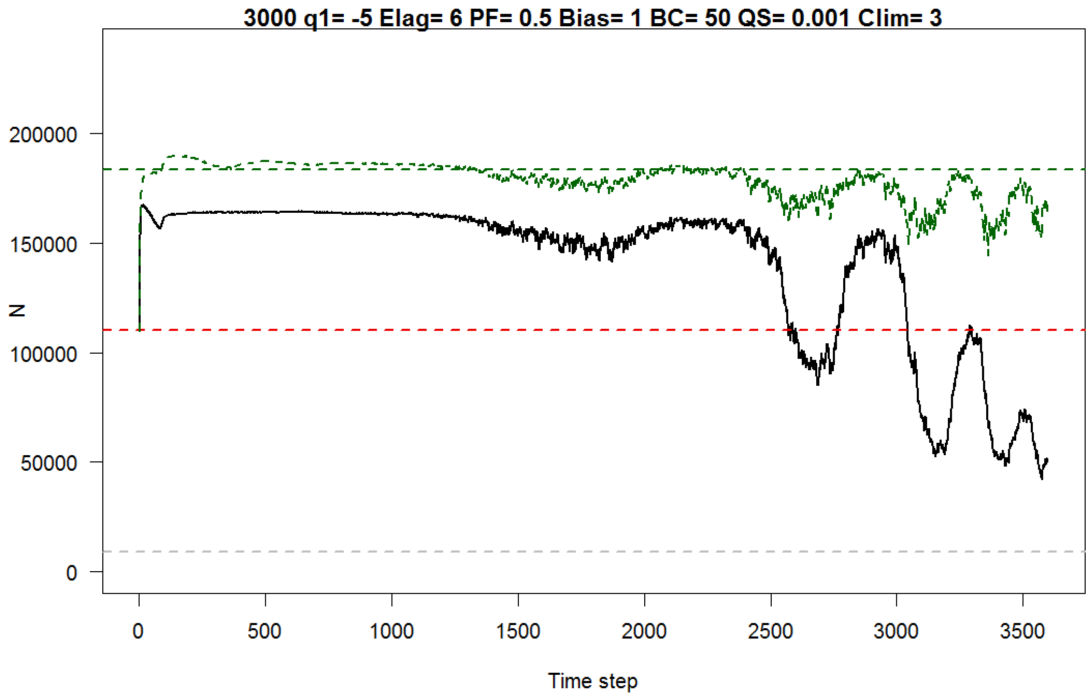


Figure A.1.4-3 Example model run. Control population subject to the same climate conditions vector of scenario 3, but not to hunting and bycatch in green, model hunted population in black. A run consists of 1K monthly time steps to allow the adaptive hunting algorithm to stabilize, 1K steps of relatively benign climate conditions to weed out parameter combinations that do not produce stable dynamics, and 1K steps of increasingly negative mean and variance to assess the differences under changing conditions. Green dotted line marks K, red dotted line tuning level 0.6K.

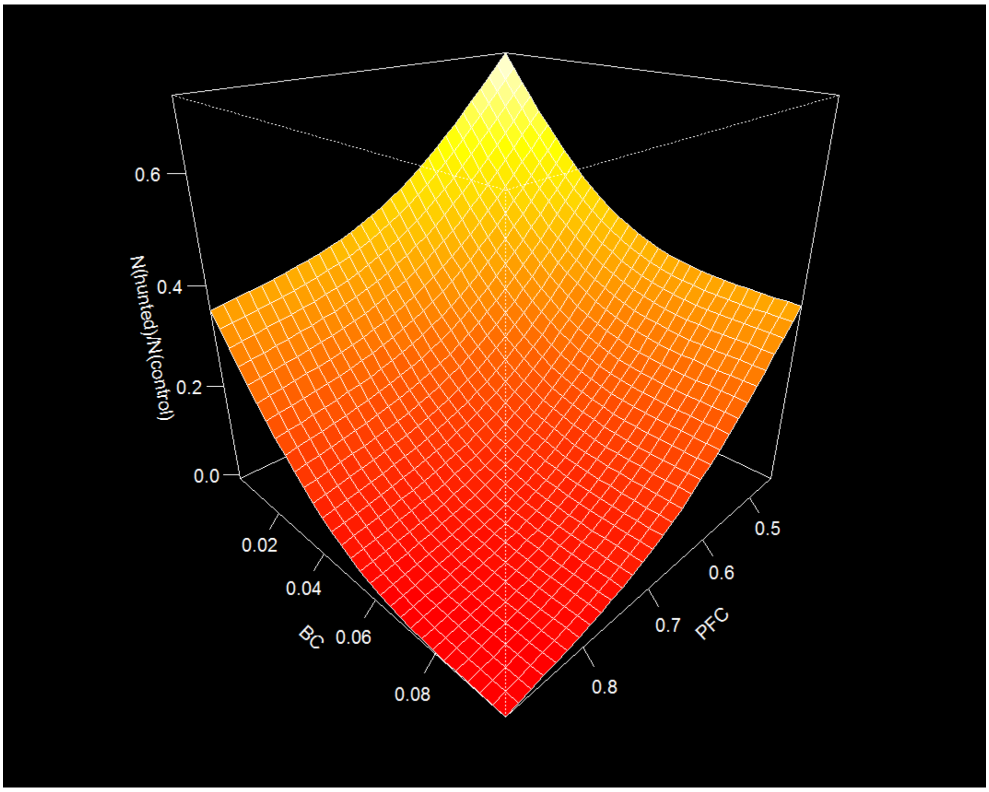


Figure A.1.4-3 Joint effects of proportions of catch being females (PFC) and bycatch rate (Bc) on the proportion of hunted populations to control populations in the last 360 time steps of simulation runs.

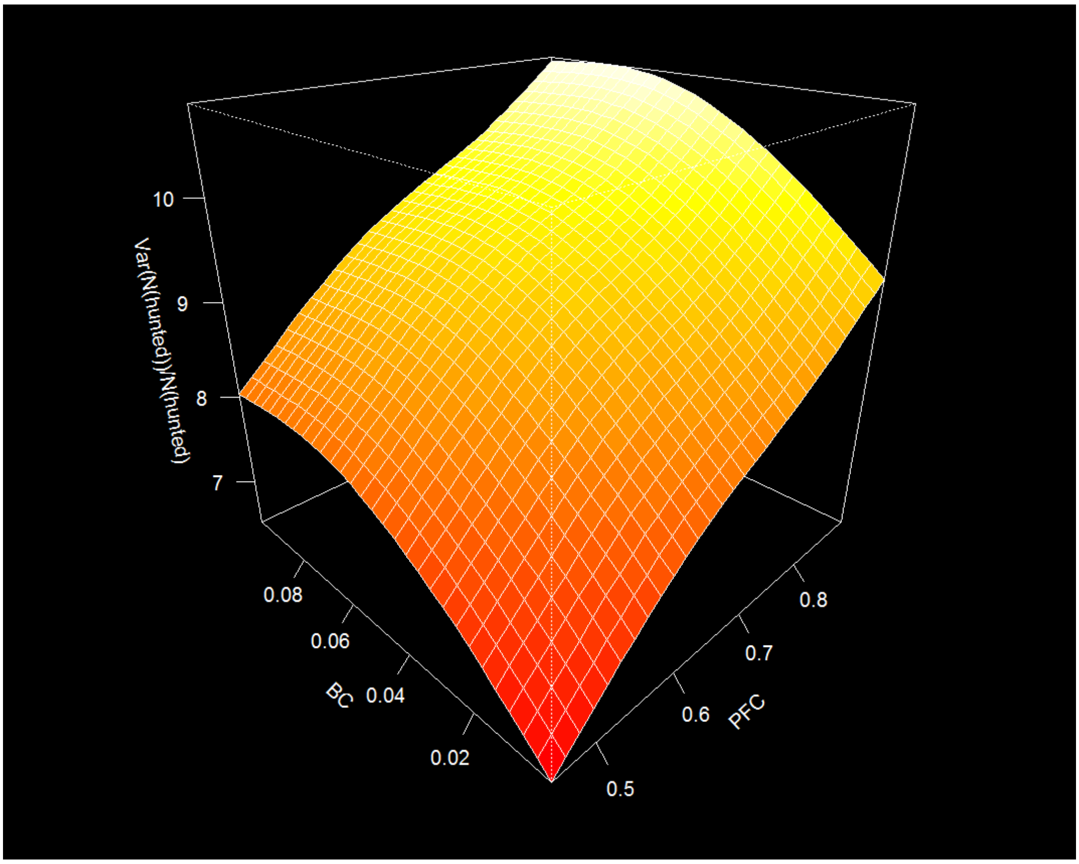


Figure A.1.4-5 Joint effects of proportions of catch being females (PFC) and bycatch rate (Bc) on the variance to mean ratio of hunted populations in the last 360 time steps of simulation runs.

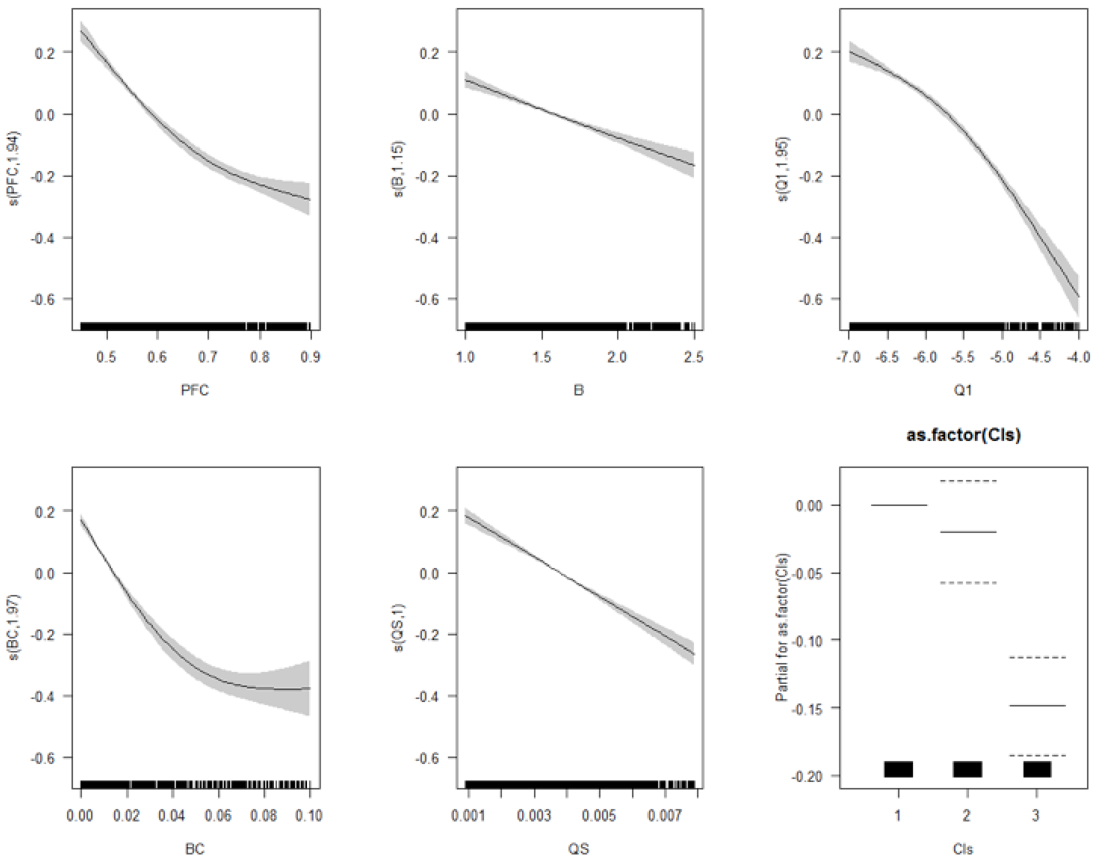


Figure A.1.4-6 Effects of all main management parameters varied on the proportion of hunted populations to control populations in the last 360 time steps of simulation runs. PFC = proportion of catch being female, BC = bycatc rate

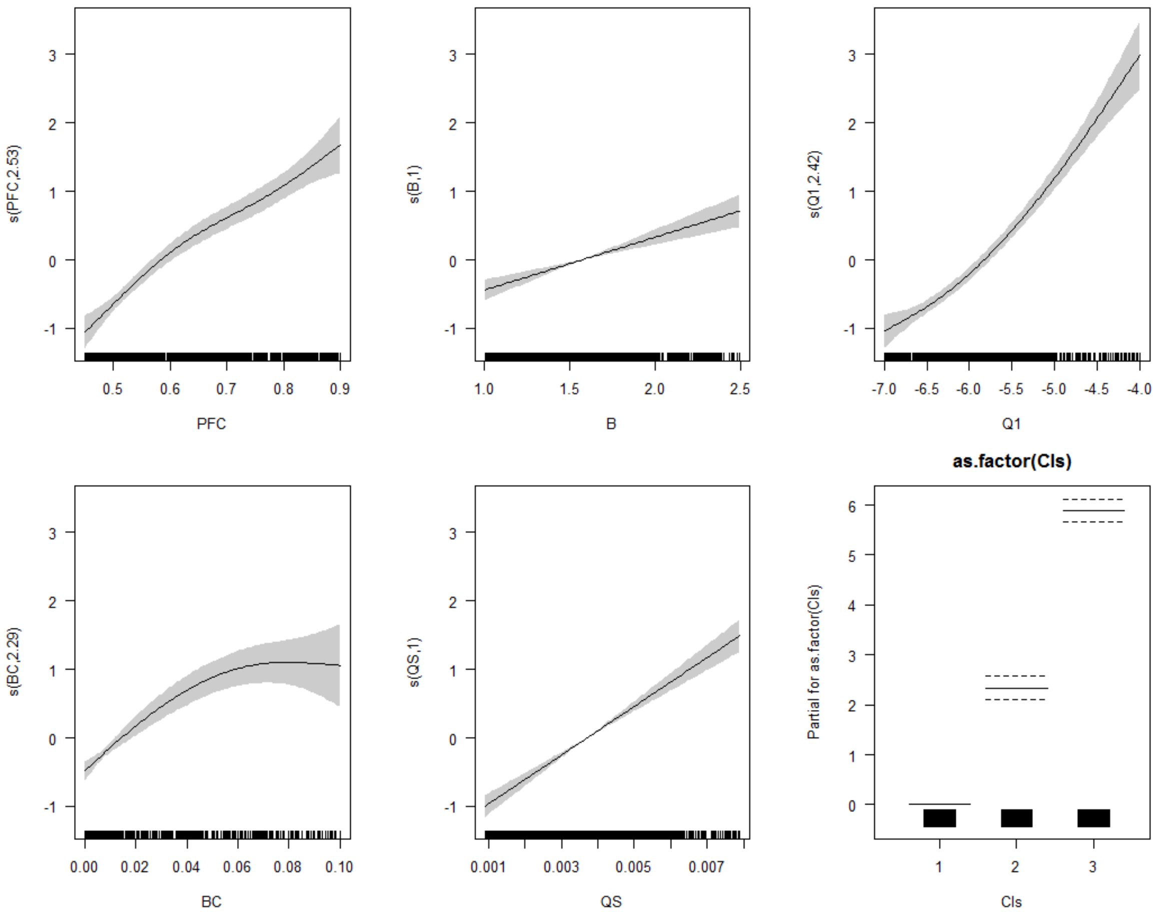


Figure A.1.4-7 Effects of all main management parameters varied on the variance to mean ratio of hunted populations in the last 360 time steps of simulation runs. PFC = proportion of catch being female, BC = bycatc rate

Appendix II

Catch data

Year	Area	Catch	Quota	%females
2018	E	454	1108	
2018	CM	0	170	
2018	Total	454	1278	77
2017	E	432	829	
2017	CM	0	170	
2017	Total	432	999	86
2016	E	591	710	
2016	CM	0	170	
2016	Total	591	880	75
2015	E	660	1016	
2015	CM	0	270	
2015	Total	660	1286	76
2014	E	736	1016	
2014	CM	0	270	
2014	Total	736	1286	67
2013	E	594	1016	
2013	CM	0	270	
2013	Total	594	1286	66
2012	E	464	1016	
2012	CM	0	270	
2012	Total	464	1286	67
2011	E	533	1016	
2011	CM	0	270	
2011	Total	533	1286	68
2010	E	467	1016	
2010	CM	1	270	
2010	Total	468	1286	77
2009	E	485	750	
2009	CM	0	135	
2009	Total	485	885	74
2008	E	506	900	
2008	CM	30	152	
2008	Total	536	1052	67
2007	E	597	900	
2007	CM	0	152	
2007	Total	597	1052	69
2006	E	545	609	
2006	CM	0	443	

2006	Total	545	1052	58
2005	E	634	651	
2005	CM	5	145	
2005	Total	639	796	75
2004	E	527	525	
2004	CM	17	145	
2004	Total	544	670	70
2003	E	626	674	
2003	CM	21	37	
2003	Total	647	711	65
2002	E	599	635	
2002	CM	35	36	
2002	Total	634	671	61
2001	E	521	518	
2001	CM	31	31	
2001	Total	552	549	62
2000	E	430	591	
2000	CM	57	64	
2000	Total	487	655	61
1999	E	530		
1999	CM	59		
1999	Total	589	753	67
1998	E	568		
1998	CM	57		
1998	Total	625	671	78
1997	E	482		
1997	CM	20		
1997	Total	502	580	76
1996	E	348		
1996	CM	40		
1996	Total	388	425	85
1995	E	175		
1995	CM	42		
1995	Total	217	232	83
1994	E	237		
1994	CM	41		
1994	Total	278	319	51
1993	E	213		
1993	CM	13		
1993	Total	226	296	54