* *c*: Country
* *t*: Time
* *b* = {corals*,* mangroves} and *v* = {non-market use*,* non-use}
* *pc,t* is the annual per-area value 2005 USD per km2 comes Brander et al (2024).

*b c,t*

* *A*

: Area of marine biome [km2] from UNEP World Conservation Monitoring Centre

* *T* : Global mean temperature
* ∆*T* : Global mean temperature anomaly since pre-industrial times
* *V b,v*: Annual total values [2005 USD per year]

*c,t*

# Corals

## Non-market use and non-use

*pcoral,v* = *pcoral,v* · (1 + *γv* · *GDPpc growthc,t*/ (1)

*c,t*+1

*c,t*

*c,t*

*c,*0

*c*

*Acoral* = *Acoral* · (1 + *δcoral* · ∆*Tt*) (2)

*V coral,v* = *pcoral,v* · *Acoral*

(3)

*c,t*

*c,t*

*c,t*

*γv* comes from. Brander et al (2024). Area damage coefficient *δcoral* are estimated as follows:

*c*

1. Projected changes in coral area at 2,949 sites for 2050 and 2100, RCP 4.5, 8.5, from Sully et al
2. Estimate damage coefficient for each site: *A*(*i*)*t* = *α* + *δcoral*∆*GMSTt* + *ϵt* ∀*i*

*i*

1. Assign a *δcoral* to all corals reefs, based on nearest sites.

*i*

*A* · *δcoral*

1. Coral-area-weighted average damage coefficient *δcoral* for each country *δcoral* = ¿

*c*

*c*

*i*(*c*) ¿

*i*(*c*) *i*(*c*)

*i*(*c*)

*Ai*(*c*)

1. The uncertainty around *δcoral* is given by *σδ* , the square root of coral-area-weighted average variance of *δcoral*.

*σ*2 *coral* = ¿

*c*

/

( 1: *Ai*(*c*)

*c* *i*

2 · *σ*2 *coral*.

*c*

## Market use

*i*(*c*)

*i*(*c*) *Ai*(*c*)

*i*(*c*)

Market damage coefficient *λcoral* is estimated fitting separately for each country

1*,c*

*Dcoral* = *λcoral*∆*Tt* + *ϵt* ∀*c*

*t* 1

with damages being the value of corals with and without damages:

*Dcoral* = *pcoral* · (*Acoral* − *Acoral*)*.*

## Uncertainty

*c,t*

*c,t*

*c,t*

*c,*0

Call *σλcoral* the standard error of *λcoral*. The adjusted variance of *λcoral* is ... ..

1 1

# Mangroves

1*,c*

## Non-market use and non-use

*mangroves,v av bv*

*pc,t* = *e c* · *GDPpc c* (4)

*c,t*

*Amangroves* = *Amangroves* · (1 + *δmangroves* · ∆*Tt* + *δmangroves* · ∆*T* 2) (5)

*c,t*

*c,*0

1*,c*

2*,c t*

*V mangroves,v* = *pmangroves,v* · *Amangroves*

(6)

*c,t*

*c,t*

*c,t*

* + *av* and *bv* estimated fitting *pmangroves,v* = *eav* · *GDPpccv* + *ε* ∀*c*

*c c t t t*

* + *δ*1*,c* and *δ*2*,c* from Bastien-Olvera et al. (In Prep.)

## Market use

Market damage coefficients *λmangroves* and *λmangroves* are estimated fitting

1*,c*

2*,c*

*Dmangroves* = *λmangroves*∆*Tt* + *λmangroves*∆*T* 2 + *ϵc,t*

where

*c,t*

1*,c*

2*,c t*

*Dmangroves* = *pmangroves,v* · (*Amangroves* − *Amangroves*) · *GDPc,t*

**Uncertainty**

Call *σD* the standard deviation of

# Fisheries

*c,t*

*c,t*

*c,t*

*c,*0

*Health benefitsc,t* = (1 + *βcTt*) · *TAME* · *Popc,t* · *µc* · *η* · *V SLt*

Where *η* is the percentage of nutrient intake that cannot be made up by consuming other foods, *µc* thr percentage of population in country *c* dependent on fisheries, and *TAMEc* is the total avoided mortality effect of country *c*, defined as the sum of the baseline mortality rate (MR) associated with health condition *h*, times the protective effect *ρ* that each nutrient *n* has on such condition:

*TAMEc* = *ρn,h* · *MRc,h,*2020

L

(*n,h*)∈*M*

*M* is the set of specific pairs (*n, h*) for which we have values in our meta-analysis dataset. The Value of a Statistical Life (*V SL*) is uniform across countries and it changes across time, following recommendations by Bressler and Heal. We scaled the VSL using the global population-weighted mean GDP per capita:

*V SLt*

= *V*---*SLt*

*Global GDPpct*

· *.*

*Global GDPpc*2020

*V*---*SLt* is the VSL estimate currently used by the U.S. Environment Protection Agency, which fits a Weibull distribution to 26 studies with a central value of $7.4 million (2006 USD), and a standard deviation of $4.7 million (2006 USD).

## Market use

Free et al. (2020) projects national profits from fisheries at full adaptation for 4 RCPs until 2100 at 5-year intervals [CHECK]. We compare the difference in profits from RCP2.6 and the deviation in GMT from RCP2.6, summarizing the relationship between economic damages and climate change with a linear relation, separately for each country. We do so fitting the following line:

*Dfisheries* = *α* + *λfisheries* ∆*Tt* + *εt* ∀*c*

*t*

with *Dfisheries* = *Profitst,RCP* ̸=2*.*6 − *Profitst,RCP* 2*.*6.

*t*

# Ports

1*,c*

*RCP* 2*.*6

Verschuur et al project the economic value at risk (EVaR) for 7 SSP-RCP scenarios in 2050. We compute change since today in economic value at risk (EVaR) as a fraction of GDP

*Dports* = *EV aRc,t* − *EV aRc,*0 *.*

*c,t*

*GDPc,t*

*GDPc,*0

We summarize the relationship between economic damages on ports and climate change with a linear relation that passes through the origin, separately for each country:

*Dports* = *λports*∆*Tt* + *εt* ∀*c*

# Consumption

*t* 1*,c*

1*,c*

1*,c*

1*,c*

1*,c*

(1 + *λmangrove*) · ∆*T* 2]

*Cc,t* = *C*-*c,t*·((1 + *λcoral* + *λmangrove* + *λfish* + *λport*) · ∆*Tt*+ (7)

2*,c*

*t*

where *C*-*c,t* is consumption absent climate change damages to the ocean ecosystems.

# Utility

*Utility*

= ((1 − *s* ) · Use*θ* + *s* · Non-use*θ* ] 1

(8)

where

= ((1 − *s*1) · *C*-*θ*

*c,t*

2

2 *t,n* 2

\_ L

+ *s*

·

2 *θ*2

!*θ*1

]

1

*V b,*non-mkt use

1

*θ*1

and

*t,n*

1

*b*=*m,c,f*

Use*t,n*

*t,n*

Non-Use*t,n* = L (*V b,*non-use)

*t,n*

# Social cost of carbon

*b*=*m,c*

We compute the Social Cost of Carbon from oceans based on the nested welfare function and separate it by the different categories and types of services *V b,v*, based on the instantaneous utility function *Uc,t*(*cc,t, V b,v*) and intertemporal welfare function *Wc* =

*c,t c,t*

¿2300 1 *U* 1−*η*. We run the model once (all variables denoted without hat) and then a second time adding one additional pulse of

1*MtCO*2 of emissions in 2020. First we compute the monetary-equivalent utility impact at any time *t* and in country *i* by computing

*t*=2020 1−*η*

*c,t*

for each combination of *b* and *v*

1

∆*U b,v* = · (*U* 1−*η* − *U* 1−*η* /*,*

*c,t*

1 − *η*

*b,v,pulse,c,t*

*b,v,nopulse,c,t*

that is, the difference in utility due to a change only due to impacts on *V b,v*, whereas all other variables are kept at levels of the model run without emission pulse. This utility loss is then converted into monetary equivalents by the marginal utility of one unit of consumption *∂Uc,t*(*cc,t,V b,v* ) . Finally, we use the endogenous global Ramsey discount factor as for instance in Rennert et al. (2022),

*c,t*

*c,t*

*∂cc,t*

−(*t*−2020)

1:

*lc,t*

*c* 1:*c′ lc′,t cc,t*

)*−η*

which in our case can be computed as *DFt* = (1 + *δ*)

1:

*lc,*2020

*c* 1:*c′ lc′,*2020 *cc,*2020

)*−η* . Thus, we can compute the Social Cost of

Carbon for 2020 in US-$[2020] based on the sum of the disaggregated impacts as

L

1:

¿ *popc,t*

*OCEAN*

*SCC*2020 =

*popc,*2020

*cc,*2020

*c*

*c ,*2020

2300

·

*popc,t.*

−(*t*−2020)

(1 + *δ*)

*t*=2020

*c c′ popc′,t*

*c* 1: *′ pop ′*

*cc,t*

¿

)−*η*

)−*η*

L

*c*

*b,v*

∆*U*

¿

*b,v c,t*

*,V b,v* ) · ¿

*∂Uc,t*

(*c*

*c,t*

*c,t*

*∂cc,t*

*popc,t*

*popc′,t*

*c*

 L

*c*

The sum of the contributions adds to the total utility difference. As an additional test, we also ran a grid of carbon prices verifying that the welfare levels are maximized at the level of the SCC obtained.

# For internal use

Subscripts omitted for readiblity.

\_\_ (

*θ θ* / *θ*2 *θ*

1 1−*η*

*θ*2

)  !

*Utility* =

(1 − *s*2)

(1 − *s*1) *C* 1 + *Q* 1 *s*1

1 − *η*

 \_\_

(1 − *s*1) *C* 1 + *Q* 1 *s*1

*θ*1

(1 − *s*2)

*θ*1 + *Z* 2 *s*2

) 1 !1−*η*

(1 − *s*1) *C* 1 + *Q* 1 *s*1

*θ*1 + *Z* 2 *s*2

*θ* −1 (

(1 − *s*1) (1 − *s*2) *C* 1

·

*∂U*

*θ θ* / *θ*2 −1

( *θ θ*

/ *θ*2 *θ θ*2

*∂C* (1 − *s* ) ((1 − *s* ) *Cθ* + *Qθ s* ) *θ*2 + *Zθ s*

=

*θ*

2

with *Q* = ¿*b,v* = *V b,nonmkt* and *Z* = ¿*b,v* = *V b,nonuse*

1 1 1 1 1 2 2