

## 4. Direct and indirect drivers of change indifferent perspectives of human well-being (quality of life)

Ži šY š±°«@ flj a @S ' 2j Y» a E . « a ° @ ± ° ¥ E š ± ° « @ fl 3 Š S a ( ± a n a ! š @ Ž 2 š @ ° ° @ fl š a a j i t 2 j - - š « ž š ' l « m a a μ " j @ ± a Y fl š a - fl 0 Š a ž š ' ( j @ ! ± ° « a j a ° a Y j @ fl 0 E 3 4 Š j ; j @ j a \$ @ > j a . š ± j a l 0 @ j a ž ' fl š a j a l 2 š & « ° m ž š @ fl š @ @ Y ° \$ Š " « @ ¥ E J š a S o @ j a J « m š a a š R o « S ± š a a j V » 2 š @ M ¥ @ š j l K o ¥ P « ± j a

### Box 8: Summary

(m j - ± @ « j « C l š " l ' š - j - - @ j a ° - š ° « Y j - ¥ @ m « 3 ° m j a š ± @ Š 3 « @ Y š a Y m ± @ š a - « @ Y - ¥ ° j @ Š 3 ¥ m j š o « « m j @ š o « a p - ° ± š " j 2 j " - š @ j i ° š " fl š ¥ š ° Y j E @ Y š ° « a j ± @ - m ¥ @ « a @ m ¥ E š a Y @ Š ° j o š a E j š @ j i ' š @ - j - « C Y @ j @ « C o š a E j ° m š ° š @ @ » « @ Y @ Š - š ° m š ¥ š ° - \$ « ¥ p š a Y E « 2 j @ š a o p a @ - @ Š - š a Y ¥ @ @ d @ j @ t m š ° b « ° m c « ± Y l j š Y t « d j @ j a a Y Y j ° j @ Š ° « a - a - 3 j " a - ¥ @ - @ 2 j @ j a ° - a Y r j @ 2 j @ j - « C N « @ Y @ m š @ j e a 2 ¥ a @ j a ° -

š ° j o š a E j 3 ¥ š @ @ » « @ Y @ Š @ j > ¥ Y ¥ j @ ¥ μ - @ @ ± a Y μ ¥ ° m j @ ± @ > μ o š a E j - ¥ @ @ j ' š @ - j > ¥ @ j @ Š 3 o p o j - š a Y ¥ ° m j Y ¥ @ ± ° « a « C > ¥ Y ¥ j @ ¥ μ ' ± o š o š a E j - @ ¥ m ° j š Y ° « ¥ @ Š ° j Y « μ E j a Y j - j ° « a ¥ @ š μ š @ Š - j š S S E j « C a ± @ « a ° - o š a E j Y ° @ - m ¥ @ - @ @ Š @ - š a Y - @ Š Y « C - š ° « E j a - - š @ & « j a > j @ fl @ E « @ j i ° š " E ¥ ° m j @ @ « C - š @ « ± a ° ¥ @ - @ Š a o p ° m š ° j @ @ Š j E « 2 j @ š a o p ¥ Y j 2 j " « j Y ° « @ ¥ š ° j ¥ - š o Š « a a š ° ± @ - @ a ° @ ± ° « a - ° « - j - j " . \$ ) š a Y ° « > ± Y ± - š ¥ š ¥ μ š a Y - @ Š ° E j - @ @ ± - š ¥ š ¥ μ . m š - ¥ j ° š " ž i - - « 2 j @ Š m ¥ E j - j - j ± @ - m ¥ @ « a @ 3 j @ - « ± a ° - š a Y j ° j @ š a Y ± j š a Y a š o p - @ j o Š a š @ @ j š ± @ - t m š ° w ¥ j i - @ 2 j t m j o 2 j @ - j - ¥ a o p o C N « @ Y @ « š - š ° e a 2 ¥ a @ j a ° -

### 4.1 Introduction

š " l ' š - j - - @ j a ° - š ° « o « a p - ° ± š " μ Y j - ¥ @ m « 3 ° m j a š ± @ Š 3 « @ Y š a Y m ± @ š a - « @ Y - ¥ ° j @ Š 3 ¥ m j š o « « m j @ ) " l \$ H ± @ š a š o Š a - @ š μ ¥ C ± j a o p a š ± @ Š Y @ j @ š a Y g ¥ j r ¥ j ° « a j 3 - « @ - « C Y @ j @ « C o š a E j ° m š ° š @ @ » . \$ ¥ š @ ± ° ¥ ± Y j « C 3 š μ / « @ ¥ - š a o p @ @ @ - š ° « a j š Y ¥ E ° « > @ 3 a ¥ @ Š ° « a ¥ j ° m j - @ o p - « C m ± @ ¥ @ - ± - š a o p - @ @ @ @ - š a Y @ « « @ 3 m ¥ @ « C j a š @ @ « ± @ Y » @ 3 a Y ± j « š ° š o j Y ¥ a a @ @ r ¥ j @ a Y c « š - š " h š ¥ š ° - ( K @ j j i @ 2

- ¥ @ Š @ j @ « C o š a E j > « m a š ± @ Š a Y š a ° m @ - « E j a ¥ @ j @ @ š a š o p Y ¥ @ j μ š a Y ° m j @ > μ ¥ - > ¥ Y ¥ j @ ¥ μ š a Y " . \$ E Y ¥ @ Š @ j @ « C o š a E j - ± o š o š a E j - š a Y E « 2 j @ š a o p - μ j i @ - @ @ « @ 3 - j « - j š a Y - « @ Y - « @ Š a ¥ j ° m j @ j 2 j - š a Y ° m j ¥ ¥ j ° j @ Š a - 3 ¥ m a š ± @ š ° Y @ @ a ° - o š j - fl « 2 j @ š a o p š " a E 3 ¥ m j @ « « @ Š - « @ Š

°j oē<sup>a</sup> «<sup>o</sup> EYōō<sup>o</sup> š<sup>a</sup> Ÿōē<sup>o</sup> ±ōō<sup>o</sup> Ÿj 2j «<sup>o</sup> -ōj<sup>o</sup> a<sup>o</sup> - šō<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> qō<sup>o</sup> ŸŸōō<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> «<sup>o</sup> cōōš<sup>a</sup> E<sup>o</sup> (m<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> cē<sup>o</sup> cš<sup>a</sup> b<sup>o</sup> j<sup>o</sup> b<sup>o</sup> j<sup>o</sup> a<sup>o</sup> j<sup>o</sup> cōōō<sup>o</sup> o<sup>o</sup> d<sup>o</sup> j<sup>o</sup> °ōō<sup>o</sup> j<sup>o</sup> °ōō<sup>o</sup> t<sup>o</sup> «<sup>o</sup> s<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> μ<sup>o</sup> pš<sup>o</sup> μ<sup>o</sup> d<sup>o</sup> j<sup>o</sup> -j<sup>o</sup> a<sup>o</sup> ŸŸ<sup>o</sup> E<sup>o</sup> «<sup>o</sup> t<sup>o</sup> m<sup>o</sup> c<sup>o</sup> «<sup>o</sup> a<sup>o</sup> j<sup>o</sup> °

## 4.2 Direct drivers – definition

### 4.2.1 Natural direct drivers

" š<sup>o</sup> ±ōō<sup>o</sup> ŸŸōō<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> -j<sup>o</sup> °mš<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> «<sup>o</sup> š<sup>o</sup> ŸŸōō<sup>o</sup> cēŸōōj<sup>o</sup> ±ōō<sup>o</sup> «<sup>o</sup> c<sup>o</sup> m<sup>o</sup> ±ōō<sup>o</sup> š<sup>a</sup> šōōŸŸōō<sup>o</sup> - š<sup>a</sup> Ÿ<sup>o</sup> 3<sup>o</sup> m<sup>o</sup> -j<sup>o</sup> «<sup>o</sup> cōōō<sup>o</sup> qō<sup>o</sup> Ÿ<sup>o</sup> > j<sup>o</sup> μ<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> m<sup>o</sup> ±ōō<sup>o</sup> š<sup>a</sup> cōō<sup>o</sup> «<sup>o</sup> m<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> μ<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> m<sup>o</sup> š<sup>o</sup> 2j<sup>o</sup> a<sup>o</sup> j<sup>o</sup> Eš<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> š<sup>o</sup> 3<sup>o</sup> j<sup>o</sup> -j<sup>o</sup> «<sup>o</sup> -ŸŸōō<sup>o</sup> j<sup>o</sup> Ÿōō<sup>o</sup> «<sup>o</sup> a<sup>o</sup> š<sup>o</sup> ±ōō<sup>o</sup> qō<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> m<sup>o</sup> ±ōō<sup>o</sup> š<sup>a</sup> - «<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> (m<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> cēŸōō<sup>o</sup> Ÿ<sup>o</sup> a<sup>o</sup> š<sup>o</sup> ±ōō<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> j<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> 3<sup>o</sup> j<sup>o</sup> š<sup>o</sup> m<sup>o</sup> j<sup>o</sup> pš<sup>o</sup> °j<sup>o</sup> ®<sup>o</sup> - e<sup>o</sup> °m<sup>o</sup> cō<sup>o</sup> j<sup>o</sup> e<sup>o</sup> 2j<sup>o</sup> a<sup>o</sup> - s<sup>o</sup> ±ōō<sup>o</sup> a<sup>o</sup> - d<sup>o</sup> qō<sup>o</sup> ±<sup>o</sup> E<sup>o</sup> m<sup>o</sup> - f<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> - a<sup>o</sup> Ÿ<sup>o</sup> v<sup>o</sup> «<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> cē<sup>o</sup> - °m<sup>o</sup> «<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> -j<sup>o</sup> cōōō<sup>o</sup> μ<sup>o</sup> cōō<sup>o</sup> m<sup>o</sup> j<sup>o</sup> " «<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> E<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> qō<sup>o</sup> -j<sup>o</sup> a<sup>o</sup> 3<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> °ōō<sup>o</sup> š<sup>a</sup> E<sup>o</sup> > j<sup>o</sup> °3<sup>o</sup> j<sup>o</sup> j<sup>o</sup> a<sup>o</sup> °m<sup>o</sup> " š<sup>o</sup> Ÿ<sup>o</sup> cē<sup>o</sup> j<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> t<sup>o</sup> m<sup>o</sup> N<sup>o</sup> «<sup>o</sup> m<sup>o</sup> S<sup>o</sup> j<sup>o</sup> š<sup>o</sup> a<sup>o</sup> - w<sup>o</sup> j<sup>o</sup> " a<sup>o</sup> - oōōō<sup>o</sup> «<sup>o</sup> š<sup>o</sup> - e<sup>o</sup> - Ÿ<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> cē<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> p<sup>o</sup> š<sup>a</sup> ° d<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> š<sup>o</sup> -j<sup>o</sup> -

### 4.2.2 Anthropogenic direct drivers

° a<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> -j<sup>o</sup> °mš<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> ±ōō<sup>o</sup> «<sup>o</sup> c<sup>o</sup> m<sup>o</sup> ±ōō<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> cōōŸ<sup>o</sup> a<sup>o</sup> - š<sup>a</sup> Ÿ<sup>o</sup> šōōŸ<sup>o</sup> a<sup>o</sup> - ' «<sup>o</sup> cō<sup>o</sup> j<sup>o</sup> j<sup>o</sup> š<sup>o</sup> cō<sup>o</sup> -j<sup>o</sup> - «<sup>o</sup> c<sup>o</sup> š<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> -j<sup>o</sup> qō<sup>o</sup> ±ōō<sup>o</sup> Ÿ<sup>o</sup> E<sup>o</sup> qō<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> a<sup>o</sup> - Ÿ<sup>o</sup> cōō<sup>o</sup> «<sup>o</sup> «<sup>o</sup> ®<sup>o</sup> š<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> «<sup>o</sup> cō<sup>o</sup> j<sup>o</sup> a<sup>o</sup> «<sup>o</sup> c<sup>o</sup> š<sup>o</sup> Ÿ<sup>o</sup> ±<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> š<sup>o</sup> E<sup>o</sup> cōō<sup>o</sup> ±ōō<sup>o</sup> qō<sup>o</sup> qō<sup>o</sup> - qō<sup>o</sup> °m<sup>o</sup> j<sup>o</sup> °ōōō<sup>o</sup> a<sup>o</sup> «<sup>o</sup> c<sup>o</sup> E<sup>o</sup> cōō<sup>o</sup> 2j<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> -j<sup>o</sup> š<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> E<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> - °m<sup>o</sup> cōō<sup>o</sup> a<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> 2j<sup>o</sup> «<sup>o</sup> -ōj<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> š<sup>o</sup> š<sup>o</sup> qō<sup>o</sup> š<sup>o</sup> - ' «<sup>o</sup> cō<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> šō<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> cēŸ<sup>o</sup> - «<sup>o</sup> c<sup>o</sup> ±ōō<sup>o</sup> Ÿ<sup>o</sup> a<sup>o</sup> - mš<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> ±<sup>o</sup> - ±<sup>o</sup> - °s<sup>o</sup> cō<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> š<sup>a</sup> E<sup>o</sup> - qō<sup>o</sup> Ÿ<sup>o</sup> ±ōō<sup>o</sup> Ÿ<sup>o</sup> > μ<sup>o</sup> š<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> «<sup>o</sup> a<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> -j<sup>o</sup> š<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> E<sup>o</sup> «<sup>o</sup> - «<sup>o</sup> ±ōō<sup>o</sup> «<sup>o</sup> c<sup>o</sup> - «<sup>o</sup> Ÿ<sup>o</sup> wš<sup>o</sup> j<sup>o</sup> ®<sup>o</sup> o<sup>o</sup> a<sup>o</sup> m<sup>o</sup> qō<sup>o</sup> d<sup>o</sup> cēŸ<sup>o</sup> j<sup>o</sup> ®<sup>o</sup> l<sup>o</sup> j<sup>o</sup> š<sup>o</sup> Ÿ<sup>o</sup> t<sup>o</sup> mš<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> d<sup>o</sup> j<sup>o</sup> E<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> «<sup>o</sup> w<sup>o</sup> m<sup>o</sup> qō<sup>o</sup> š<sup>o</sup> - o<sup>o</sup> m<sup>o</sup> qō<sup>o</sup> t<sup>o</sup> mš<sup>o</sup> a<sup>o</sup> qō<sup>o</sup> t<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> qō<sup>o</sup> t<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> - ±ōō<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> - l<sup>o</sup> j<sup>o</sup> š<sup>o</sup> Ÿ<sup>o</sup> ° e<sup>o</sup> cēŸ<sup>o</sup> «<sup>o</sup> a<sup>o</sup> - o<sup>o</sup> cōō<sup>o</sup> cōō<sup>o</sup> cē<sup>o</sup> a<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> - F<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> E<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> «<sup>o</sup> m<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> cōō<sup>o</sup> - «<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> j<sup>o</sup> - Ÿ<sup>o</sup> E<sup>o</sup> «<sup>o</sup> c<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> - «<sup>o</sup> -j<sup>o</sup> ±ōō<sup>o</sup> «<sup>o</sup> - š<sup>o</sup> 3<sup>o</sup> j<sup>o</sup> -j<sup>o</sup> -j<sup>o</sup> cōō<sup>o</sup> - Ÿ<sup>o</sup> °m<sup>o</sup> Ÿ<sup>o</sup> ±ōō<sup>o</sup> «<sup>o</sup> - š<sup>o</sup> qō<sup>o</sup> j<sup>o</sup> š<sup>o</sup> cō<sup>o</sup> -j<sup>o</sup> «<sup>o</sup> c<sup>o</sup> Ÿ<sup>o</sup> - «<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> cēŸ<sup>o</sup> j<sup>o</sup> ®<sup>o</sup> 3<sup>o</sup> Ÿ<sup>o</sup> m<sup>o</sup> - «<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> - °m<sup>o</sup> a<sup>o</sup> E<sup>o</sup> Ÿ<sup>o</sup> - šōō<sup>o</sup> «<sup>o</sup> a<sup>o</sup> °m<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> j<sup>o</sup> a<sup>o</sup> 2<sup>o</sup> Ÿ<sup>o</sup> a<sup>o</sup> cō<sup>o</sup> j<sup>o</sup> a<sup>o</sup> E<sup>o</sup> cōō<sup>o</sup> š<sup>a</sup> μ<sup>o</sup> cōō<sup>o</sup> -j<sup>o</sup> - Ÿ<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> «<sup>o</sup> > j<sup>o</sup> °3<sup>o</sup> j<sup>o</sup> j<sup>o</sup> a<sup>o</sup> š<sup>o</sup> ±ōō<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> š<sup>a</sup> °m<sup>o</sup> qō<sup>o</sup> - «<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> cēŸ<sup>o</sup> j<sup>o</sup> ®<sup>o</sup> cōō<sup>o</sup> m<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> j<sup>o</sup> o<sup>o</sup> m<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> cōō<sup>o</sup> qō<sup>o</sup> t<sup>o</sup> m<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> cē<sup>o</sup>

## 4.3 Indirect drivers – definitions

E<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> šō<sup>o</sup> °m<sup>o</sup> ±<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> μ<sup>o</sup> Ÿ<sup>o</sup> E<sup>o</sup> cōō<sup>o</sup> ±<sup>o</sup> -j<sup>o</sup> «<sup>o</sup> cōōš<sup>a</sup> E<sup>o</sup> °mš<sup>o</sup> šō<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> «<sup>o</sup> ±ōō<sup>o</sup> Ÿ<sup>o</sup> °m<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> μ<sup>o</sup> -j<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> -j<sup>o</sup> °m<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> -j<sup>o</sup> °m<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> μ<sup>o</sup> Ÿ<sup>o</sup> cēŸ<sup>o</sup> a<sup>o</sup> qō<sup>o</sup> š<sup>o</sup> -j<sup>o</sup> cē<sup>o</sup> «<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> «<sup>o</sup> m<sup>o</sup> Ÿ<sup>o</sup> > j<sup>o</sup> °3<sup>o</sup> j<sup>o</sup> j<sup>o</sup> a<sup>o</sup> -j<sup>o</sup> «<sup>o</sup> -j<sup>o</sup> š<sup>a</sup> Ÿ<sup>o</sup> a<sup>o</sup> š<sup>o</sup> ±ōō<sup>o</sup> l<sup>o</sup> š<sup>o</sup> cō<sup>o</sup> -j<sup>o</sup> - Ÿ<sup>o</sup> cēŸōō<sup>o</sup> j<sup>o</sup> E<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> «<sup>o</sup> a<sup>o</sup> °m<sup>o</sup> «<sup>o</sup> cōōš<sup>a</sup> Ÿ<sup>o</sup> «<sup>o</sup> c<sup>o</sup> «<sup>o</sup> cōō<sup>o</sup> š<sup>o</sup> Ÿ<sup>o</sup> - Ÿ<sup>o</sup> Ÿ<sup>o</sup> ±ōō<sup>o</sup> a<sup>o</sup> - š<sup>a</sup> Ÿ<sup>o</sup> °m<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> «<sup>o</sup> Ÿ<sup>o</sup> (m<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> cē<sup>o</sup> cōō<sup>o</sup> > j<sup>o</sup> - «<sup>o</sup> - Ÿ<sup>o</sup> Ÿ<sup>o</sup> «<sup>o</sup> ®<sup>o</sup> j<sup>o</sup> Eš<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> m<sup>o</sup> j<sup>o</sup> Ÿ<sup>o</sup> š<sup>o</sup> - «<sup>o</sup> ±ōō<sup>o</sup> j<sup>o</sup> ®<sup>o</sup> - «<sup>o</sup> Ÿ<sup>o</sup> -j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> a<sup>o</sup> «<sup>o</sup> a<sup>o</sup> cōō<sup>o</sup> j<sup>o</sup> ° (m<sup>o</sup> j<sup>o</sup> š<sup>o</sup> qō<sup>o</sup> cōō<sup>o</sup> Ÿ<sup>o</sup> j<sup>o</sup> qō<sup>o</sup> Ÿ<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup> > j<sup>o</sup> cōō<sup>o</sup> ±<sup>o</sup> -j<sup>o</sup> Ÿ<sup>o</sup> °m<sup>o</sup> 2<sup>o</sup> š<sup>o</sup> - cōō<sup>o</sup> š<sup>o</sup> «<sup>o</sup> cōō<sup>o</sup> -j<sup>o</sup> - °m<sup>o</sup> j<sup>o</sup> μ<sup>o</sup> Ÿ<sup>o</sup> a<sup>o</sup> «<sup>o</sup> š<sup>o</sup> cōō<sup>o</sup> cē<sup>o</sup> a<sup>o</sup> š<sup>o</sup> ±ōō<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> μ<sup>o</sup> > ±ōō<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> °m<sup>o</sup> qō<sup>o</sup> ±<sup>o</sup> E<sup>o</sup> t<sup>o</sup> m<sup>o</sup> Ÿ<sup>o</sup> cōō<sup>o</sup> a<sup>o</sup> d<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> «<sup>o</sup> E<sup>o</sup> j<sup>o</sup> a<sup>o</sup> Ÿ<sup>o</sup> cēŸōōj<sup>o</sup> ®<sup>o</sup>







Leisure boating affects many Nordic coastal regions. At Lumparn in the Åland archipelago, habitat degradation has been linked to intensive boating, which is thought to have adverse impacts on macrophytes (submerged plants), as well as on other benthic organisms (Vävare & Häggblom, 2018).

*Acidification* is a significant driver in the Bothnian Bay (Swedish Water Authority, 2017), in the Quark area and in the estuaries in Ostrobothnia (western Finland around the Quark archipelago). Because of discharges from acidified rivers, fish kills and metal loading occasionally occur in the coastal environment (HELCOM, Kronholm *et al.*, 2005). Acidification of water bodies is a result of acidic sulphate soils and is a process that is accelerated by the draining of land for agriculture and forestry. Acidification is also a mounting threat on a global scale, due to the increased atmospheric content of CO<sub>2</sub>, which leads to a higher content of carbonic acid in seawater.

**Box 9: Competition for space in the most densely populated Nordic area**

Competition for space both on land and at sea is a critical issue in densely populated areas. The Sound region is the most densely populated area in Scandinavia with about two million inhabitants, who with their modern lifestyles and high demand for various resources, have the potential to effect ecosystems and biodiversity in a multitude of ways (Fig. 33). There is an urgent need for regulating the use of marine and coastal space in the region due to shipping, fishing, recreation and tourism, housing and infrastructure development projects such as a bridge and tunnel across the Sound, new harbours and offshore wind turbine parks. The extraction of sand and other materials also put strains on the bottom habitats in the Sound (c.f. <https://www.theguardian.com/cities/2017/feb/27/sand-mining-global-environmental-crisis-never-heard>, viewed April 17, 2018). Policy instruments that aim to deal with spatial planning and clarify which interests take priority in various areas at the coast and in the sea include Marine Spatial Planning using an ecosystem – approach, the introduction of exclusive economic zones and Integrated Coastal Zone Management.

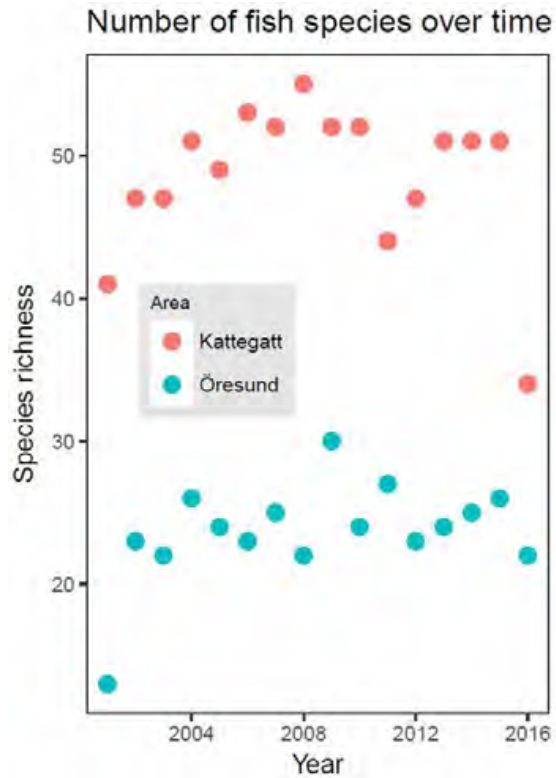
Figure 33: Competition for space and demand of NCP: The Sound is the most densely populated area in Scandinavia, still there are numerous bathing places to visit and the quality of bathing water is mostly good to excellent



Note: High bathing water quality also means clearer water and improved conditions for higher biodiversity.

Source: Data from the European Environment Agency for 2016: see Petersen *et al.* 2018.

Figure 34: Cod abundance in the Kattegat and Öresund over time: Catch per unit effort (kg cod per trawling hour)



Source: Data have been retrieved from [www.ices.dk](http://www.ices.dk), viewed in March 2, 2018.

**Box 10: Competition for space in the most densely populated Nordic area: trawling ban regulation**

The Sound region is one of the most densely sea-trafficked places in the world oceans. This condition affects the environment both directly through emissions of various hazardous substances and underwater noise. These demands for space have led to responses by governance systems, with unintentional benevolent consequences: because the Sound has been heavily trafficked for a long time, towing of fishing gears was already forbidden in 1932 (Anon., 1932).

It is hence interesting to note that there are indications of a somewhat healthier status of the Sound cod stock relative to the nearby stocks in Kattegat (Fig. 34). Fishery management of the Sound is co-managed with the rest of the western Baltic (e.g. ICES, 2016), which as a consequence, means that fishing quotas seldom are limiting in the Sound. Instead, it is the ban on trawling that is regulating; fishing is carried out with less efficient and less size-selective artisanal fishing methods, which in the end has preserved the stock in a much more productive state compared to other adjacent cod stocks in the Baltic (Svedäng & Hornborg, 2017).



*Eutrophication* is a key anthropogenic driver of change and involves complex processes of nutrient discharges from e.g. municipalities, agriculture, fish farms, shipping and transport. This enrichment may lead to increased production of organic material such as filamentous algae, or phytoplankton blooms that can cause changes in trophic structures. The outcome of the enrichment depends both on the flow of nutrients and the trophic structure.

In the Sound, discharges of nutrients from municipalities and surrounding intensively cultivated land have enriched the environment and resulted in higher primary production. This higher production of organic matter sometimes results in seasonal hypoxia, especially during the late summer. Improved sewage treatment and changed land management practices have counteracted the degree of eutrophication. Musselbeds and eelgrass meadows also help to mediate the inflow of nutrients, hence increasing ecosystem resilience. Because of the filtering of the water masses by the mussel beds, phytoplankton biomasses are lowered, counteracting water turbidity (e.g. Lindahl *et al.*, 2005). This improved water transparency favours eelgrass growth at greater depths. Eelgrass meadows are beneficial for mediating nutrient flows (Oshima *et al.*, 1999).

The more natural, or less truncated, fish population size structures found in the Sound in comparison to adjacent sea areas (Box 10) also ensure that more regular trophic relationships prevail, which in turn, support macroalgae and macrophytes at the expense of filamentous algae (Moksnes *et al.* 2008). When predatory fish such as Atlantic cod disappear, grazing pressure on filamentous algae is reduced, leading to shadowing and suffocation of eelgrass meadows, decreased biodiversity and less suitable nursery habitats for many fish, including Atlantic cod.

In the Helgeland area on the northwest coast of Norway, transportation of nutrients by sea currents from western Europe may be causing eutrophication (Andersen *et al.*, 2016, Gundersen *et al.*, 2016). The response of seagrass ecosystems to coastal nutrient enrichment has shown to follow a “threshold pattern”. When nutrient enrichment exceeded moderate levels, a switch from positive to negative net leaf production was observed. Epiphyte load also increased with nutrient enrichment, potentially driving this shift (Connell *et al.*, 2017). Eventually, it may cause eelgrass meadows to decrease. As a consequence, biodiversity and fish nursery areas will disappear as well.

The inshore area at Lumparn in the Åland archipelago is highly sensitive to local enrichment, leading to eutrophication due to its limited water circulation. Nutrients are discharged from agriculture, settlements and private sewers, leading to severe problems with algae blooms in some years. When water quality declines, it affects recreational values and quality of life.

*Fishing* is an essential direct driver in all Nordic coastal waters. For instance, the rich herring fishery in the Sound may have been the main reason and motivation for its first settlements (Fig. 35). Fishing in the Nordic countries often includes intense professional, subsistence and leisure fishing.

Fishing may lead to erosion of size and genetic structure, lower productivity, changed trophic relationships, trophic cascades or starvation of seabirds. The effects of

fishing are more or less related to the amount of fishing (effort) and the selectivity of fishing, which is a result of gear constructions, mesh sizes, and temporal and spatial allocations of fishing. Fishing may extract higher proportions of some subgroups (e.g. subpopulations, age and size groups, sex) than others, potentially leading to lower productivity (Svedäng & Hornborg, 2014; 2017) and evolutionary changes in life history parameters such as age and size at maturity (Hutchings, 2009).

Figure 35: Woodcut, illustrating the herring fishery in the Sound in the Middle Ages



Note: Please note the axe standing upright in a herring shoal, indicating an exceedingly high density of fish.

Source: Olaus Magnus (1555)

Other kinds of imbalances in trophic relationships may result in growth stunting in fish. For example, the protection of juvenile fish species has led to food competition in specific size classes and stunted growth in Baltic cod. Here, management actions interact with population dynamic processes with unforeseen implications (e.g. Svedäng & Hornborg, 2014; 2017).

Fishing also results in emissions of greenhouse gases, abrasion of the seabed and by-catches of mammals and birds. These problems are aggravated by tax exemptions on fuel for the fishing industry.

*Pollution from hazardous substances* including the loading of heavy metals, organic substances place serious pressures on NCP and on quality of life. Seals and other mammals in the Baltic Sea declined in numbers during the latter part of the 20th century, due to reproductive failure caused mainly by PCBs and other organochlorides (Hårding *et al.*, 2007). The decline in sea mammals has had an impact on existential and recreational values.

Due to stricter regulations and measurements, some of these problems have been curtailed. However, cadmium and organochlorides in Baltic herring (*Clupea harengus*)

still pose serious risks for human health (Kiljunen *et al.*, 2007). Dioxin is still released in to the marine environment from the paper and pulp industry. Higher levels of dioxin in Baltic herring has resulted in recommendations of restricted intake, especially by children and women in the fertile age.

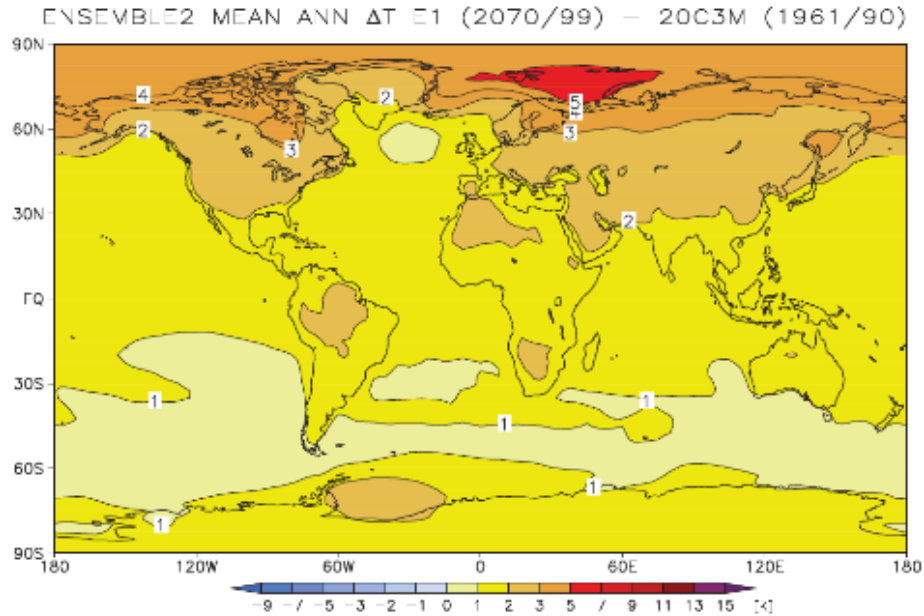
Albeit far from the industrial or urban areas of Europe, the level of mercury in sea mammals in the Faroese and Greenlandic waters may be at high levels (AMAP, 2011; Weihe & Joensen, 2012). Effects of a mixture of chemicals, the “cocktail effect”, must also be considered. Whilst the concentration of each substance is below safe toxicological limits, the total effect may be substantial (e.g. Backhaus & Faust, 2012).

*Invasive species* may lead to significant impacts on biodiversity, which in turn lead to changes in ecosystem function and productivity. For instance, the alien species round goby (*Neogobius melanostomus*) is spreading quickly in the southern Baltic Sea, as well as in other parts of Europe and the US. In test fishing in the Muskö area of the Stockholm archipelago, the number of round goby individuals caught increased from nine in 2013 to 1835 in 2017 (SLU, 2017). Originally first observed in the Bay of Gdańsk in the southern Baltic, it now completely dominates the coastal fish fauna. It is expected to spread throughout the Baltic Sea, including the Bothnian Bay, and may result in significant impacts on ecosystems in the future.

Invertebrates such as the polychaete *Marenzelleria sp.*, sea walnut (*Mnemiopsis leidyi*) and the Arctic comb jelly (*Mertensia ovum*) have accidentally spread from ballast water, but the consequences remain unclear (Ojaveer & Kotta, 2015). Mink (*Mustela vison*) and racoon dog (*Nyctereutes procyonoides*) have escaped from fur farms and cause severe problems among seabirds locally. Some plants such as *Rosa rugosa* ([https://www.nobanis.org/globalassets/speciesinfo/r/rosa-rugosa/rosa\\_rugosa.pdf](https://www.nobanis.org/globalassets/speciesinfo/r/rosa-rugosa/rosa_rugosa.pdf)) spreads along the shores, changing the local plant communities.

*Climate change*, which is related to greenhouse gas emissions, can profoundly affect Nordic marine biodiversity. Climate-related pressures include melting sea ice, decreased snow cover and permafrost thawing and increased discharges of organic matter, which may lead to altered trophic relationships (e.g. Andersson *et al.* 2015). Even in a scenario where CO<sub>2</sub> levels have been stabilised at 450 PPM, dramatic consequences can still be expected in the Nordic region (Fig. 36). Higher seawater temperatures lead to increased ecosystem respiration rates (Hoegh-Guldberg & Bruno, 2010). For instance, due to the higher respiration rates oxygen deficits return faster in deeper water layers and seabed than previously after inflows of fresh, well-oxygenated water masses into the Baltic Sea. In the northern parts of the Nordic countries and seas, fish stock productivity can be expected to increase as an effect of rising water temperature (e.g. Stenevik & Sundby, 2007).

Figure 36: Projection of the departure (anomaly) in annual mean temperature for the years 2077–2099 relative to the estimated temperature during the period 1960–1999



Note: This scenario of changes in temperature on a global scale is modelled according to the optimistic assumption at which atmospheric CO<sub>2</sub> stabilises at 450 PPM by 2140.

Source: van der Linden & Mitchell, 2009

Increased fishing opportunities in Greenland waters may already be observed. Local fishers and hunters in Disko Bay point to climate change as the likely reason for the ever-changing status of fish and wildlife populations (Danielsen *et al.*, 2016). Sea ice loss affects the entire food web and human communities that rely on sea ice for travel (Eamer *et al.*, 2013). Many marine species, as well as some marine invasive species, have the potential for northward expansion as sea-surface temperatures increase (Fernandez *et al.*, 2014).

There are indications of changes in food webs in the waters around the Faroe Islands (Beaugrand *et al.*, 2010). A northward shift in the distribution of plankton has been observed, which negatively affects gadoid recruitment, with implications on the local cod stock. Some pelagic fish species like Atlantic mackerel and Atlantic herring are at present more abundant in Faroese waters (Sørensen, Roto, & Tunón, 2018) than around a decade ago.

Changes in hydrography due to global warming has resulted in significantly decreased populations of seabirds in the Faroes. In particular, populations of kittiwake (*Rissa tridactyla*), puffin, guillemot (*Uria aalge*), Arctic tern (*Sterna paradisaea*) and seagulls have been affected. On the contrary, species like gannet (*Morus bassanus*), fulmar (*Fulmarus glacialis*), shag (*Phalacrocorax aristotelis*) and black guillemot (*Cepphus grylle*) are less affected (Sørensen, Roto, & Tunón, 2018).

In the ocean-connected and sea-like ecosystems such as those in Näättämö river and Lake Puruvesi, which are crucial ecosystems for both Skolt Saami and Atlantic salmon (*Salmo salar*), climate change will most likely increase water temperatures and cause changes in ice cover thickness and duration. Extreme heat waves and changes in precipitation can also be expected to lead to population declines of species such as Atlantic salmon, vendace (*Coregonus albula*), trout (*Salmo trutta*), grayling (*Thymallus thymallus*), Saimaa ringed seal (*Pusa hispida saimensis*) and other cold-dependant species (Mustonen, 2018a & b).

In the Bothnian Bay, climate change is expected to result in intensified acidification, with potentially significant negative impacts on marine life. Cold water species like burbot (*Lota lota*), salmon, trout, vendace, whitefish (*Coregonus lavaretus*) and herring may be directly negatively affected, while warm water species like perch, pike and roach may increase in abundance. New research (Jonsson *et al.*, 2017) predicts that methyl-mercury may increase three to six-fold in zooplankton in the Bothnian Sea through expected biogeochemical and ecological changes, with continued bio-accumulations further up in the food chains.

#### 4.4.3 Indirect drivers

*The legislation* is the juridical manifest of policies, established by parliament and governmental agencies on a national level. On an international level, intergovernmental bodies such as IMO (International Maritime Organization) or HELCOM may be empowered as lawmakers. Legislation regulates the interaction between people and their activities and between people and nature. The EU is a unique intergovernmental body that operates on different levels of sovereignty, depending on the policy area. For instance, regarding fisheries, the EU member states have transferred all their legislative power to the EU, although the EU has by delegation, returned some of its legislative power to the member states. The Common Fisheries Policy (CFP) concerns four policy areas: conservation policy, structural policy and market policy, and an external dimension. The CFP aims to achieve sustainable fishery. However, a second objective of the CFP is to support and promote the fishing industry and economic development, which may lead to a conflict of interests (Sterner & Svedäng, 2005).

Legislation and protective measures are important indirect drivers for the local economy and regulate how NCP are utilized by local communities. Protective measures taken to enhance sea trout stocks in the Kalix archipelago is an example of how different interests need to be balanced. Local participation is essential to achieve positive results, since many of the actions that need to be taken will affect local culture and use of biological resources. In this case, legislation severely restricts local fishing of other species and is a threat to the survival of fishing communities (Kvarnström & Boström, 2018). Instead, the fishers recommend local co-management based on monitored fishing and regular follow up of population trends.

In most Nordic countries, constructions and other physical changes close to the shoreline are firmly regulated, albeit political and commercial interests often

challenge these protection policies. There are exceptions to this approach. On Åland for instance, exploitation is governed by legislation, municipal planning and the homestead right (hembygdsrätt). As Åland has no formal protection of the shoreline, it is the homestead right that regulates who may purchase houses along beaches and shorelines and thereby .

*Policies* on the other hand, are usually underpinned by legislation, information and economic incentives. Subsidies and taxation are often of crucial importance for the management of fisheries as economic incentives. However, lowering the costs of fishing causes problems with over-utilisation of fishery resources.

Environmental awareness in Nordic countries underpins public demand on environmentally friendly methods and well-functioning NCP. The right of public access to most of the countryside in Nordic countries (exceptions are cultivated grounds or private areas in the vicinity of houses) is an important convention that codifies people's often close relationships to nature. The possibility to bathe publicly in, for instance, the harbour areas of Copenhagen and Malmö or in Stockholm and Helsinki, is also an expression of the high expectations of well-functioning governance systems that respect and maintain NCP. The Sound bridge construction is another example where public environmental awareness has spurred the governance systems to adopt more environmentally friendly approaches (Petersen *et al.*, 2018).

*Economic development* is a key driver in all aspects of human activities exerting influence on nature. All Nordic countries are economically advanced welfare societies, meaning among other things that their "ecological footprint" is considerable in spite of environmental awareness and measures taken to protect nature.

There is a general understanding that a more sustainable economy requires a global reduction in resource use and energy conversion (e.g. Fiksel, 2006). The concept of "decoupling" has been applied to this challenge, meaning "using less resources per unit of economic output and reducing the environmental impact of any resources that are used or economic activities that are undertaken" (UNEP, 2011). Technological development is also of paramount importance for all aspects of human activities exerting influence on nature. There are however numerous trade-offs between prosperity, technological advancements and their ecological impact (e.g. Chertow, 2001).

*Demographic changes* in population numbers and age structure are important factors that may alter the use of and relationship to nature. All Nordic countries show population ageing due to increasing life expectancy and low fertility rates. As a consequence, the increases in population numbers are rather modest. Population number is factor of great importance on the impact on NCP, however also depending on economic performance and life-style.

A critical indirect driver is the ongoing urbanization. As a part of demographic and economic development, people are moving from rural areas towards bigger municipalities and towns. As a consequence, competition for space is declining in rural areas, whereas competition for space in the urban areas is increasing. However, rural areas that struggle to keep up their population numbers may have benefitted from immigration from other parts of the world, although the bigger cities tend to grow

more.<sup>19</sup> As urbanisation proceeds, traditional cultural landscapes are changing. In coastal areas, the urban lifestyle manifests through the conversion of many farmhouses into summerhouses, local communities turn to seasonal living and local inhabitants commute instead of engaging in the local economy. Local fishermen and local farmers disappear, as do domestic animals grazing coastal semi-natural grasslands with implications for biodiversity.

Due to ongoing urbanisation on for instance the Faroe Islands, customary use of biological resources like hunting, fishing and sheep farming – the backbone of the settlement structure – is declining. Over the last decades, Faroese economy has been orienting towards service and knowledge sectors. Furthermore, globalisation has changed traditional preferences and challenged the traditional settlement structure. Today some 40% of the Faroese population live in the growing capital region, whereas just 1% of the population live on small islands without road connection (Hagstova, 2017). This depopulation may change the general attitude towards traditional activities such as the egg-harvest, hunting of some bird species, as well as pilot whale hunting (Sørensen, Roto, & Tunón, 2018).

*Cultural development* has a profound influence on our view of nature. Aesthetic and ethical perspectives on nature and the use of different NCP are usually very important for how governance is developed. The precautionary approach adopted during the construction of a bridge between Denmark and Sweden, as to avoid any large-scale effects on the ecosystem in the short- and long-term, is an expression of caring for nature.

*Tourism* is an increasingly important cultural and economic indirect driver in Nordic coastal areas. Biodiversity and other NCP are increasingly exploited and capitalised upon in event-related “health” and “wellness” industries. Nature-based wellness tourism is a growing industry that capitalises on the findings that water and water-based nature have a rejuvenating effect on people (e.g. <https://www.luke.fi/en/wellness-from-water>, viewed on April 17, 2018).

The expansion of tourism may indeed generate new challenges, with higher demands on the development of infrastructure causing negative impacts on ecologically sensitive regions (Thostrup & Rasmussen, 2009). Development can cause disturbances to migrating birds, marinas potentially destruct sheltered bays, wetlands and shorelines.

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<sup>19</sup> [http://www.scb.se/sv\\_/Hitta-statistik/Artiklar/Urbanisering--fran-land-till-stad/](http://www.scb.se/sv_/Hitta-statistik/Artiklar/Urbanisering--fran-land-till-stad/)

Figure 37: Popular recreational activities in the Helgeland area are kayaking, bicycling, riding, hiking, fishing and hunting



Note: These NCP are in principle indirect anthropogenic drivers but attempted arranged to impose minimal impact on nature and its benefits to people through organized tours with a Sustainable Destinations trademark.

Source: [www.innovasjon Norge.no](http://www.innovasjon Norge.no)

Ecotourism and cultural tourism involve visiting fragile, pristine and relatively undisturbed natural areas. These low-impact activities have become popular in many parts of the Nordic region. Examples include “Blue care” in the Quark area (<https://www.luke.fi/en/wellness-from-water/>) and recreational activities in the Helgeland area on the Norwegian coast (Fig. 37). Many tourists are interested in familiarising with local traditions and e.g. Saami villages have always been popular for tourists. Ecologically and culturally sustainable tourism is dependent on NCP, as well as the ILK on their sustainable use.



#### 4.5 Knowledge gaps and future monitoring

- We need better knowledge and understanding of the interactions and coupling between different drivers, especially with regard to the dynamics of marine and coastal ecosystems and how such drivers may ultimately influence the provision of various NCP;
- Due to the fact that our knowledge concerning ecosystem function and connectivity always will be limited, it is of paramount importance that management issues are handled according to the precautionary principle;
- As to avoid irreversible losses of biodiversity in coastal areas, both on land and at sea, we need improved monitoring of natural and semi-natural environments and their biodiversity for planning purposes. We also need to impose an overriding legal perspective that ensures commitment for implementation of effective management processes;
- Integrated approaches should be sought for and “good practice” examples should be explored and utilised in practical management;
- The impact of tourism on fragile environments needs to be evaluated and monitored;
- In some cases, we lack knowledge regarding how different decisions and regulations may affect biodiversity, NCP and people’s opportunity to use them.

#### 4.6 Policy Recommendation

- It is recommended to safeguard the right to public access and to protect the coastal environments from further exploitation, since seashores and natural environments close to cities are increasingly under threat due to privatisation and exploitation. New constructions in unexploited areas should be avoided as far as possible;
- Better management and conservation of the “naturalness” of landscapes in order to preserve and/or improve NCP;
- The knowledge from cultural traditions and closeness with nature in many ILK communities needs to be included in stakeholder processes towards an environmentally, socially, economically balanced and sustainable society;
- Nordic societies, together with other partners, should draw benefits from technological development. This enables change towards a less-energy dependent society and thus promotes “decoupling” of economic development from expanding resource utilisation;
- A target of zero emissions of greenhouse gases should be set for the whole Nordic community by endorsing carbon capturing techniques;

- In this study, the successful, albeit unintentional protection of the fish stocks in the Öresund by the trawling ban is highlighted as an interesting aspect of fisheries management. Experiences such as this kind of *partial* protection of an entire watershed should be used in future development of Marine protected areas (MPAs);
- Nordic countries should be in the forefront for advocating and developing best practices in coastal areas for ecologically and culturally sustainable economic development, using ILK and tradition.

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**Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment. Volume 1. The general overview**

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This report describes the status and trends of biodiversity and ecosystem services in the Nordic region, the drivers and pressures affecting them, interactions and effects on people and society, and options for governance. The main report consists of two volumes. Volume 1 The general overview (this report) and Volume 2 The geographical case studies. This study has been inspired by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES). It departs from case studies (Volume 2, the geographical case studies) from ten geographical areas in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) and the autonomous areas of Faroe Islands, Greenland, and Åland. The aim was to describe status and trends of biodiversity and ecosystem services in the Nordic region, including the drivers and pressures affecting these ecosystems, the effects on people and society and options for governance. The Nordic study is structured as closely as possible to the framework for the regional assessments currently being finalized within IPBES. The report highlights environmental differences and similarities in the Nordic coastal areas, like the inhabitants' relation to nature and the environment as well as similarities in social and policy instruments between the Nordic countries. This study provides background material for decision-making and it is shown that Nordic cooperation is of great importance for sustainable coastal management and should be strengthened in future work.

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## Volume 1

## The general overview





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# Contents

Foreword.....	7
Summary .....	9
1. Setting the scene.....	15
1.1 Context of the Nordic coastal zone assessment .....	16
1.2 Previous assessments and the conceptual "IPBES" framework .....	17
1.3 The Nordic model for ecosystem assessment .....	19
1.4 Stakeholders in the Nordic context .....	34
1.5 Introduction to Nordic case studies where the IPBES approach is tested .....	34
1.6 Methods and approaches .....	35
1.7 The structure of the Nordic assessment and the core questions.....	39
1.8 References.....	41
2. Nature's Contributions to People and Human Well-being in a Nordic coastal context .....	45
2.1 Introduction.....	45
2.2 Relationships and impacts of changes regarding nature's contributions to people ..	48
2.3 Identifying aspects of biodiversity and ecosystem services critical to social relationships, spirituality and cultural identity .....	54
2.4 Innovations and conflicts with biodiversity .....	62
2.5 Biocultural diversity .....	64
2.6 Multiple values of biodiversity and NCP.....	66
2.7 Knowledge gaps .....	67
2.8 Policy Recommendations.....	67
2.9 Acronyms .....	68
2.10 References.....	69
3. Status and Trends of Biodiversity and Ecosystem Function .....	75
3.1 Introduction.....	75
3.2 Defining biodiversity and its importance to Nordic marine life .....	77
3.3 Defining Ecosystem function and value to human societies in Nordic countries .....	78
3.4 Biodiversity of the North East Atlantic coast.....	80
3.5 Biodiversity of the Baltic Sea region .....	86
3.6 Trends in biodiversity and changes in ecosystem function .....	89
3.7 Biodiversity of the Arctic.....	94
3.8 Differences and similarities between regions.....	96
3.9 Local and indigenous knowledge.....	100
3.10 Case examples .....	102
3.11 Knowledge gaps .....	103
3.12 Policy recommendations.....	104
3.13 References.....	106
4. Direct and indirect drivers of change indifferent perspectives of human well-being (quality of life) .....	111
4.1 Introduction.....	111
4.2 Direct drivers – definition .....	112
4.3 Indirect drivers – definitions .....	112
4.4 Past and current trends of direct and indirect drivers of change – a Nordic overview .....	113
4.5 Knowledge gaps and future monitoring.....	127
4.6 Policy Recommendation .....	127
4.7 References.....	129

5. Analysis of interactions between Biodiversity (B), Ecosystem Services (ES), and Nature's Contributions to People (NCP).....	133
5.1 Introduction .....	133
5.2 Qualitative comparative analysis based on expert judgements.....	134
5.3 Results and Discussion.....	139
5.4 Integrated assessment.....	150
5.5 Future Perspectives .....	154
5.6 Policy recommendation.....	156
5.7 References .....	157
6. Options for governance, institutional arrangements and private and public decision-making across scales and sectors.....	161
6.1 Introduction .....	161
6.2 Framing institutions and policy options for biodiversity and ecosystems governance .....	162
6.3 International and EU governance.....	164
6.4 Formal institutional framework for Nordic governance – comparing WFD implementation in the Nordic region .....	167
6.5 Mainstreaming biodiversity and ecosystem services across sectors in the Nordic region: Examples from water governance and the case studies .....	171
6.6 Opportunities and challenges for policy and decision-making .....	181
6.7 Detected uncertainties and options for the future .....	183
6.8 Knowledge gaps .....	184
6.9 Policy recommendations .....	184
6.10 References .....	186
Sammanfattning.....	191
Annexes.....	193
Chapter 5 (Supplementary Material).....	193
Annex C – List of editors, co-chairs, authors and reviewers .....	193
Volume 1 General overview .....	194

# Summary

This study has been inspired by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES). The aim of the assessment was to describe the status and trends of biodiversity and ecosystems in the Nordic region, including the drivers and pressures affecting these ecosystem components, as well as the effects on people and society and options for governance. Ultimately, this study provided an opportunity to aid the process of utilizing scientific results in the policy and decision-making realm, thus forwarding the science-policy interphase. The Nordic study is structured as closely as possible to the framework for the regional assessments currently being finalized within IPBES. This assessment has been based on information provided by the following case study areas in the Nordic countries: Näätämmö/ Neiden basin, Kalix Archipelago, Kvarken/the Quark, Puruvesi Lake in North Karelia, the Lumparn area, Öresund, Helgeland coast, Faroe Islands (Føroyar), Broddanes West Fjords and the coastal areas of Húsavík (Iceland) and Disko Bay (Greenland).

The objectives of the assessment were to address the following questions:

- What are the main drivers and pressures affecting biodiversity, ecosystem services and ecosystem function?
- How does global, regional and national policy influence biodiversity, ecosystem services and human well-being in the Nordic region? What opportunities exist in policy-making?
- How can we better integrate indigenous and local knowledge (ILK) perspectives on biodiversity, ecosystem services and nature's contributions to people (NCP) in decision-making? How can we apply their culture and traditional management methods to support decision-making?
- What opportunities exist for sustainability and nature-dependent human well-being in Nordic societies?
- What biodiversity and ecosystem values define NCP in the Nordic coastal region?
- How can data sources such as Earth Observation and GIS spatial data be used in assessments to support decision-making?
- What are the major gaps in data, knowledge, management and decision-making systems? How can these gaps be minimized?

The outcomes from the assessment has been summarized in the following key messages:

- A. The Nordic coastal region has many natural assets and provides numerous ecosystem services:
  - A1. *The Nordic coastal region is unique due to the variability in nature types and biodiversity.* Its coastal areas support examples of many different habitats spanning the temperate to the Arctic zone. This diversity supports considerable biodiversity that people depend on for their livelihoods;
  - A2. *The Nordic coastal region contains several globally important species and habitats.* These include the wintering bird assemblages in the shallow seas around Denmark, the unique habitats of the Baltic Sea (the largest brackish water area in the world), the kelp forests and breeding seabird colonies on offshore islands and cliffs in northern regions along the Norwegian coast, the recovering populations of whales in the North Atlantic Ocean, the assemblages of Arctic species and the recovering stocks of cod and other species in the North Sea and further north;
  - A3. *Most of the region's biological value is in the form of large concentrations of fairly common species.* The region houses habitats and assemblages of species that are typical of temperate seas warmed by the Gulf Stream, along with the Arctic and the Baltic Seas, parts of which are seasonally frozen. The strong seasonality also results in long and short distance migration of many fish, birds and mammals using the coastal and marine systems in the region. These include globally important winter concentrations of migrant seabirds and shorebirds in the southern part of the region and similarly important summer concentrations in the northern and Arctic regions;
  - A4. *The ecological status in the North East Atlantic and Bothnian Sea is good.* The status is moderate in the Arkona Basin and the Sound, but poor in the Baltic Proper and Gulf of Finland;
  - A5. *Many biological values of the region are slowly recovering from very low values following past overexploitation.* These biological values include populations of fish-eating sea birds and white-tailed eagle, grey heron, crane and several geese species in the Baltic Sea. It also includes cod, herring, mackerel, ringed seal, grey seal, harbor seal, hooded seal, North Atlantic fin whale and bowhead whale along the Norwegian coast, along with wintering and breeding populations of geese and swans in Danish coastal areas. In the Baltic Sea, and particularly in the Bothnian Bay, there is a slow recovery from DDT and PCB pollution events. However, pollution from heavy metals and contamination from persistent toxic chemical and radiation events remains a challenge;
  - A6. *The network of marine and coastal protected areas is important for preserving biodiversity and ecosystem services in the Nordic region.* Regulations to accomplish sustainable use of these areas are under development;

- A7. *The coastal natural resources in the region have provided food for people living in the Nordic region for thousands of years. They continue to provide this today, especially from fisheries in the shallow seas, but also from animals feeding on the coastal habitats and birds breeding on the coastal cliffs. These resources are under various management regimes; some traditional going back at least hundreds of years and others with a more recent natural science basis;*
- A8. *The diversity of Nordic coastal and marine ecosystems continues to deliver goods and services that are vital to the livelihoods of many people in the region. Beaches and other coastal areas are important leisure resources for tourists from other countries. Particularly holidaymakers and weekend visitors from within the Nordic countries frequent the southern parts of the region. There are also continuing traditions and systems of using coastal and marine resources across the Nordic region. These are integrated into the modern lives of people living both in the rural areas and, increasingly, in cities throughout the region;*
- A9. *The Nordic coastal regions support communities with strong traditional ties to nature, which provides opportunities for resource management based on traditional use, management and governance regimes. These communities include both Inuit/ Greenlandic and Saami peoples in the north, coastal communities along the seaboard of Norway, Sweden, Finland and Denmark, as well as populations in the Faroe Islands and Iceland;*
- A10. *The coastal natural resources of the region provide inspiration for the people living in the Nordic countries. Some are strongly embedded in cultural identities and ways of living. These cultural values provide a powerful bond between people and nature and are a major reason for the persistence, and in some cases recovery, of natural resources in these coastal regions.*
- B. The coastal Nordic region is under pressure:
  - B1. *Some species are still in decline in the region despite conservation actions aiming to assist their recovery. This includes the globally important populations of breeding auks (puffin, razorbill, common guillemot, Brünnich’s guillemot) and some breeding seabirds (e.g. kittiwake). There has been a considerable decline in sea grass meadows, kelp forests and fucoid algae/or brown seaweeds in different parts of the region. Due to population crashes in the past century, species like sturgeon and lamprey in the Baltic Sea remain at very low populations;*
  - B2. *The Arctic – also the parts within the Nordic region – is the part of the planet most heavily affected by climate change and is warming at a far higher rate than any other region on earth. This is having and will continue to have dramatic impacts on ecosystems and their services, including through ocean acidification. Throughout the region, there are emerging impacts of climate change. Northern species of birds, fish and bivalves cease to breed in southern countries like Denmark, migrating northward and expanding their*

- breeding grounds along the coasts of Norway, Sweden and Finland. Fish e.g. mackerel, herring and tuna, are moving to more northern waters around Iceland and Greenland. There are changes in the coastal food web, potentially impacting food sources for some of the largest marine creatures in the region, e.g. humpback whale. Ocean warming is having negative impacts on the extensive kelp forests in the western oceans off Norway;
- B3. *Chemical pollutants, eutrophication and plastics are affecting the coastal waters of the region.* The historical heavy industrial and nuclear radiation pollution is still affecting parts of the Baltic Sea. The situation has greatly improved over the past 30 years. In other parts of the region, there is considerable run-off of agricultural fertilizers and pesticides, although the amount has been reduced from past levels. Eutrophication of the coastal waters remains a problem, evidenced by impacts to species composition in many areas. In recent years, fears have emerged on what consequences the high quantities of plastics and nanoparticles in the oceans may lead to. It will take many centuries for these particles to degrade in the regions' colder northern waters, and their impact on marine life is negative;
  - B4. *Invasive species pose serious challenges to parts of the Nordic coastal ecosystems.* Significant challenges arise from the Japanese rose (*Rosa rugosa*) on coastal foreshores and sand dune areas in Denmark and southern Sweden. Challenges also arise as a result of a variety of invasive marine animals and plants, including the round goby in the Baltic Sea and in the North Sea, and king crab in the Bering Sea. Measures against alien invasive species may mitigate the effects of these species. Such measures may include the implementation of legislation and/or physical measures to remove already established species;
  - B5. *Infrastructure development in marine and coastal areas poses challenges.* The Nordic region is a global frontrunner in near- and offshore wind turbine technological development and installation. However, wind power plants have impacts on e.g. migratory birds and bats. In addition, there are impacts associated with the construction of the large bridges between Denmark and Sweden, and Denmark and Germany. The trend to set aside coastal or near-coastal areas for building summer cottages brings challenges of reduced access, increased disturbance and the need for water treatment. There is oil and gas exploration and mining industry in the northern seas that has potential to impact these areas. Of particular concern is the slow break-down of pollutants in cold waters of low biological capacity.
- C. Building resilient futures in the Nordic coastal region:
    - C1. *The political and governance systems of the Nordic region are transparent and fair.* There is a broad interest within the Nordic countries to pursue development pathways to reduce local and global impacts on natural resources. There is good access to coastal areas and strong emphasis on the use of nature and natural areas for livelihoods and recreation. These values



- and traditions need to be maintained to continue to provide space for nature and to allow people to benefit from natural coastal areas. Nordic countries are able to implement and maintain systems for improved coastal management and sustainable harvesting of species, habitats and resources;
- C2. *There are good examples of indigenous and local peoples participating in coastal nature management in the northern regions.* This is critically important for continued subsistence use and for maintaining ecosystem services in the north. Better integration and support of indigenous and local knowledge within conservation management and in governance of resource use in the region would be beneficial;
  - C3. *Ongoing progress to clean up pollution and reduce eutrophication in rivers, lakes, coastal areas and open seas needs to be continued.* This relates to all the countries in the Nordic region and is equally important on national, regional and international scales. This can be achieved through catchment-based management approaches, as eutrophication is mainly caused by run-off from land. There have been intensive efforts to reduce the secondary environmental impacts from the large marine aquaculture industries (e.g. salmon farmed in the Norwegian fjords), shell fish farming (e.g. blue mussels on poles and other structures in Danish and Swedish seas), along with the emerging seaweed farming industries;
  - C4. *Some fish stocks and populations of marine mammals are recovering in the region.* Further recovery can be accomplished through careful review and changes to policies as required. However, some populations (e.g. seals) have recovered to the point where they are causing problems. For those fisheries and populations of marine mammals that are still in decline, further efforts are required to help return populations to a healthy state;
  - C5. *Cooperation among the Nordic countries is needed to improve coastal zone planning and management.* Policies and their implementation need to balance the needs of the natural system and human development in coastal areas (e.g. summer houses, urban areas, industry). Examples can be drawn from ongoing marine spatial planning initiatives;
  - C6. *Coastal resilience to rising seas needs to be enhanced, e.g. through nature-based solutions offered by natural or moderately modified ecosystems.* Changes in the coastal regions may be dramatic in the future due to climate change and related sea level rise, flooding, extreme weather events and increased run off from inland water bodies and melting ice;
  - C7. *The legal frameworks in most Nordic countries have national laws, EU directives and regulations and follow regional marine conventions including HELCOM and OSPAR.* These are often developed from agreed targets of international non-binding agreements, such as those under the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. This legislative framework is strong, but can always be

further developed to enhance the outcomes for nature and people in the coastal regions.

The following options for policy makers have been proposed:

- Evaluate the costs and benefits of existing environmental policies, prioritise and streamline them to help overcome the high density of policies;
- Where possible, coordinate the implementation of policies across the Nordic region to reduce policy conflicts;
- Identify and adjust policies that counteract incentives for conservation and the sustainable use of biodiversity in coastal areas;
- Increase political focus on the status of marine biodiversity and the influence of human activities on species and habitat diversity. This is closely related to work with the UN Sustainable Development Goals (SDGs);
- Involve science-based assessments and priorities in policymaking in terms of identifying most needed conservation and management policy initiatives;
- Safeguard the right to public access of coastal areas as access to nature maintains access to a number of non-material nature's contributions to people, such as identity, physical and psychological experiences, knowledge and inspiration, as well as material benefits such as food and ornaments. This collectively helps maintain society's sense of duty to protect the environment;
- Implement ecosystem-based adaptation to increase the coastal region's resilience to climate change;
- Draw benefits from technological developments that reduce the region's ecological footprint; and
- Identify pathways to achieve the 2050 vision of the Strategic Plan for Biodiversity and implement the Sustainable Development Goals and their targets.



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### **Biodiversity and ecosystem services in Nordic coastal ecosystems: an IPBES-like assessment Volume 1. The general overview**

This report describes the status and trends of biodiversity and ecosystem services in the Nordic region, the drivers and pressures affecting them, interactions and effects on people and society, and options for governance. The main report consists of two volumes. Volume 1 The general overview (this report) and Volume 2 The geographical case studies. This study has been inspired by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES). It departs from case studies (Volume 2, the geographical case studies) from ten geographical areas in the Nordic countries (Denmark, Finland, Iceland, Norway, Sweden) and the autonomous areas of Faroe Islands, Greenland, and Åland. The aim was to describe status and trends of biodiversity and ecosystem services in the Nordic region, including the drivers and pressures affecting these ecosystems, the effects on people and society and options for governance. The Nordic study is structured as closely as possible to the framework for the regional assessments currently being finalized within IPBES. The report highlights environmental differences and similarities in the Nordic coastal areas, like the inhabitants' relation to nature and the environment as well as similarities in social and policy instruments between the Nordic countries. This study provides background material for decision-making and it is shown that Nordic cooperation is of great importance for sustainable coastal management and should be strengthened in future work.



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