Annex on non-stunning interventions

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Generic prep

```
rm(list=ls())
library(tidyverse)
library(scales)
library(rlang)
library(gt)
library(RColorBrewer)
library(forcats)
library(magrittr)
library(webshot2)
```

Run code to load useful montecarlo simulation functions and general seabream seabass assumptions

```
#Useful monte carlo functions
source("0a Useful functions.R")
source("0b Assumptions for seabream,seabass and trout.R")
source("0c  Modelling assumptions.R")
```

Modelling assumptions

Define parameters over which to calculate share of simulation results. Definition of xvar provided in the table below.

Approach	Meaning of 'xvar' variable means in context of calculations
Moral Value	Moral value of improving fish welfare for 1 year through intervention relative to gaining 1 DALY
Welfare Range	Welfare gain from intervention - expressed as % of entire fish welfare range (negative to positive

```
# Share of fish life affected by welfare intervention
  fishlifeshare_values <- c(0.01,0.02,0.05,0.10,0.15,0.25,0.35,0.50)

# Moral value points
  mv_table_values <- c(0.01,0.05,0.1,0.25,0.5,0.75,1,5,10,25)

# Moral value points
  wr_table_values <- c(0.001,0.01,0.025,0.5,0.1,0.15,0.35,0.5,0.75,0.9,1)
```

Calculations

Helper functions

Write helper functions to call object/vectors

```
consumption <- function(country,species)  obtain(species,country,"tons")
mshare <- function(country) obtain("mshare_welfare",country)
psuccess <- function() get("psuccess_welfare")
weight <- function(species) obtain("weight",species)
lifexp <- function(species) obtain("lifexp",species)
cost <- function() get("cost_welfare")
stun_share <- function(species) obtain(species,"stunned")
```

Number of fish affected/$ and associated lifespan

Core calculation functions

Calculate number of fish affected per dollar spent

```
# Number of fish affected per dollar
no_fish_affected <- function(country,species) {
consumption(country,species)*1E3/
```

```
    weight(species)*
    mshare(country)*
    psuccess()*
    stun_share(species)*
    years_credit*
    implementation_discount*
    fish_grocery
  }
```

Life span of affected fish

```
# Fish years of affected fish}
lifespan_affected_fish <- function(country,species) {
no_fish_affected(country,species)*lifexp(species)/12
}
```

Execution functions

Produce a table that produces every possible combination of country and species, and a list of functions over which to calculate results.

```
no_of_countries <- length(country_list)
country_species <- expand.grid(country=country_list,species=species_list)
measure_list <- c("lifespan_affected_fish","no_fish_affected")
```

I now write a function that calculates number of fish / lifespan affected per country/species pair, sums across all the country/species pairs, and then divides by costs across all countries.

```
output_per_dollar <- function(fish_function) {

      pmap(                          # Allows repeated calcs across different input vecto
          country_species,               # Input vector 1: countries to run function over
          get(fish_function)           # Calculation function (no of fish or minutes)
                ) %>%
       as.data.frame() %>%                 # Convert to data.frame
       mutate(
         total=rowSums(.)) %>%             # Work out sum of all country and species comb
       pull(total)/(no_of_countries*cost()) # Divide by costs across all countries

}
```

I then produce tables with montecarlo simulation results for each measure in both wide and long format.

```
impact_per_dollar_wide <- map(measure_list,output_per_dollar) %>%
                              set_names(measure_list) %>%
                              as.data.frame()

impact_per_dollar_long <-  impact_per_dollar_wide %>%
                            pivot_longer(
                                cols=1:length(measure_list),
                                names_to="description",
                                values_to="number")
```

Finally I produce a vector called fypd, that calculates the lifespan of affected fish, which is needed in the $/DALY and share of simulation results.

```
fypd <- output_per_dollar("lifespan_affected_fish")
```

$/DALY results

Core calculation functions

```
results_dollar_per_daly <-
   1/(
    fypd*
    salmon_wr*
    interventionlifesshare*
    fish_welfarerange_impact/
    DALY_share_of_welfare_range) %>%
    tibble() %>%
    set_names("dollars_per_daly")
```

Share of simulations beating $$/DALY benchmark

Core calculation functions

```
#Moral value approach
share_mv <- function(xvar,fishlifeshare,bar) {
  mean(bar>(1/(fypd*fishlifeshare*xvar)))
}

# Welfare range approach
share_wr <- function(xvar,fishlifeshare,bar) {
  mean(bar>
      (1/
        (xvar*
        fypd*
        fishlifeshare*
        salmon_wr/
        DALY_share_of_welfare_range
        )))
}
```

Calculations

Define xvar (moral value or welfare range) values for calculating share of simulations beating a particular $/DALY bar and create combinations of xvar values, bar values and, lifeshare values over which to calculate results.

```
 chart_values<- 10^seq(-4,4,0.01)
  xvar_values <- c(chart_values,mv_table_values,wr_table_values)

share_sims_calculation_grid <-   expand_grid(
                                      xvar=xvar_values,
                                      bar=bar_values,
                                      fishlifeshare=fishlifeshare_values)
```

Calculate results

```
share_sims_results_table <-
# Generate one row for unique combination of xvar_values and scenario lists
  share_sims_calculation_grid %>%
# Core calcualtions using share_mv and share_wr calculation functions
```

```
    rowwise() %>%
    mutate(
      moral_value=share_mv(xvar,fishlifeshare,bar),
      welfare_range=share_wr(xvar,fishlifeshare,bar)
    )
```

Format results table

```
share_sims_results_table %<>%
# Convert pivot into longer format to make results easier to plot
  pivot_longer(
    cols=c(moral_value,welfare_range),
    names_to="approach",
    values_to="share_of_simulations") %>%
# Change descriptions of variables to make results easier to interpert
  mutate(
    approach=str_to_sentence(str_replace_all(approach,"_"," ")),
    bar_factor=factor(bar,levels=bar_values,labels=c("50","1K","70K")),
    fishlifeshare_factor=factor(fishlifeshare,levels=rev(fishlifeshare_values),labels=past
```

Results tables/charts production functions

Impact per dollar density plots

```
# Code to create impact per dollar density plot

impact_density_plot <- function(desired_filter,named_description) {
  impact_per_dollar_long %>%
  filter(description==desired_filter) %>%
  ggplot(
    aes(
      x=number
    )
  ) +
  geom_density() +
  theme_light() +
  scale_x_log10(labels = scales::comma_format(drop0trailing = TRUE),n.breaks=8) +
    labs(
    title=named_description,
```

```
    y="Probability density",
    x=paste0(named_description," (log scale)"))
}
```

Share of simulations

Chart labels

```
xlab_wr="
    Welfare gain from intervention as a % of total fish welfare range"

xlab_mv="Moral value of improving a fish life year via intervention
relative to gaining a human DALY"
```

Chart function

```
share_sims_chart <- function (
                        chart_approach,
                        xvar_lower_lim=0,
                        xvar_upper_lim=max(xvar_values),
                        xlab_des,
                        bar_value=50
                        ) {

share_sims_results_table %>%
    filter(
    approach==chart_approach,
    xvar<=xvar_upper_lim,
    xvar>=xvar_lower_lim,
    bar==bar_value
    ) %>%
  ggplot(
    aes(
      x=xvar,
      y=share_of_simulations,
      color=fishlifeshare_factor))+
  geom_line()+
  scale_color_brewer(palette = "Dark2") +
  theme_light()+
  labs(
```

```
    subtitle = str_to_title(paste0(chart_approach," approach")),
    title=paste0("Share of simulations where intervention beats ",bar_value,"$/DALY benchm
    y="Share of simulations",
    x=xlab_des,
    linetype="$/DALY Benchmark",
    color="Share of fish \nlifespan affected \nby intervention",
    caption= "Note log scale on x-axis")
}
```

Table function

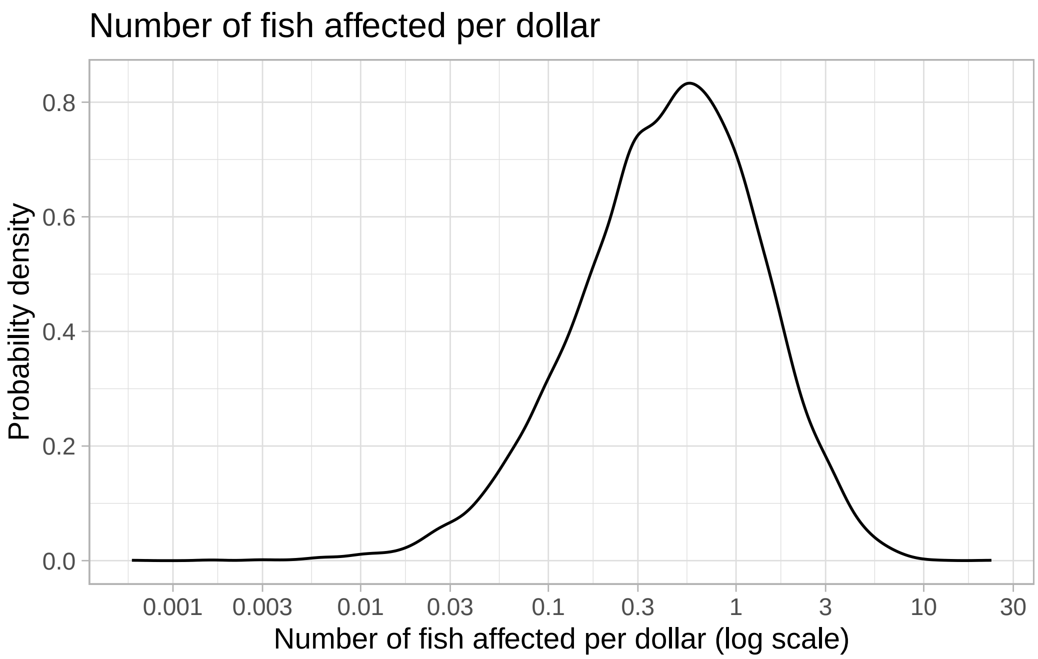
```
share_beating_bar_table <- function(values,chart_approach,bar_value) {

share_sims_results_table %>%
  filter(
      xvar %in% values,
      fishlifeshare %in% fishlifeshare_values,
      bar==bar_value,
      approach==chart_approach) %>%
      select(xvar,share_of_simulations,fishlifeshare_factor) %>%
      distinct() %>%
      pivot_wider(id_cols=xvar,names_from=fishlifeshare_factor,values_from=share_of_simula
      arrange(xvar) %>%
      gt() %>%
      tab_header(title = paste0("Share of simulations beating $",bar_value,"/DALY bar")) %
      tab_spanner(label="Share of fish lifespan affected by intervention",columns=paste0(f
}

wr_bar_table <- function(bar_value) {
  share_beating_bar_table(wr_table_values,"Welfare range",bar_value) %>%
  fmt_percent(decimals=1) %>%
  fmt_percent(columns=xvar,decimals=0) %>%
  cols_label(xvar=xlab_wr)
}

mv_bar_table <- function(bar_value) {
  share_beating_bar_table(mv_table_values,"Moral value",bar_value) %>%
  fmt_percent(decimals=1) %>%
  fmt_number(columns=xvar,drop_trailing_zeros=TRUE) %>%
  cols_label(xvar=xlab_mv)
}
```

Outputs

Impact per dollar

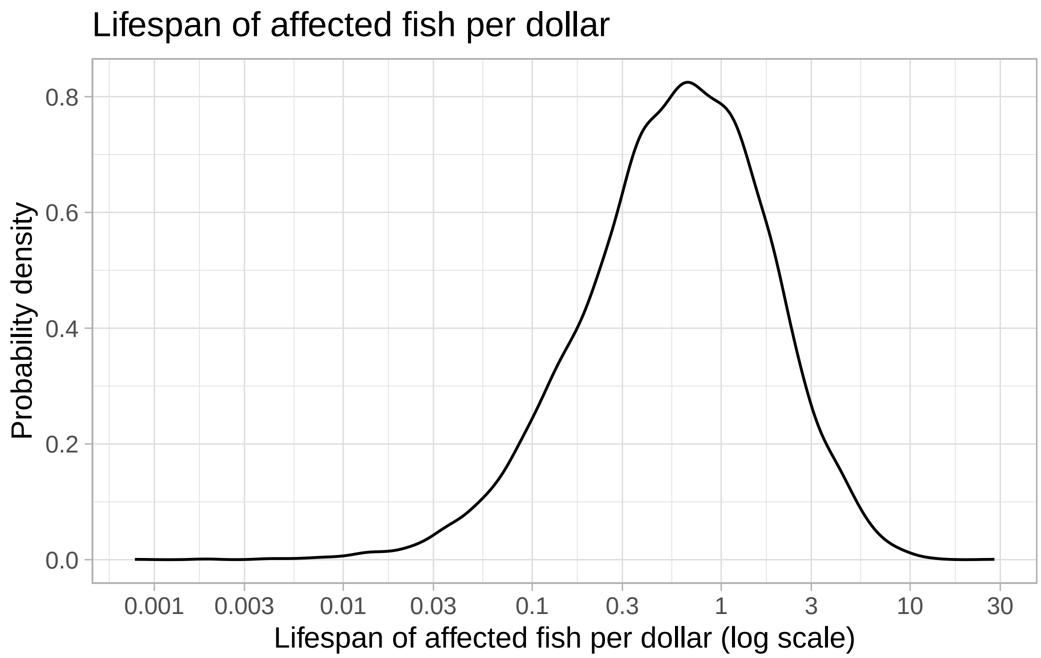
Density plot: number of fish affected

```
impact_density_plot("no_fish_affected","Number of fish affected per dollar")
```



Density plot: lifespan of fish affected

```
impact_density_plot("lifespan_affected_fish","Lifespan of affected fish per dollar")
```



Results table

```
tab_a22_impact_per_dollar_nonstunning <- summarystats(impact_per_dollar_wide)
tab_a22_impact_per_dollar_nonstunning
```

statistic	lifespan_affected_fish	no_fish_affected
mean	0.973	0.748
sd	1.15	0.892
median	0.607	0.468
p5	0.0795	0.0608
p10	0.127	0.0972
p25	0.280	0.214
p75	1.24	0.949
p90	2.19	1.69
p95	3.08	2.41

$/DALY approach

Summary stats

```
summarystats(results_dollar_per_daly)
```

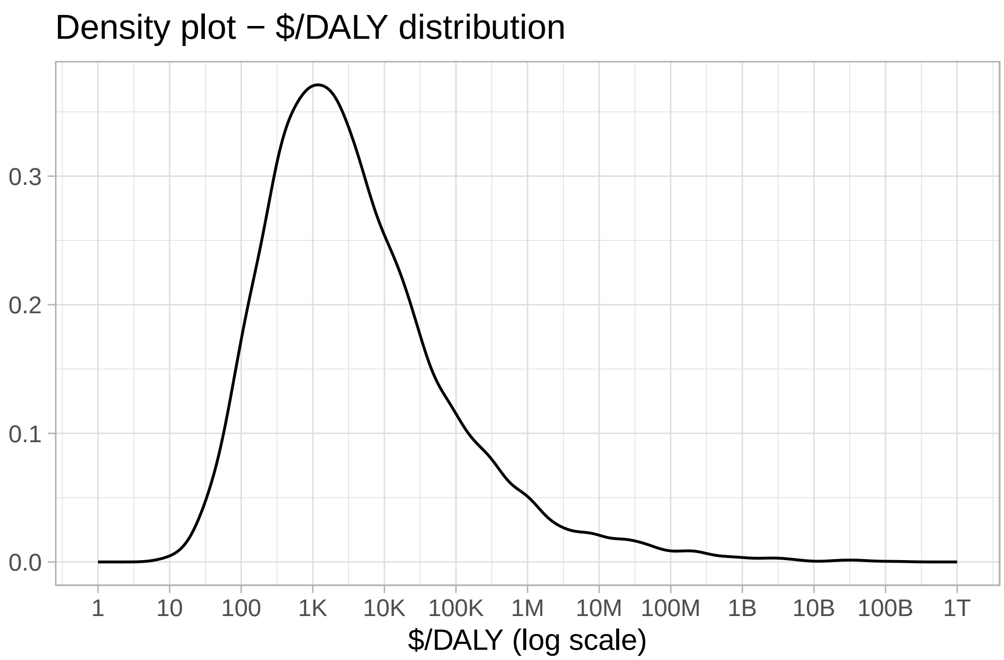
statistic	dollars_per_daly
mean	$66.7M$
sd	$2.21B$
median	$2.41K$
p5	88.6
p10	158
p25	507
p75	$18.1K$
p90	$218K$
p95	$1.23M$

Density plot

```
fig_a21_dollars_per_daly_nonstunning <- densplotv(results_dollar_per_daly$dollars_per_daly
    scale_x_log10(
      limits=c(1,1E12),
      labels = scales::label_number_si(),
      n.breaks=15)+
    labs(
      title="Density plot - $/DALY distribution",
      y="",
      x="$/DALY (log scale)")
```

```
Warning: `label_number_si()` was deprecated in scales 1.2.0.
i Please use the `scale_cut` argument of `label_number()` instead.
```

```
fig_a21_dollars_per_daly_nonstunning
```



Share beating bar

```
share_below_bar <- function(bar_value) (mean(results_dollar_per_daly<bar_value))

tibble(
  `$/DALY bar`=bar_values,
  `Share beating bar`=map_vec(bar_values,share_below_bar)) %>%
  gt() %>%
  fmt_percent(columns=`Share beating bar`,decimals =1 )
```

$/DALY bar	Share beating bar
50	2.0%
1000	35.9%
70000	84.6%

Share of simulations beating bar

Share of simulation chart: welfare range

```r
fig_a22_50benchmark_wv_nonstunning <-
share_sims_chart("Welfare range",bar_value=50,xvar_lower_lim=0.01,xvar_upper_lim=1,xlab_de
  scale_x_log10(labels = scales::percent_format(drop0trailing = TRUE),n.breaks=10)+
  scale_y_continuous(limits=c(0,0.75),n.breaks=10,labels = scales::percent_format(accuracy
```

Share of simulation chart: moral value

```r
fig_a23_50benchmark_mv_nonstunning <-
  share_sims_chart("Moral value",bar_value=50,xvar_lower_lim=0.001,xvar_upper_lim=30,xlab_
  scale_x_log10(labels = scales::label_number_si(drop0trailing = TRUE),n.breaks=11)+
  scale_y_continuous(limits=c(0,1),n.breaks=10,labels = scales::percent_format(accuracy =
```

Share of simulation results tables: $50/DALY benchmark - welfare range

```r
wr_bar_table(50)
```

Share of simulations beating $50/DALY bar

	Share of fish lifespan affected by i					
Welfare gain from intervention as a % of total fish welfare range	1%	2%	5%	10%	15%	2
0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.
1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.
2%	0.0%	0.0%	0.0%	0.0%	0.2%	0.
10%	0.0%	0.0%	0.4%	1.8%	4.0%	8.
15%	0.0%	0.1%	1.0%	4.0%	7.2%	13.
35%	0.2%	0.9%	5.0%	12.1%	17.8%	25.
50%	0.4%	1.8%	8.2%	17.0%	23.3%	31.
75%	1.0%	4.0%	13.0%	23.3%	29.8%	38.
90%	1.5%	5.3%	15.6%	26.3%	32.7%	41.
100%	1.8%	6.2%	17.0%	28.1%	34.6%	43.

Share of simulation results tables: $50/DALY benchmark - moral value

```r
mv_bar_table(50)
```

Share of simulations beating $50/DALY bar

	Sha	
Moral value of improving a fish life year via intervention relative to gaining a human DALY	1%	2%

0.01	0.0%	0.0%
0.05	0.0%	0.0%
0.1	0.0%	0.1%
0.25	0.2%	2.8%
0.5	2.8%	11.8%
0.75	6.9%	22.6%
1	11.8%	32.5%
5	64.3%	82.6%
10	82.6%	92.8%
25	95.0%	98.3%

Share of simulations - other results (not published in the main document)

```
mv_bar_table(1000)
```

Share of simulations beating $1000/DALY bar

	S	
Moral value of improving a fish life year via intervention relative to gaining a human DALY	1%	2
0.01	0.1%	1.4
0.05	11.8%	32.5
0.1	32.5%	56.9
0.25	64.3%	82.6
0.5	82.6%	92.8
0.75	89.2%	96.2
1	92.8%	97.6
5	99.5%	99.8
10	99.8%	99.9
25	100.0%	100.0

```
mv_bar_table(70000)
```

Share of simulations beating $70000/DALY bar

	S	
Moral value of improving a fish life year via intervention relative to gaining a human DALY	1%	2
0.01	88.2%	95.8
0.05	99.1%	99.7
0.1	99.7%	99.9

0.25	99.9%	100.0
0.5	100.0%	100.0
0.75	100.0%	100.0
1	100.0%	100.0
5	100.0%	100.0
10	100.0%	100.0
25	100.0%	100.0

```
wr_bar_table(1000)
```

Share of simulations beating $1000/DALY bar

	Share of fish lifespan affected by				
Welfare gain from intervention as a % of total fish welfare range	1%	2%	5%	10%	15%
0%	0.0%	0.0%	0.0%	0.0%	0.1%
1%	0.0%	0.2%	1.8%	6.2%	10.3%
2%	0.4%	1.8%	8.2%	17.0%	23.3%
10%	6.2%	14.0%	28.1%	39.5%	46.9%
15%	10.3%	19.9%	34.6%	46.9%	53.4%
35%	22.3%	33.5%	49.3%	60.0%	65.2%
50%	28.1%	39.5%	55.0%	64.5%	69.3%
75%	34.6%	46.9%	60.9%	69.3%	73.6%
90%	37.9%	49.9%	63.2%	71.4%	75.2%
100%	39.5%	51.4%	64.5%	72.5%	76.1%

```
wr_bar_table(70000)
```

Share of simulations beating $70000/DALY bar

	Share of fish lifespan affected by				
Welfare gain from intervention as a % of total fish welfare range	1%	2%	5%	10%	15%
0%	3.6%	9.5%	22.3%	33.5%	40.4%
1%	33.5%	45.7%	60.0%	68.7%	72.8%
2%	49.3%	60.0%	71.1%	77.6%	80.8%
10%	68.7%	75.5%	82.6%	86.5%	88.5%
15%	72.8%	79.0%	84.9%	88.5%	90.2%
35%	80.3%	84.5%	89.1%	91.6%	92.9%
50%	82.6%	86.5%	90.5%	92.8%	93.9%

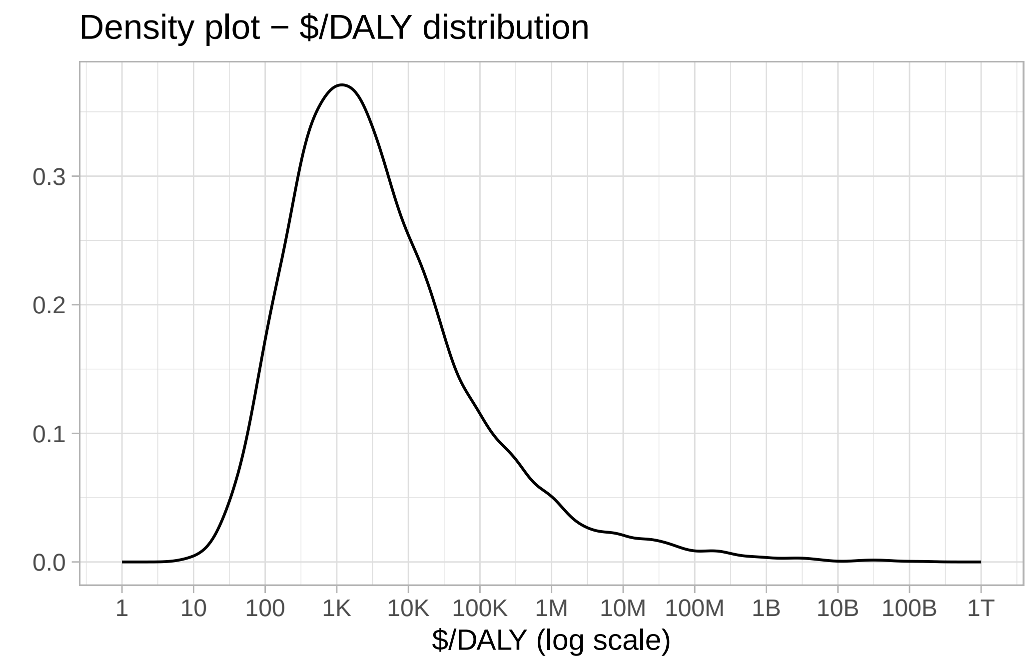
75%	84.9%	88.5%	91.9%	93.9%	94.7%
90%	86.0%	89.2%	92.5%	94.2%	95.1%
100%	86.5%	89.7%	92.8%	94.4%	95.2%

Export charts for main report

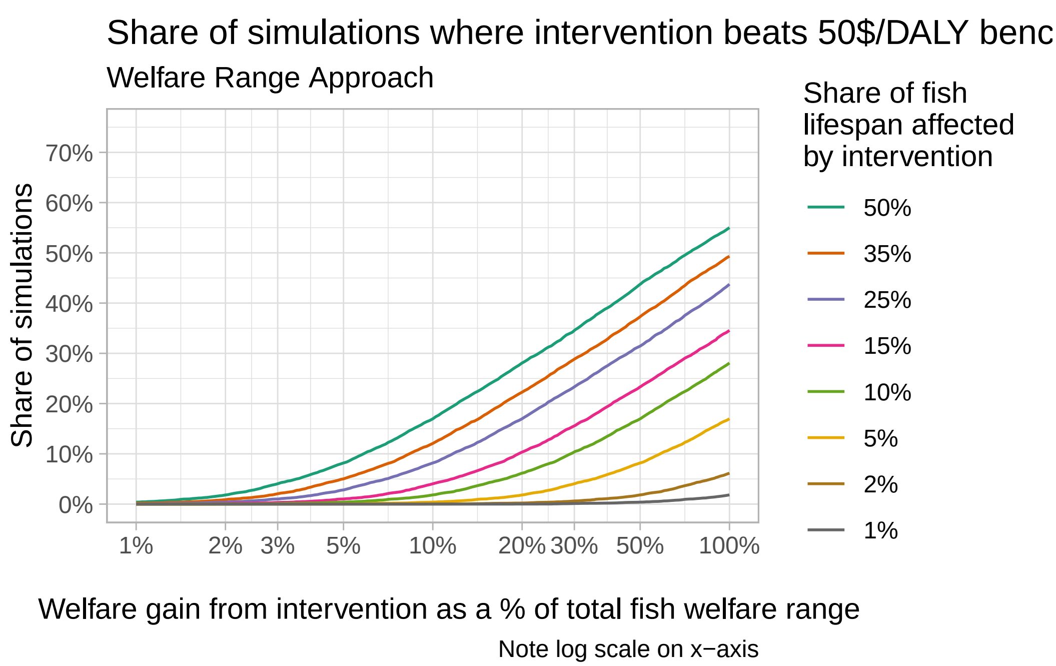
```
tab_a22_impact_per_dollar_nonstunning
```

statistic	lifespan_affected_fish	no_fish_affected
mean	0.973	0.748
sd	1.15	0.892
median	0.607	0.468
p5	0.0795	0.0608
p10	0.127	0.0972
p25	0.280	0.214
p75	1.24	0.949
p90	2.19	1.69
p95	3.08	2.41

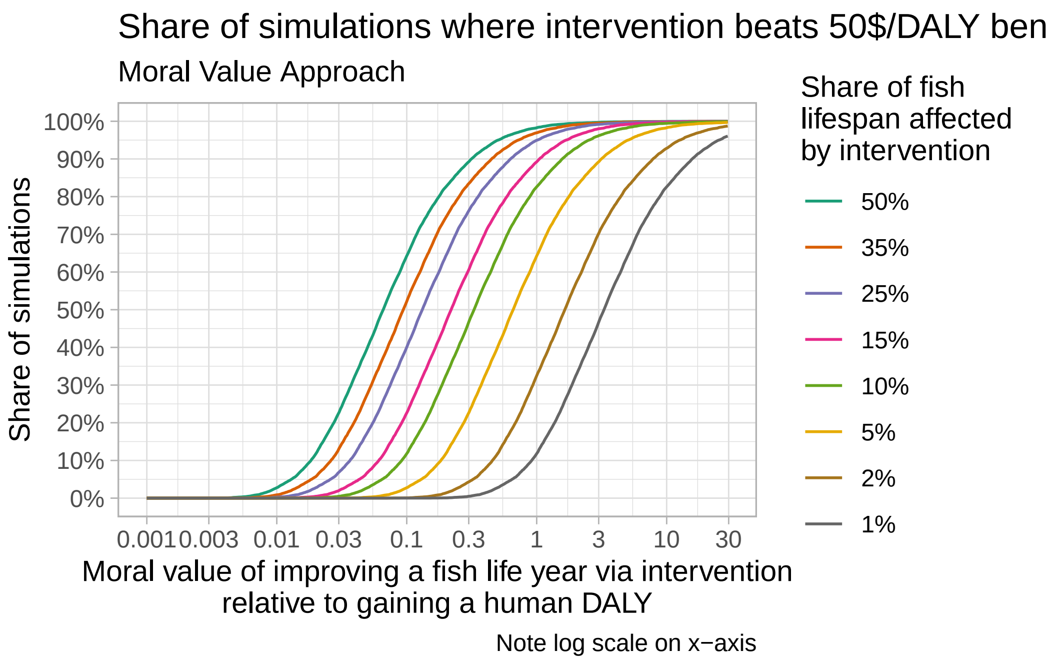
```
fig_a21_dollars_per_daly_nonstunning
```




```
fig_a22_50benchmark_wv_nonstunning
```



```
fig_a23_50benchmark_mv_nonstunning
```




```
save_chart("fig_a21_dollars_per_daly_nonstunning .png",fig_a21_dollars_per_daly_nonstunnin
save_chart("fig_a22_50benchmark_wv_nonstunning.png",fig_a22_50benchmark_wv_nonstunning)
save_chart("fig_a23_50benchmark_mv_nonstunning.png",fig_a23_50benchmark_mv_nonstunning)
save_table(tab_a22_impact_per_dollar_nonstunning,"tab_a22_impact_per_dollar_nonstunning.ht
```

Sensitivity to DALY share of welfare range assumption

```
share_wr_alt <- function(xvar,fishlifeshare,bar) {
  mean(bar>
      (1/
        (xvar*
        fypd*
        fishlifeshare*
        salmon_wr*2/
        DALY_share_of_welfare_range_alt
        )))
}
```

```
share_sims_calculation_grid_alt <-  expand_grid(
                                    xvar=wr_table_values,
                                    bar=50,
                                    fishlifeshare=fishlifeshare_values)



share_sims_results_table_alt <-
# Generate one row for unique combination of xvar_values and scenario lists
  share_sims_calculation_grid_alt %>%
# Core calcualtions using share_mv and share_wr calculation functions
    rowwise() %>%
    mutate(
      base=share_wr(xvar,fishlifeshare,bar),
      alt=share_wr_alt(xvar,fishlifeshare,bar)
    ) %>%
  distinct() %>%
  mutate(
    fishlifeshare=factor(fishlifeshare,labels=paste0(fishlifeshare*100,"%"))) %>%
  select(-bar) %>%
  pivot_longer(
    cols=c(base,alt),
    names_to="daly_assumption",
    values_to="share_of_sims")
```

```
alt_table_comparison <- function(assumption) {
share_sims_results_table_alt %>%
 filter(daly_assumption==assumption) %>%
 select(-daly_assumption) %>%
  pivot_wider(
    id_cols=xvar,
    names_from=c(fishlifeshare),
    values_from=share_of_sims) %>%
  arrange(xvar) %>%
  gt() %>%
  fmt_percent(decimals=1) %>%
  cols_label(
    xvar="Welfare gain from intervention as a share of fish welfare range") %>%
  tab_spanner(
    label="Share of fish lifespan affected by intervention",
    columns=-1
      )
```

```
}
```

```
alt_table_comparison("base") %>%
  tab_header(title="Share of simulations beating $50/DALY - baseline assumptions")
```

Share of simulations beating $50/DALY - baseline assumptions

	Share of fish lifespan affected by int					
Welfare gain from intervention as a share of fish welfare range	1%	2%	5%	10%	15%	25
0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
1.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0
2.5%	0.0%	0.0%	0.0%	0.0%	0.2%	0.7
10.0%	0.0%	0.0%	0.4%	1.8%	4.0%	8.2
15.0%	0.0%	0.1%	1.0%	4.0%	7.2%	13.0
35.0%	0.2%	0.9%	5.0%	12.1%	17.8%	25.9
50.0%	0.4%	1.8%	8.2%	17.0%	23.3%	31.4
75.0%	1.0%	4.0%	13.0%	23.3%	29.8%	38.6
90.0%	1.5%	5.3%	15.6%	26.3%	32.7%	41.7
100.0%	1.8%	6.2%	17.0%	28.1%	34.6%	43.8

```
alt_table_comparison("alt") %>%
  tab_header(title="Share of simulations beating $50/DALY - alternative assumptions")
```

Share of simulations beating $50/DALY - alternative assumptions

	Share of fish lifespan affected by in					
Welfare gain from intervention as a share of fish welfare range	1%	2%	5%	10%	15%	2
0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0
1.0%	0.0%	0.0%	0.4%	1.8%	4.0%	8
2.5%	0.0%	0.4%	2.8%	8.2%	13.0%	20
10.0%	1.8%	6.2%	17.0%	28.1%	34.6%	43
15.0%	4.0%	10.3%	23.3%	34.6%	41.7%	50
35.0%	12.1%	22.3%	37.3%	49.3%	55.9%	62
50.0%	17.0%	28.1%	43.8%	55.0%	60.9%	67
75.0%	23.3%	34.6%	50.5%	60.9%	66.1%	71
90.0%	26.3%	37.9%	53.4%	63.2%	68.3%	73
100.0%	28.1%	39.5%	55.0%	64.5%	69.3%	74

```{}
```

```
# Convert pivot into longer format to make results easier to plot
  pivot_longer(
    cols=c(moral_value,welfare_range),
    names_to="approach",
    values_to="share_of_simulations") %>%
# Change descriptions of variables to make results easier to interpert
  mutate(
    approach=str_to_sentence(str_replace_all(approach,"_"," ")),
    bar_factor=factor(bar,levels=bar_values,labels=c("50","1K","70K")),
    fishlifeshare_factor=factor(fishlifeshare,levels=rev(fishlifeshare_values),labels=past
```