



# HIDDENFJORD

RAISED IN THE WILD



# Fish welfare to prevent sea lice issues

Esbern Jóannes Patursson



**HIDDENFJORD**  
RAISED IN THE WILD

# Owners and management



# Philosophy Hiddenfjord

## Values

- Sustainability
- To be open and honest
- Innovation
- Financial prudence

## Goals

- “To do ours so the farming in the Faroe Islands can thrive and reach it’s full potential”
- To produce the world’s best salmon
- To be a good workplace



# Employees

**Fish welfare demands good leadership and meticulous employees from roe to slaughter**

Sufficient number of employees

**Development team**

Have time to concentrate and focus on ideas

**Very short time from idea to action**



**HIDDENFJORD**  
RAISED IN THE WILD



# Exposed farming

- Started farming at Skálafjørðinum in 1984
- Moved to exposed farming at Gøtuvík in 1988
- Continuing the same direction
- Less impact on sediments
- Fewer sea lice
- Fewer algae
- Healthier fish
- Better fish welfare



# Sea lice population dynamics

Has been the main driver for exposed farming, and “all” other developments, since Gøtuvík 1988  
- together with sediments

From onions to lasers..

An index of sustainability

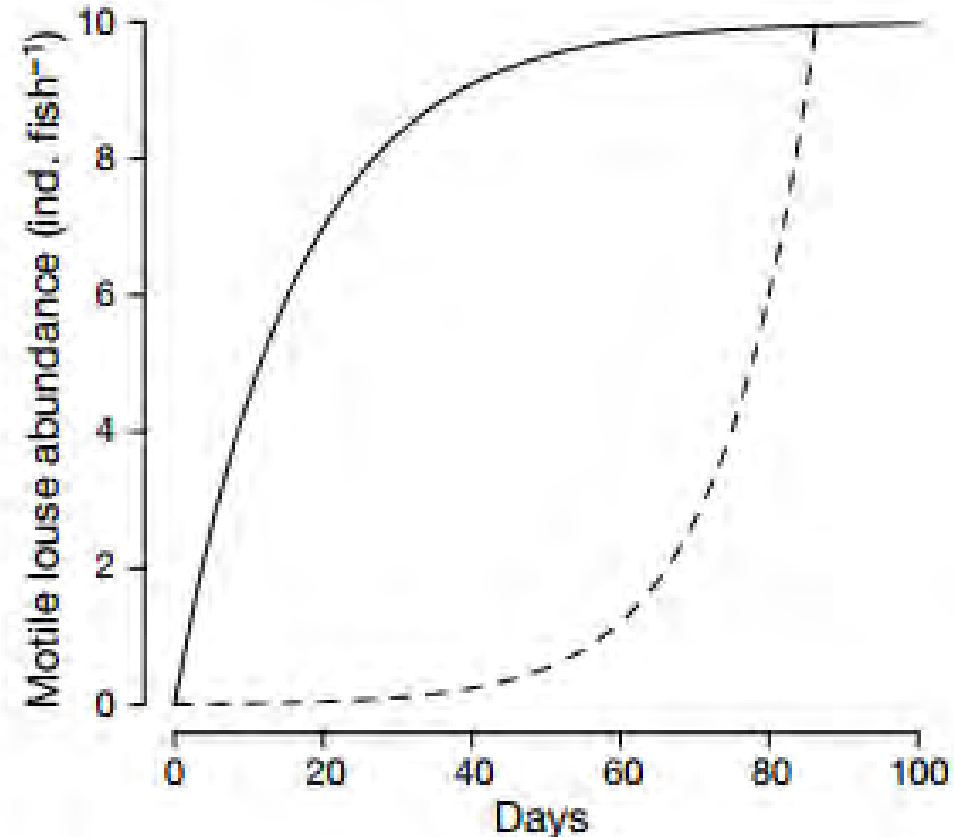
Fish welfare – quality – **Stress free harvest**

Control sea lice ~ control sustainability

## Self-infection vs external infection

Exposed farming -> external infection

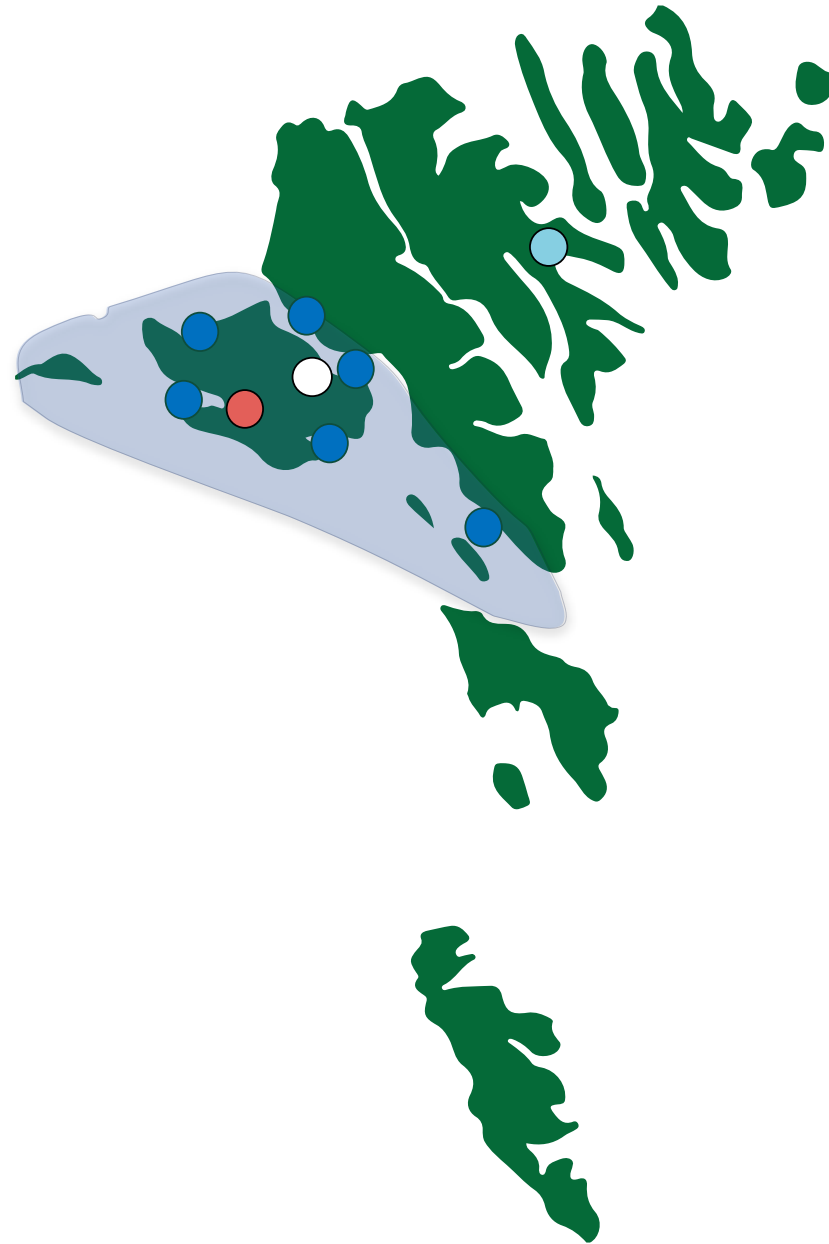
Strategic deployment



Self-infection (dashed line) external infection (line) (Krkosek *et.al.* 2010)

# Hiddenfjord

- Hatchery
- Seafarming
- Production facility
- Administration





# Exposed farming

Norwegian-Standard <- 3 m = High exposure

**Wave height (Hm050 (Hs) m)**

Víkar: 9

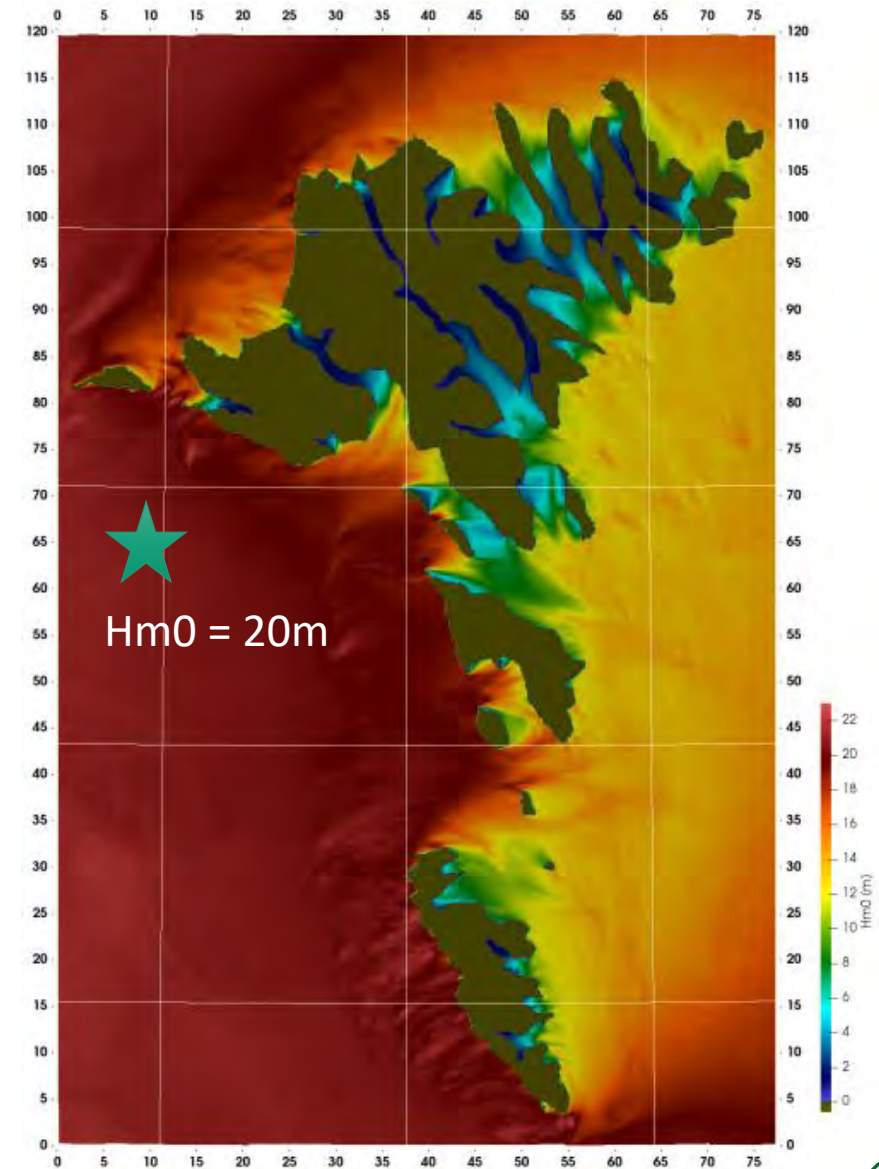
Sørvágur: 6

Miðvágur: 6

Velbastað: 6

Vestmanna: 1-2

Suðuri í bug: 2-3



Niclassen and Simonsen, 2011



**HIDDENFJORD**  
RAISED IN THE WILD

# Exposed farming

## Current (cm/second)

Suðuri í buð:220 (start spring 2022)

Vestmanna: 110

Velbastað:70

Sørvágur:50

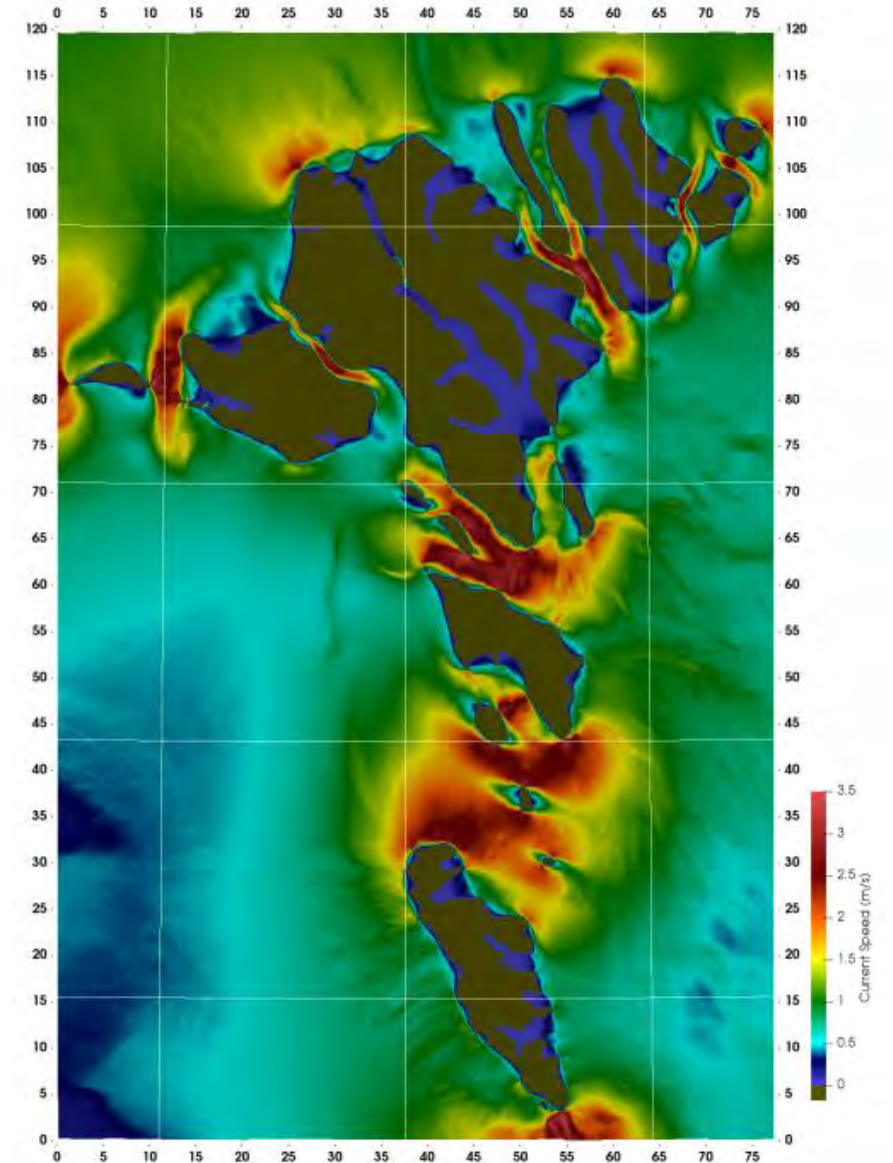
Miðvágur:30

Víkar: < 50

## Worlds most exposed farming sites

...central questions regarding offshore aquaculture... To our knowledge, there are presently only two available studies on this topic, where both were conducted at wave-exposed sites on the Faroe Islands (Dam 2015; Johannesen et al. 2020).

\*Hvas et al. 2019. aquaculture.



Niclassen and Simonsen, 2011







# Fish welfare

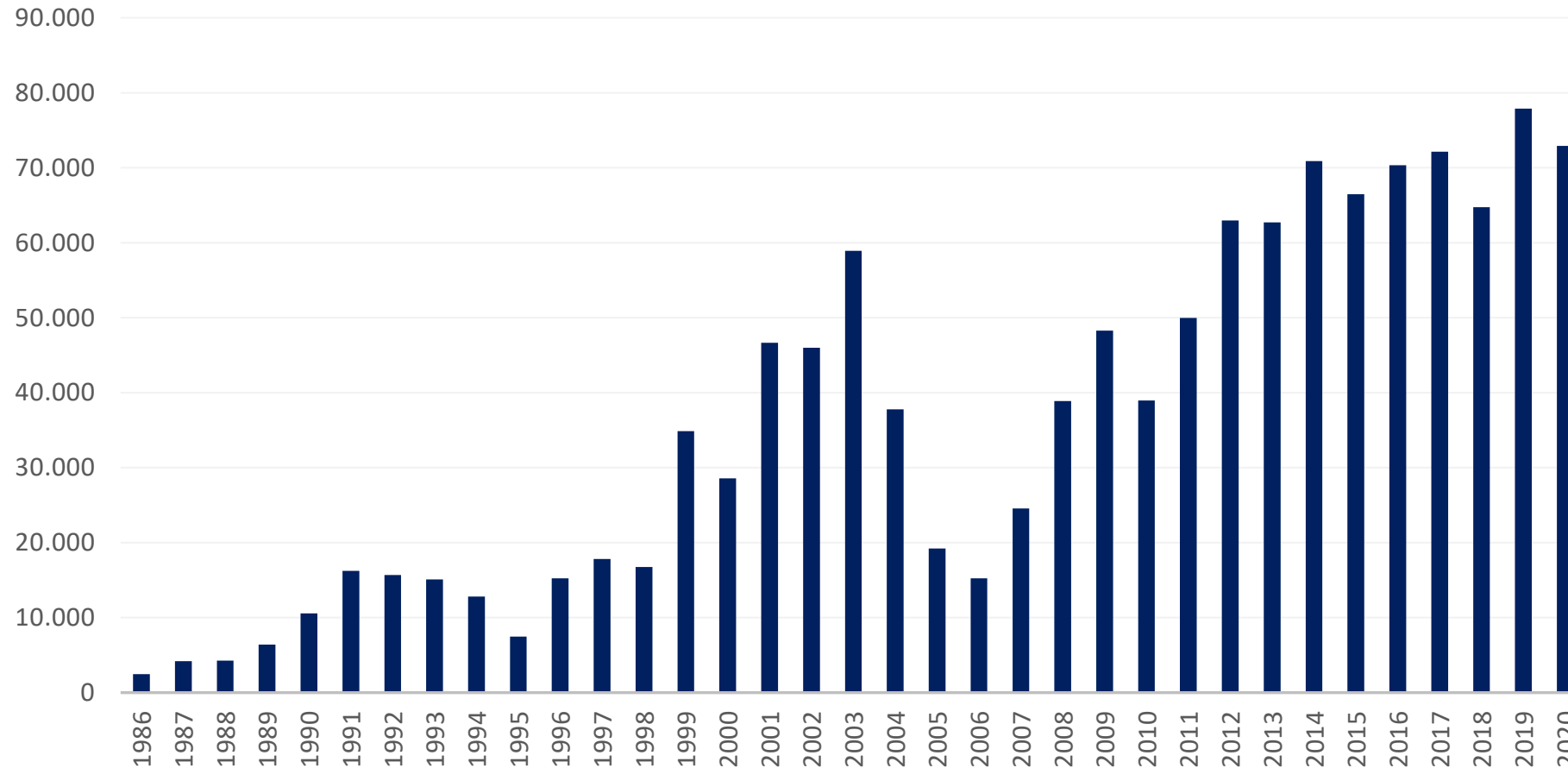
Appetite (Growth) and mortality are obvious measures of fish welfare in aquaculture , and should therefore be self-explanatory in the aquaculture business but..

«Der er som regel god økonomi i fiskehelse - mens der ikke altid er god fiskehelse i økonomi!»

*Peter Østergaard*

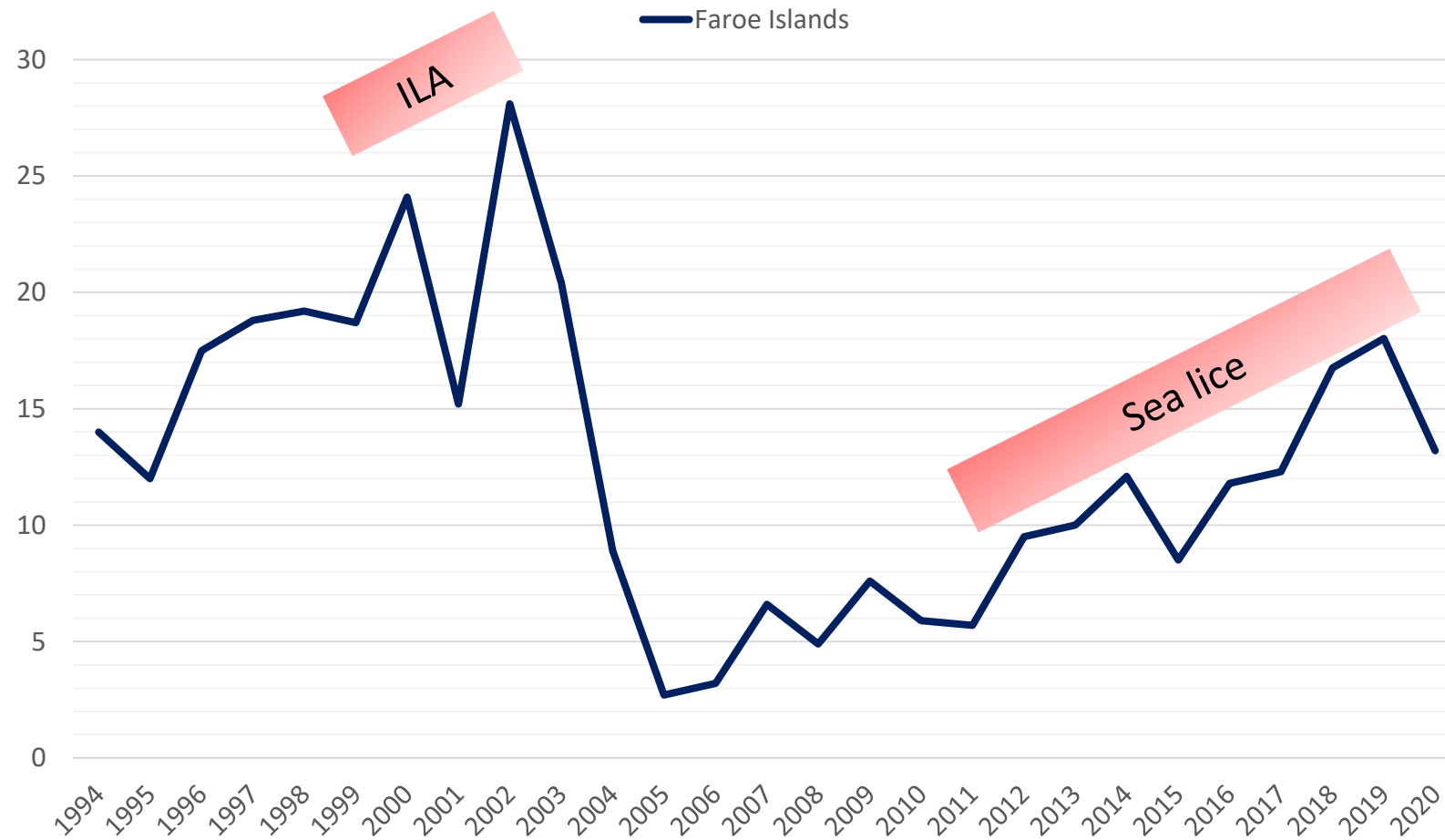
# Production Faroe islands (tons gutted weight)

Fish welfare and appropriately strict regulations important



# Yearly mortality

% of stocked salmon from stocking to harvest – pens harvested in given year.





# Sea lice strategy



# Sea lice strategy Hiddenfjord

## Exposed farming and a preventive approach

- Short time on sea
  - Large smolts -> good quality
  - Fast growth
- Lumpfish
- Strategical deployment
  - Fewer salmon on problematic sites
- Planning and research
  - Know the hydrodynamics and the population dynamics of sea lice of the farming sites
- Sea lice modelling
- Appropriately strict regulations
- If necessary – chemical treatment

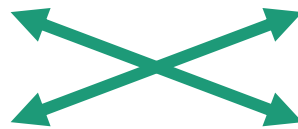


# Main goals in combatting sea lice - Change

2016

## Prevention

1. No chemicals
2. No handling



2018

## Prevention

1. No handling
2. No chemicals



HIDDENFJORD  
RAISED IN THE WILD

Short time on sea

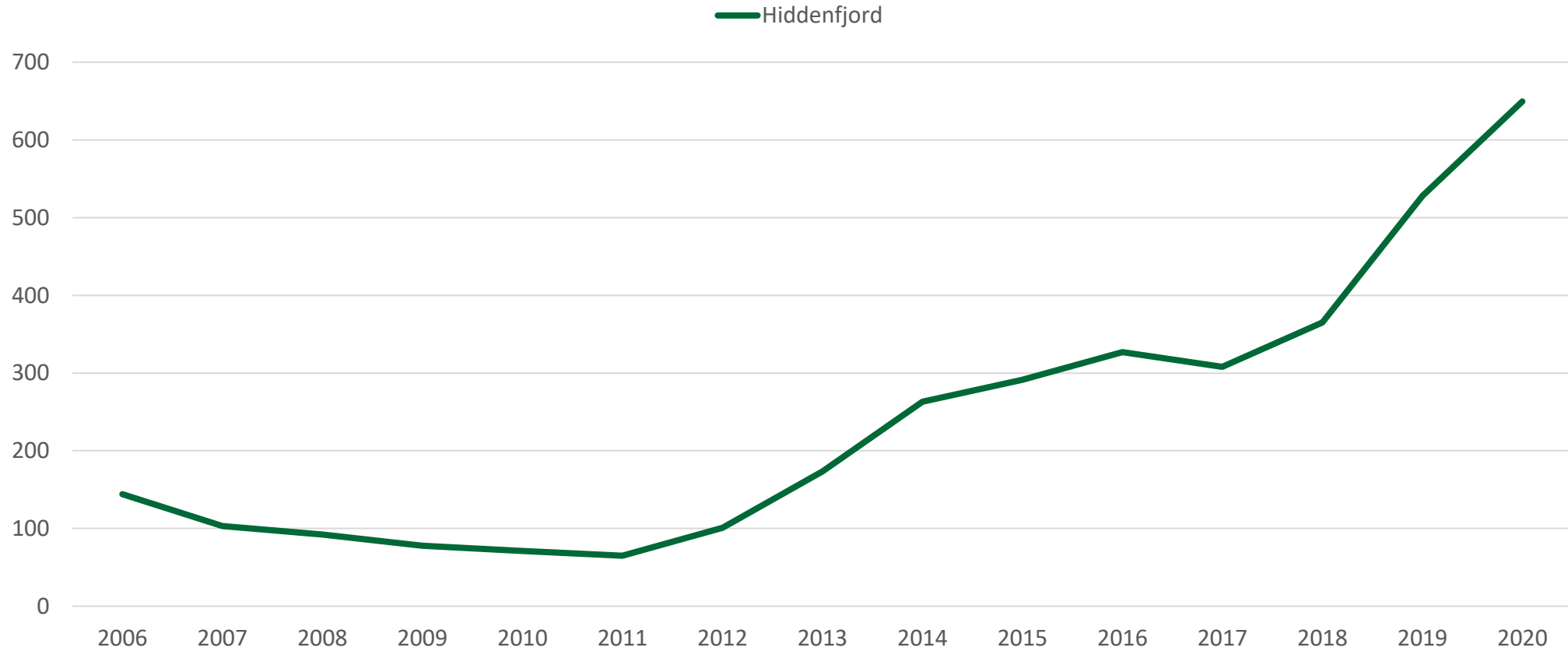


# Large smolts



# Smolt weight

From year of harvest (not stocking)



**HIDDENFJORD**  
RAISED IN THE WILD

# Fútaklettur 2000



**HIDDENFJORD**  
RAISED IN THE WILD

# Fútaklettur 2019



**HIDDENFJORD**  
RAISED IN THE WILD



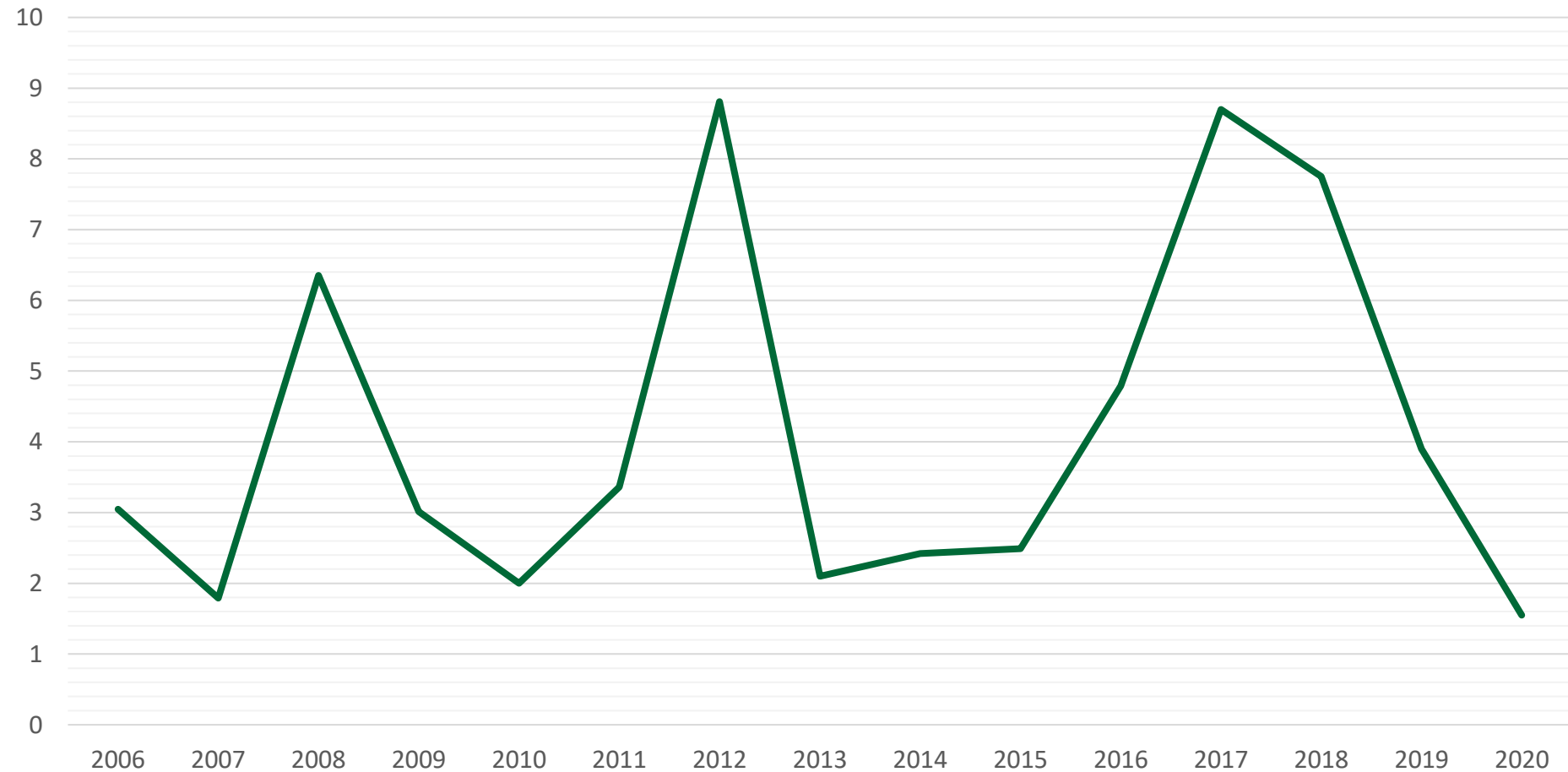
# Smoltquality



- Low mortality
- Good growth potential
- Start feeding right after stocking

# Stocking mortality %

Mortality the first 3 months on sea





# Respirometry



Heðrikur Bergsson

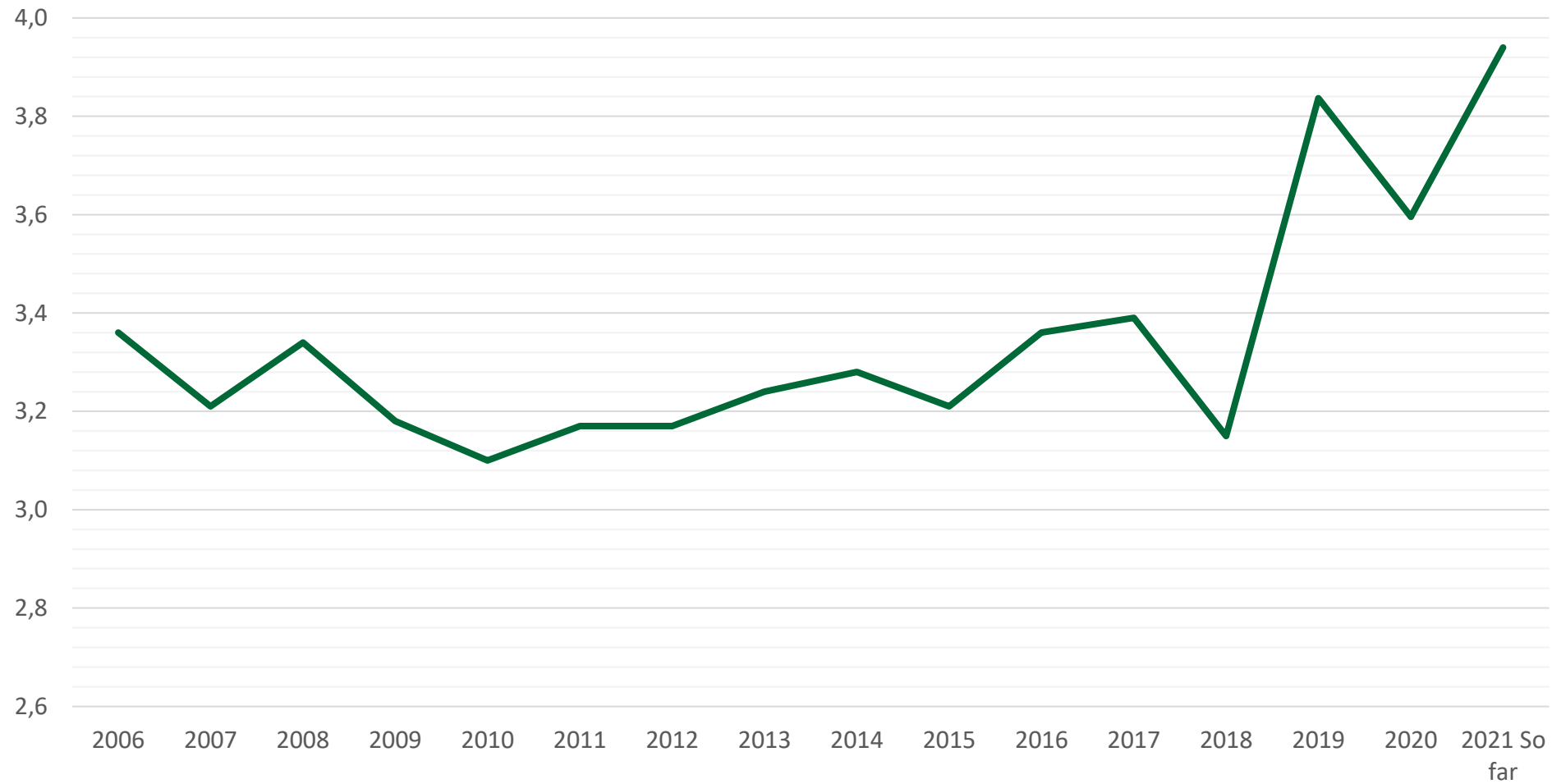
Important with exposed farming

A better start (Short time on sea)

# Growth

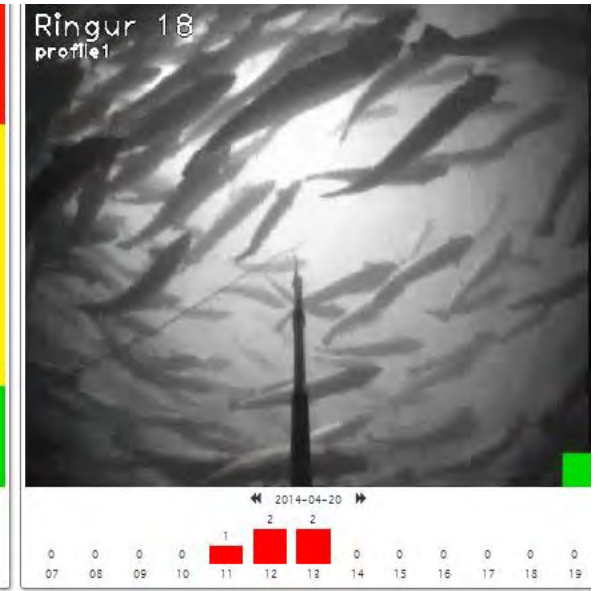


# Growth (TGC (VF3))



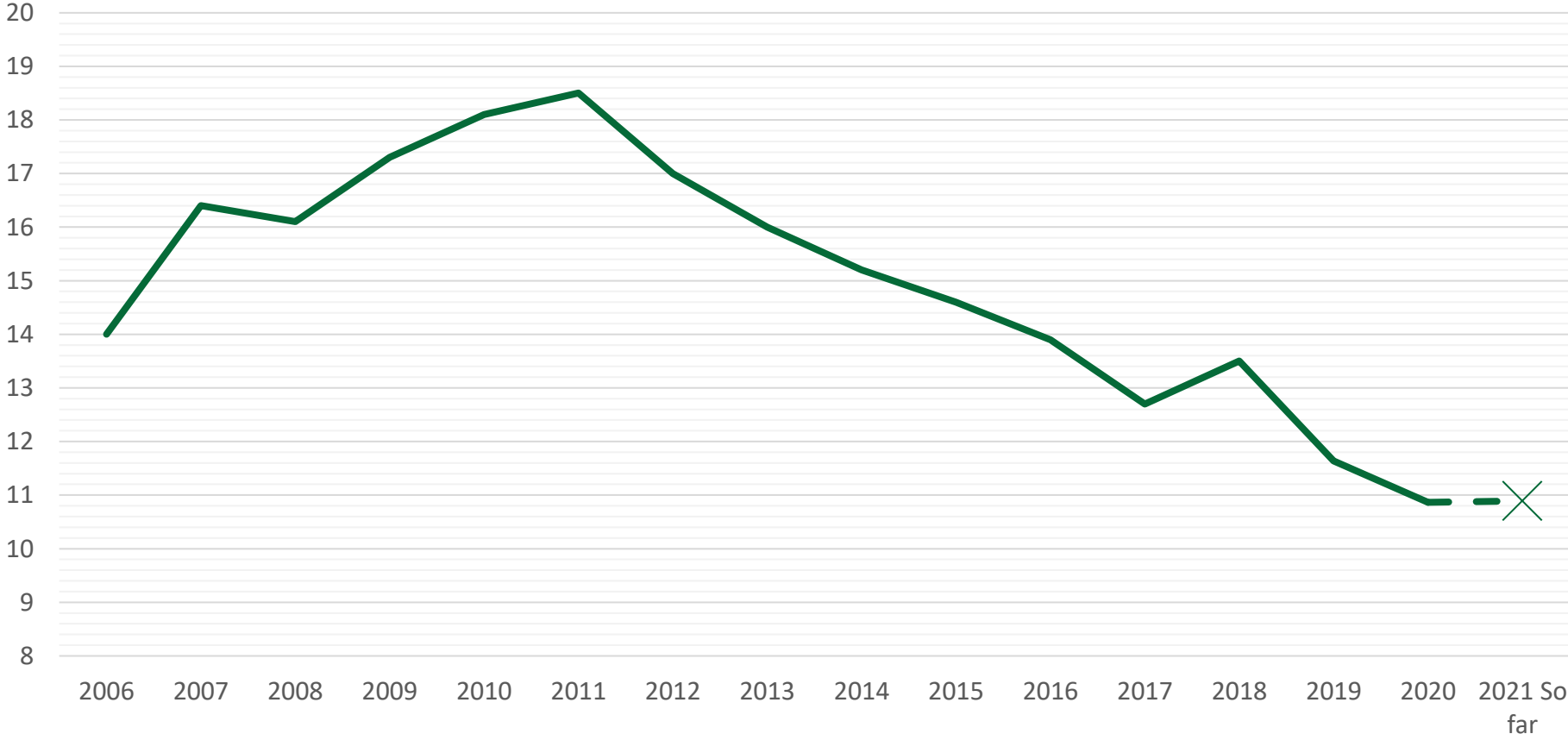
# Effort in feeding

Pellet detector and automated feeding from FaroeSea



**HIDDENFJORD**  
RAISED IN THE WILD

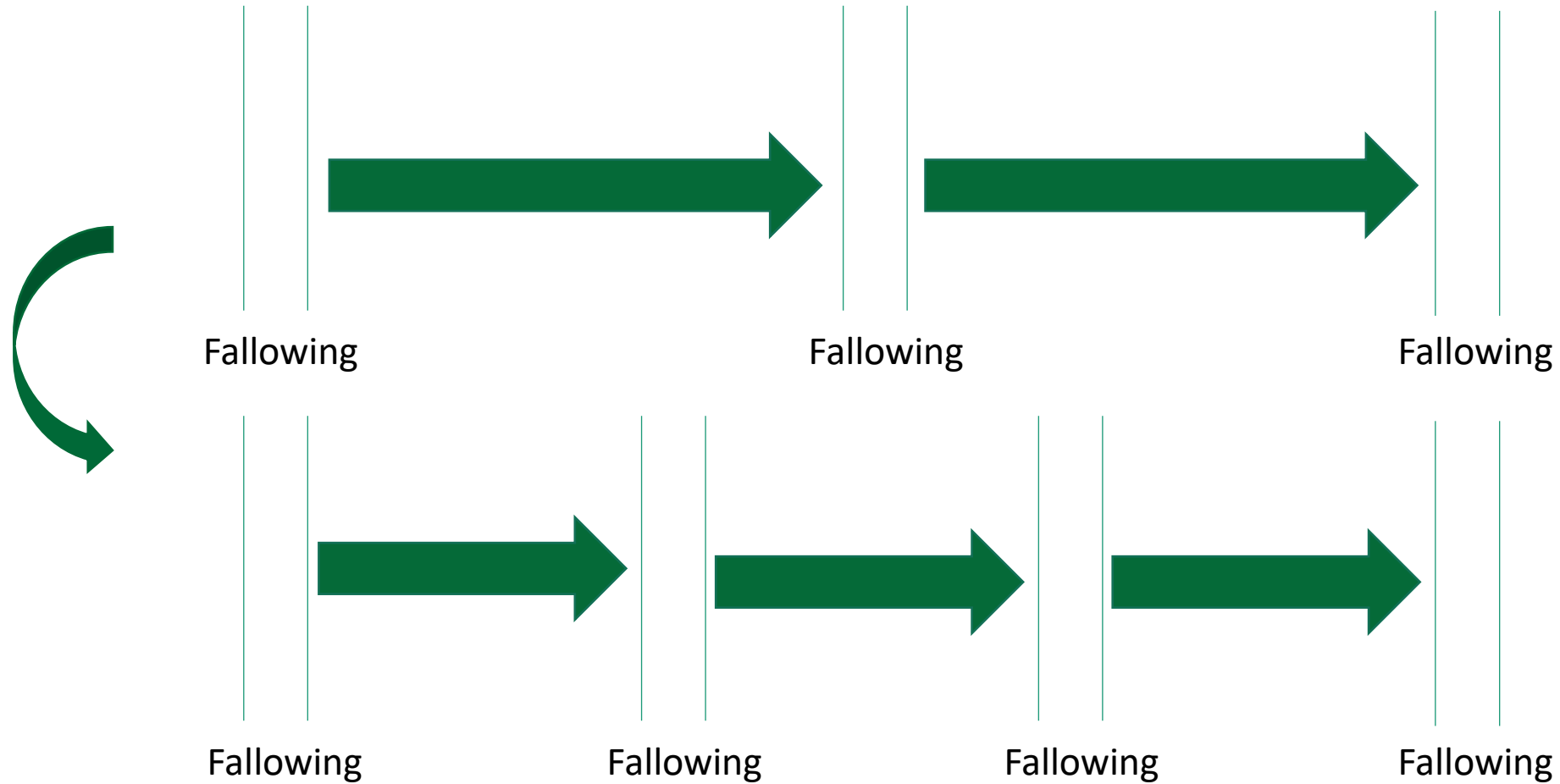
# Months on sea





# Farming cycles at Sea

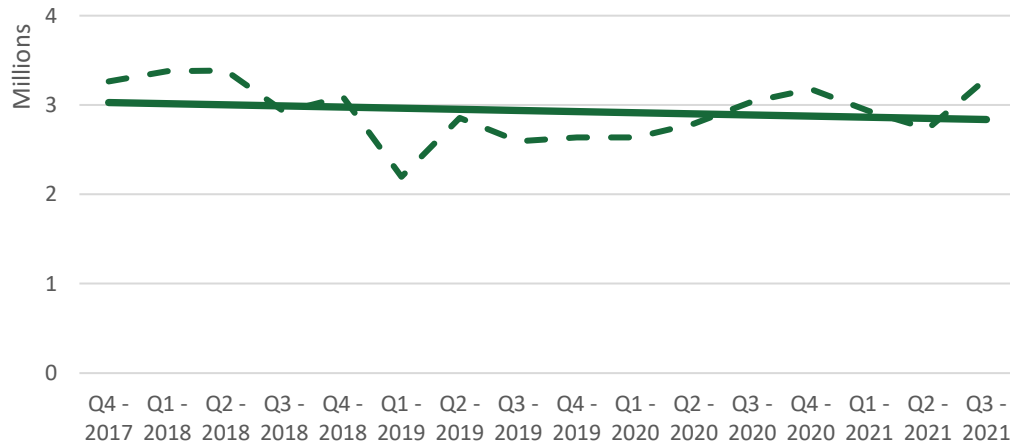
Reduces biological risk -> fewer sea lice -> improved welfare



# Sustainable farming

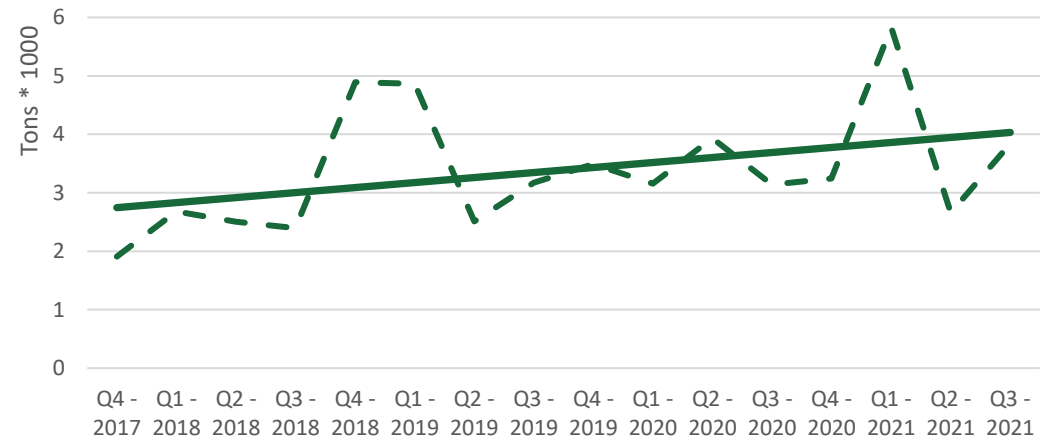
~ 7 % decrease

Average number of salmon at sea Hiddenfjord



~ 43 % increase

Production Hiddenfjord



## Large smolts with fewer/equal number of salmon

- Increased production
- Fewer sea lice
- Less handling of the salmon
- Lower biological risk
- Higher intensity -> Increased pressure on sediment
- Solution -> Exposed farming – resuspension of sediment
  - Less internal infection pressure – easier to manage sea lice



# Lumpfish

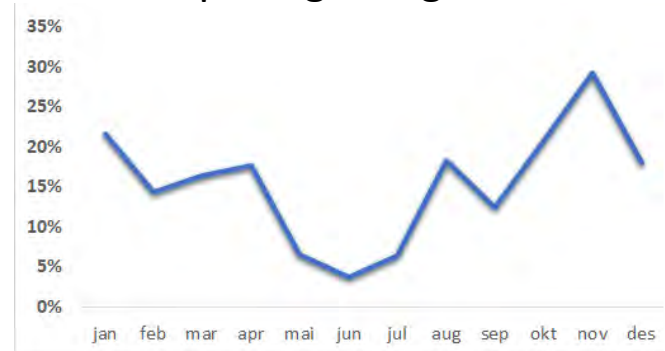
A close-up photograph of two lumpfish being held by human hands. The fish are dark blue-green with a bumpy, textured skin. They are positioned facing each other, with their heads touching. The hands are visible, with fingers supporting the fish from below and the sides. The background is blurred.

Good for salmon welfare – Lumpfish welfare has to improve

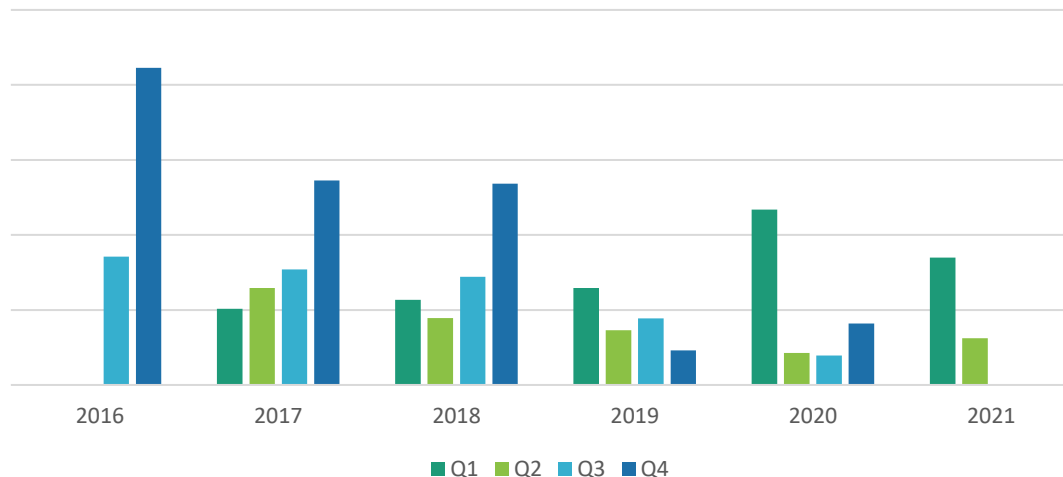
# Lumpfish

Very effective sea lice grazers  
Crucial in for our strategy  
Mortality steadily decreasing

% lumpfish grazing on sea lice



Lumpfish mortality



- New vaccines
  - *P. anguilliseptica*
  - *Pasterurella* sp.
  - *Tenacibalum* next
- Research
- Strategy
- Feeding
- Hides

We have reasonable hope that mortality and wellbeing of lumpfish will come to a satisfactory level

Planning and research

Hydrodynamic measurements

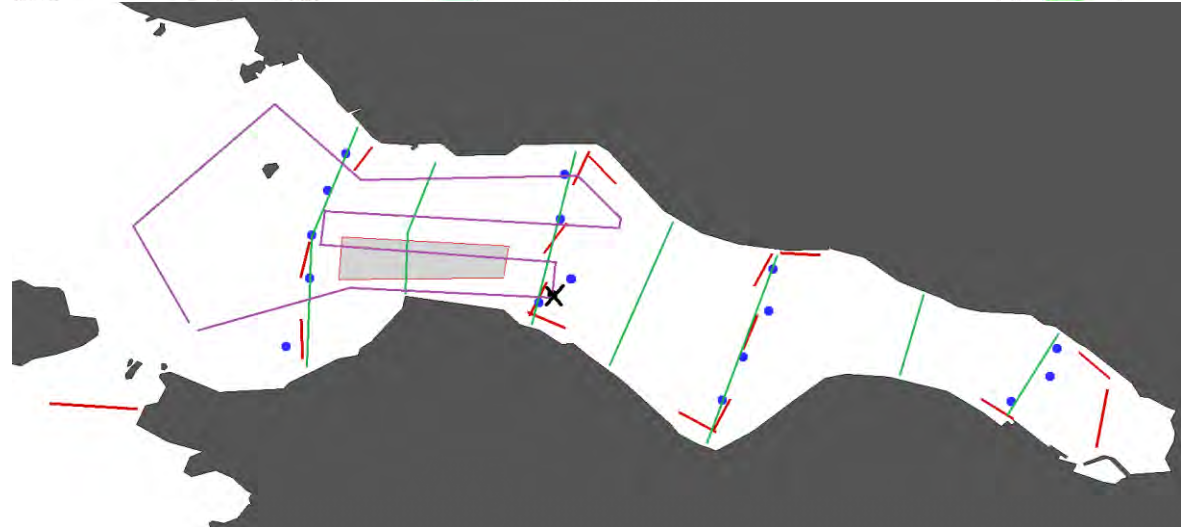
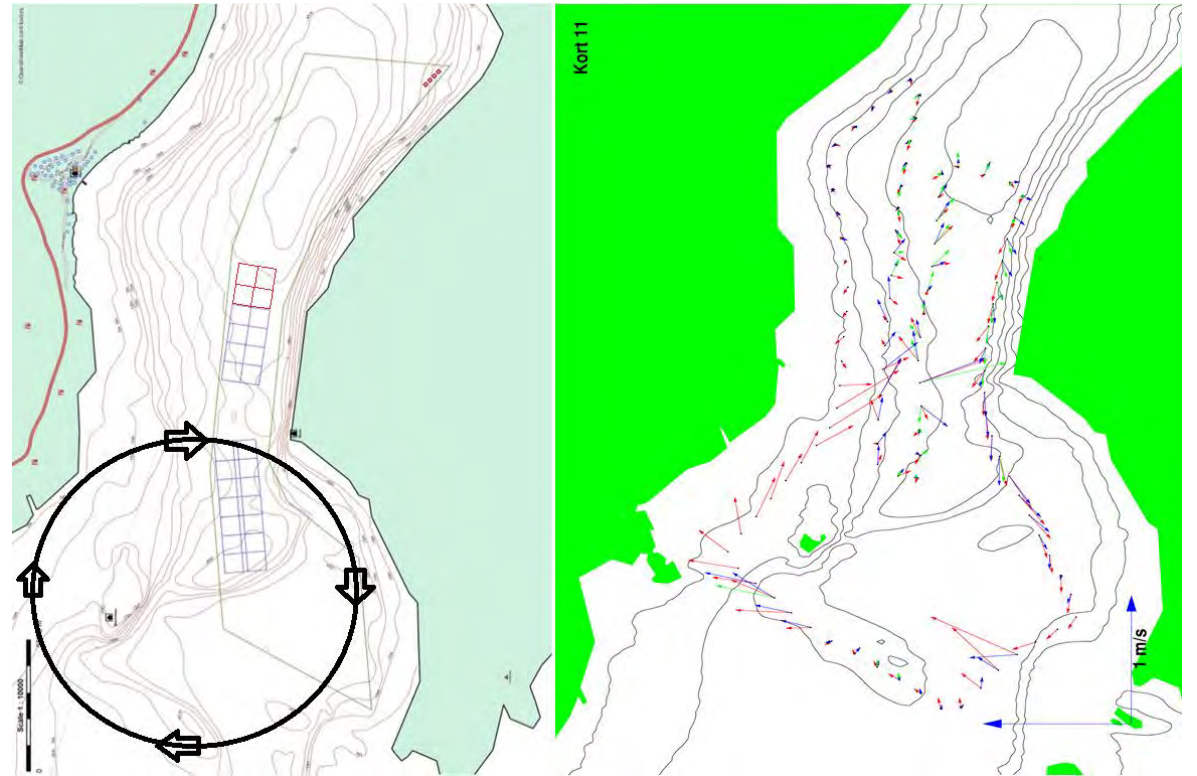
Strategical deployment



# Sørvágur

Our most problematic site

- Hydrodynamic measurements
- Sea lice tawls
- Strategic deployment – salmon count
- Self infection vs external infection



# Sea lice modelling

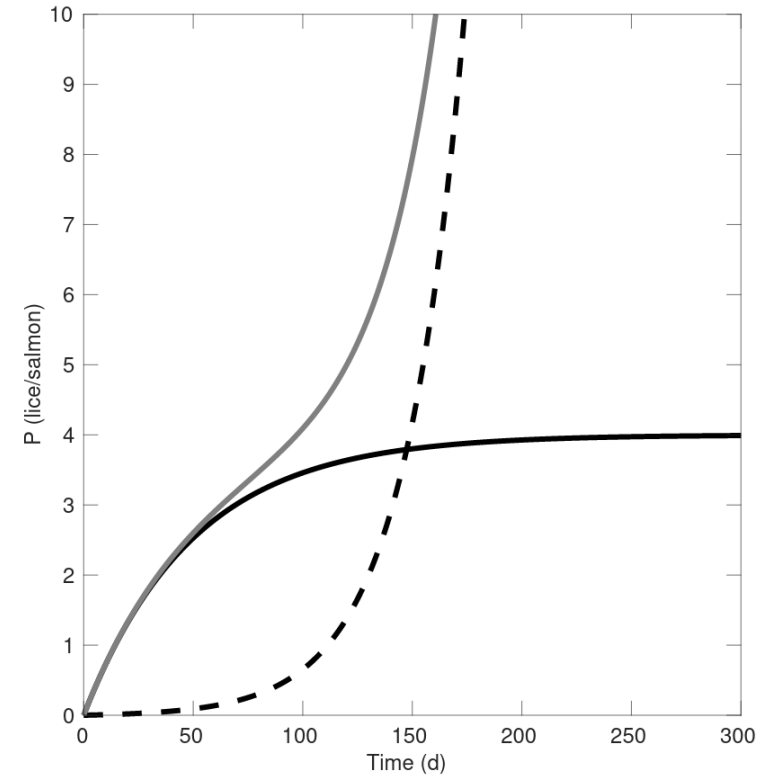
Internal infection pressure (dashed line) and external infection pressure (line) (Kragesteen, 2019)

Agent based salmon lice model, tracking development of all sea lice stages, depending on temperature.

[https://github.com/TrondurJK/Salmon\\_lice\\_simulator](https://github.com/TrondurJK/Salmon_lice_simulator)

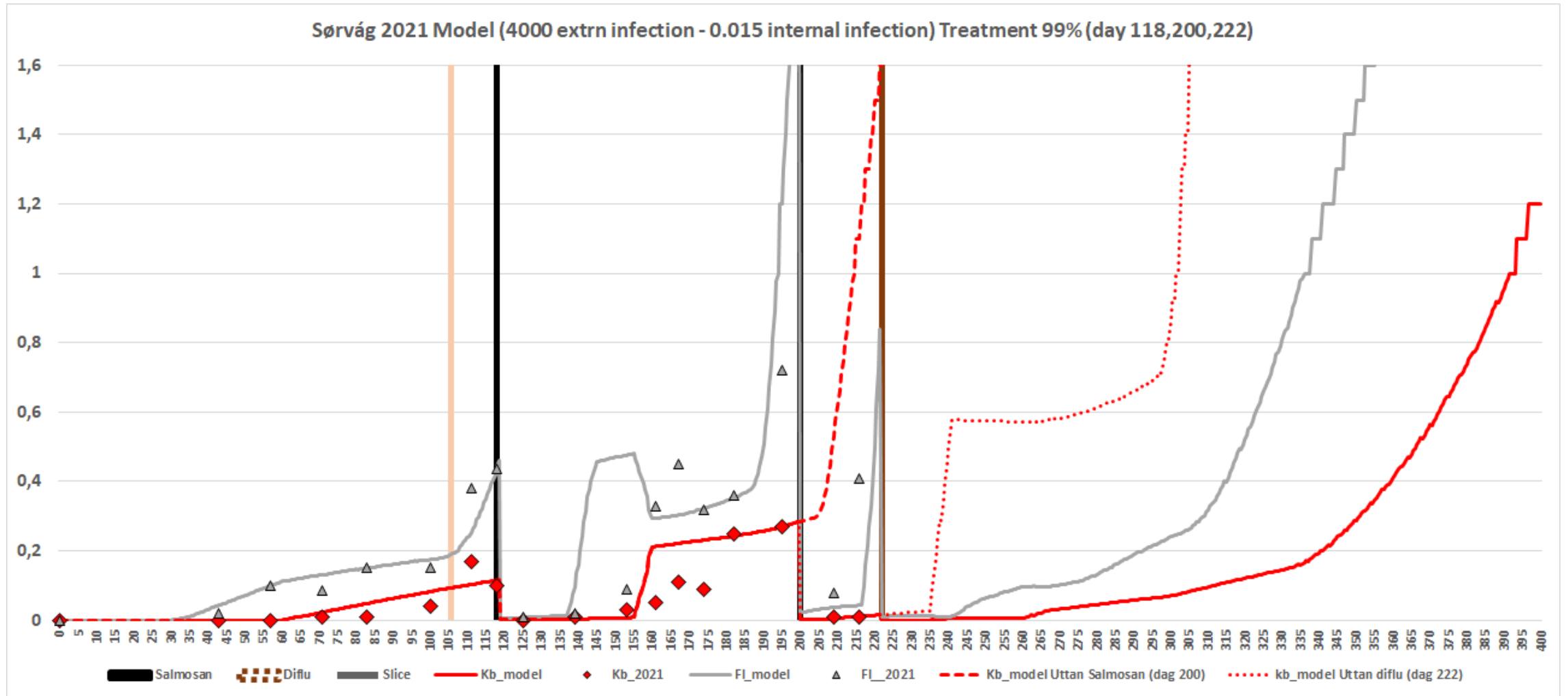
```
File Edit Search Source Run Debug Console Projects Tools View Help
C:\Users\esbern.patursson\Desktop\Salmon_lice_simulator-main\Salmon_lice_simulator-main
Test_run.py - esbern.patursson\Salmon_lice_simulator-main
Lice_agent_female.py x Lice_agent_male.py x Test_run.py - spyder.py 13.4.2024

16 #----- F8 Jopplá at koyra sum Tað skál -----
17 initial_start = 0
18 stop_time = 400
19
20 #----- make matrix to days of year -----
21 Con_matrix = np.zeros([len(farm_names),len(farm_names),365,40])#40,00002 # +0.001 or 0.1K built-in million farms
22 internal_con = 0.015 #0.001 # 1MUTON SPITTA 0.01 (0.015)
23 delay = 5
24
25 for index1 in enumerate(farm_names):
26     Con_matrix[index,index,,:delay] = internal_con
27
28 #for i in range(0,365):
29     # Run_matrix=np.stack((Run_matrix, c_matrix))
30     # Run_matrix_age = np.stack((Run_matrix_age, c_matrix_age))
31
32 #----- define treatments -----
33 treat_date = [[110,200,320]] #[[110],200]
34 num_treatment = [len(s) for s in treat_date]
35 treatment_array = [np.zeros(6, x)] for x in num_treatment
36 #treatment_array = [x*0.01 for x in Treatment_array] #0.01 or Neffektivitetur
37 #treatment_array = [treatment_array]*num_treatment
38 treatment_type = [['any', 'any', 'any', 'any', 'any', 'any'], ['any', 'any', 'any', 'any', 'any', 'any'], ['food', 'treatment', 'any', 'any']]
39
40 #----- Initiate Farm class -----
41 wrasse_data = [[0],[0]] # [[0],[0]], [[0],[0]], [[0],[0]] # [[0],[0]], [[0],[0]], [[0],[0]], [[0],[0]], [[0],[0]], [[0],[0]], [[0],[0]], [[0],[0]]
42
43 #----- Temperature -----
44 date = np.arange(initial_start, stop_time)
45 temp = np.sin(date / (365 * (np.pi * 2))) * 2.2 + 8.5
46 stop = temp > 10 # millimeterast um líkil temp skál vera hein lílja.
47 #plt.plot(date,temp)
48 #plt.show()
49 temperature = [date, temp]
50
51 farms = [
52     Farm(0,delta_time,1_000_000,
53         1,0,none, # number of larvae per day EXTERNAL SMITT
54         name=farm_names[index],
55         farm_start=farm_start[index]-initial_start,
56         prod_len = 400, # production length
57         fallow = [0],
58         treatments = np.array(treat_date[index]), # inputs the dates treatments are preferred
59         treatment_type = treatment_type[index], # inputs type of treatments
60         NumTreat=4,
61         treat_off=np.array(treatment_array[index]),
62         fish_count_history = [np.arange(0,10000)*0.1,0_000_000], # data, number of fish here set to 500
63         temperature = temperature,
64         wrasse_data = np.array(wrasse_data[index]),
65         biomass_data = [[0,stop_time],np.array([1,1])],
66         #initial_start=none,
67         #classif=0,
68         #lice_mortality=[0.01,0.01,0.02,0.02,0.02,0.02],
69         lice_mortality=[0.0005, 0.0005, 0.0005, 0.005, 0.005, 0.005, 0.005, 0.005, 0.005],
70         surface_ratio_match=0
71     )
72 ]
73 for index,farm_id in enumerate(farm_names)
```



# Sea lice modelling

A crucial tool for internally infected sites

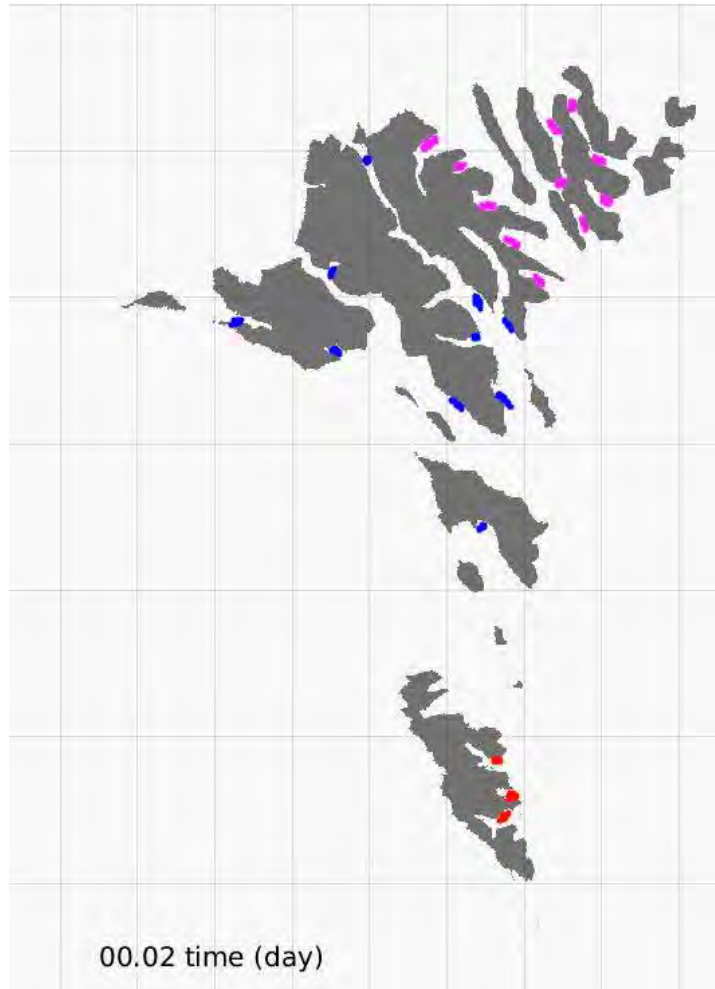




# The need for appropriately strict regulations



# Sea lice are a common enemy



- Can travel all the way around the Faroes in the infective stage
- Needs strict regulations to avoid tragedy of the commons

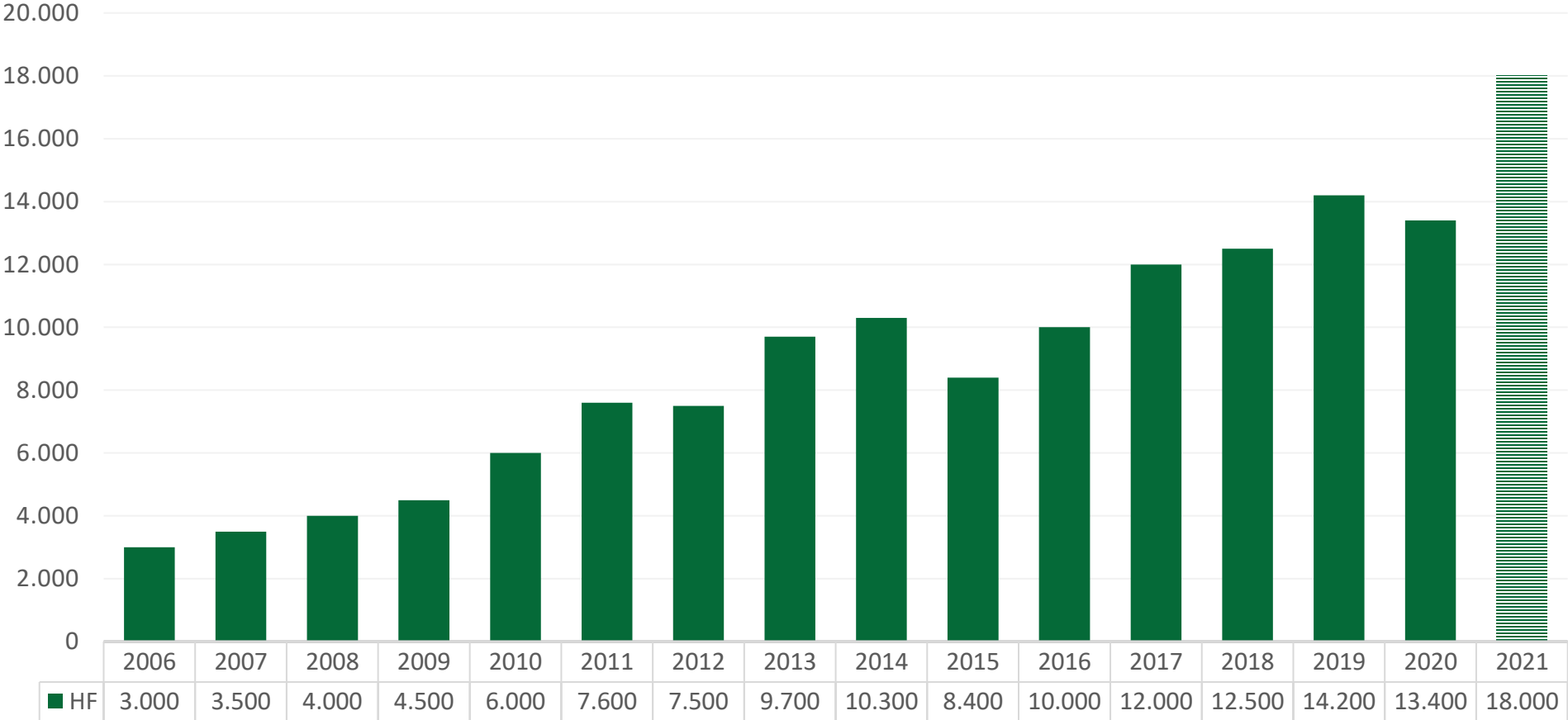
Particle simulation of sealice (Kraagesten *et.al.* 2018)

How is it going?



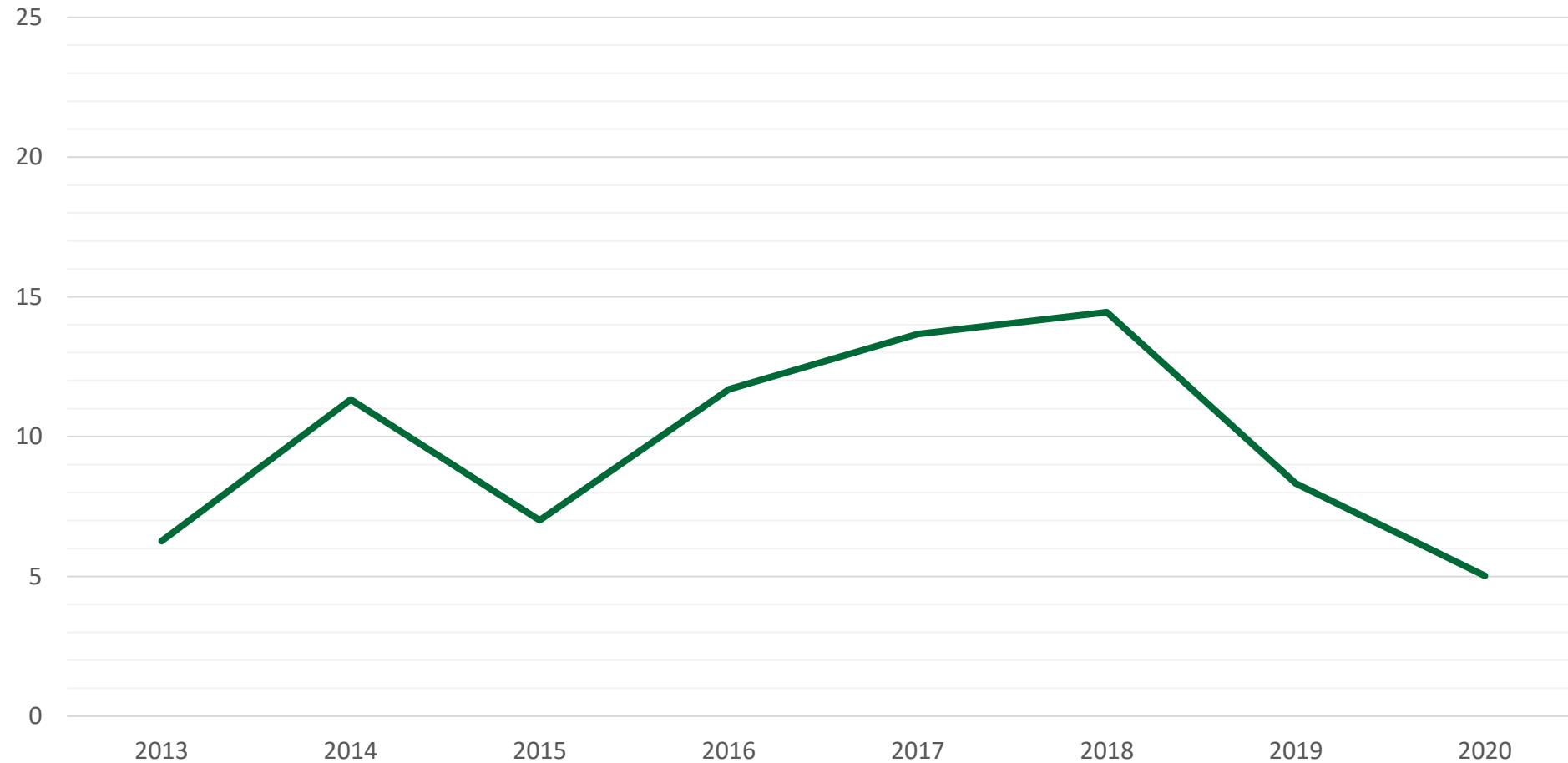
# Production Hiddenfjord

(Mt gutted weight)



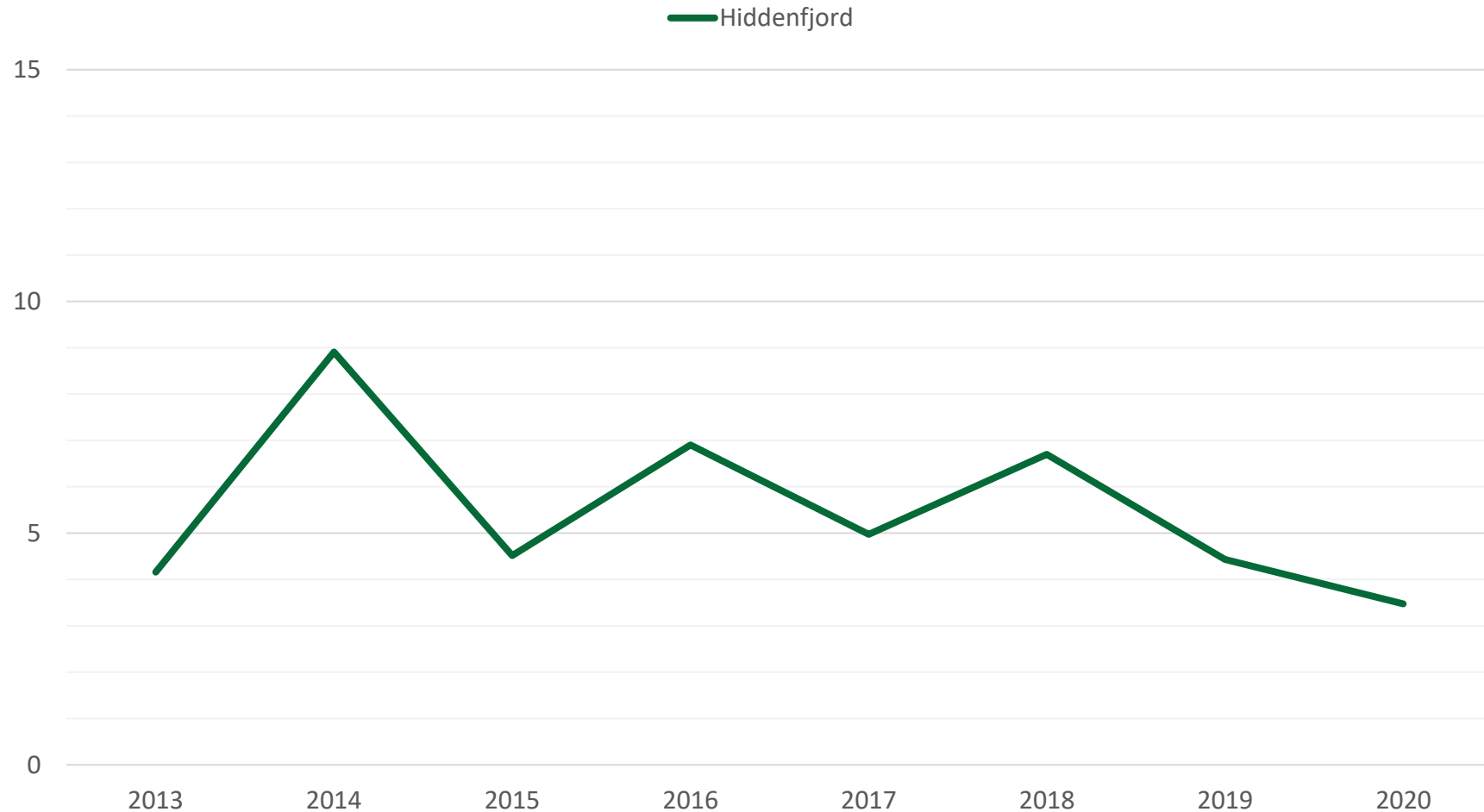
# Yearly mortality

% of stocked salmon from stocking to harvest – pens harvested in given year.



# Mortality % of large salmon

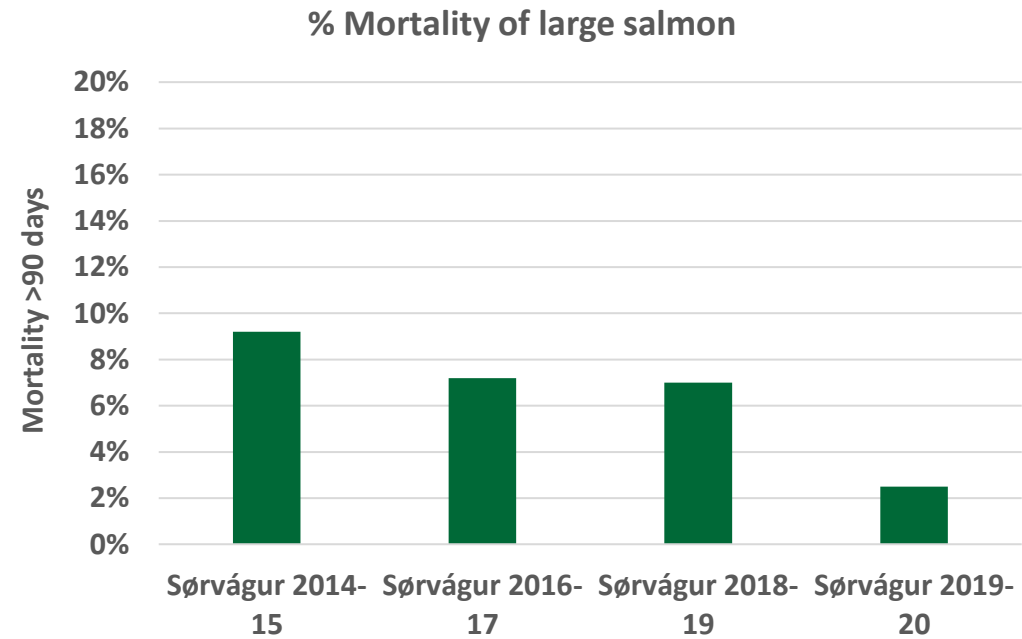
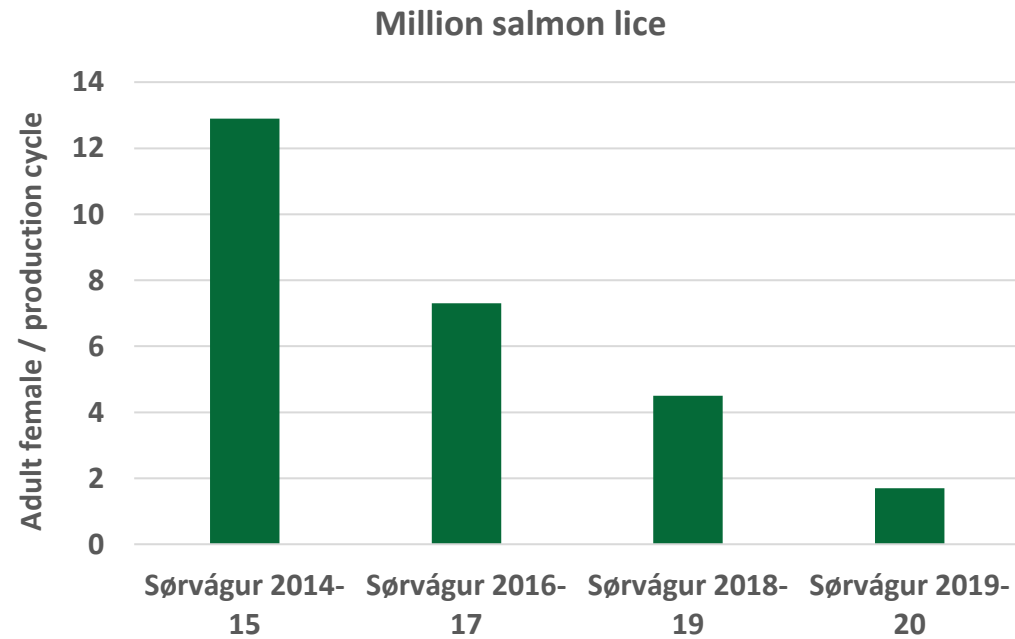
Mortality the first 3 months on sea not included.



# Sea lice strategy - Results

An aerial photograph of a salmon farming operation in a coastal region during sunset. The scene features several large, circular salmon pens arranged in a line, extending from the snow-covered shore into the dark blue water. The sky is a mix of orange and yellow, and the surrounding land is covered in snow. In the background, there are large, snow-capped mountains and islands. The text "Sea lice strategy - Results" is overlaid in the center of the image.

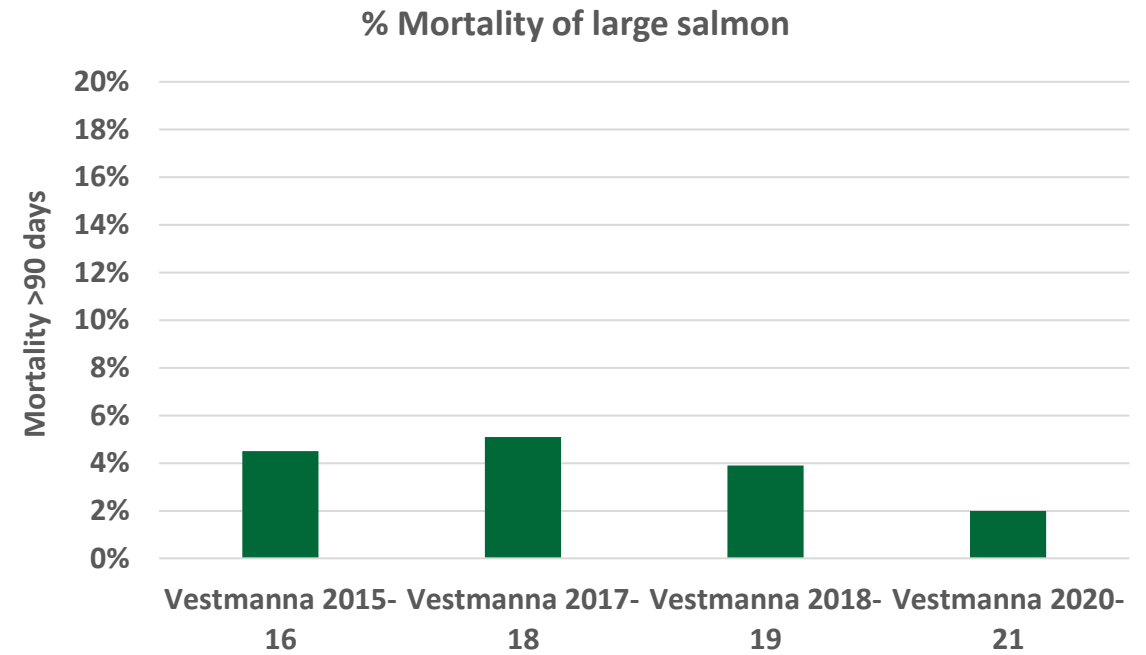
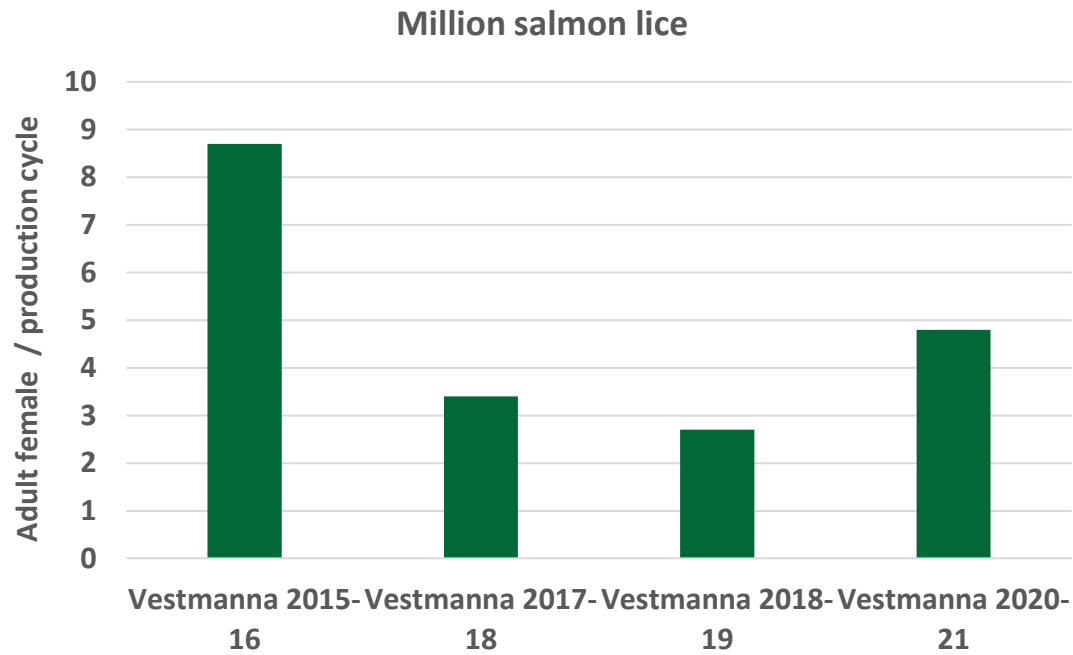
# Sørvágur



Production cycle	Stocked salmon	Sea lice	Weight	Mortality >90dg	Days on sea	Deloused pens					Total
						Slice	Salmosan	Diflu	Combi	Mechanic	
Sørvágur 2014-15	1.0 mill	12.9 mill	5,6 kg	9,2%	438	14			31	14	59
Sørvágur 2016-17	1.1 mill	7.3 mill	5,0 kg	7,2%	385	11			1	45	57
Sørvágur 2018-19	1.2 mill	4.5 mill	6,7 kg	7,0%	381	10	19	5	13	15	62
Sørvágur 2019-20	0.9 mill	1.7 mill	5,3 kg	2,5%	333	12	15	8			35



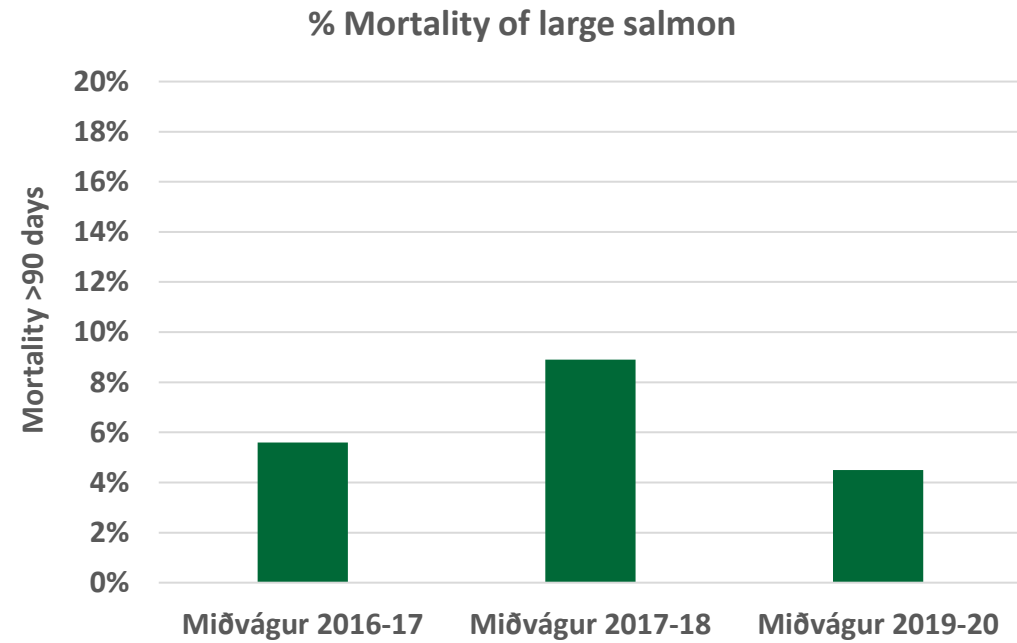
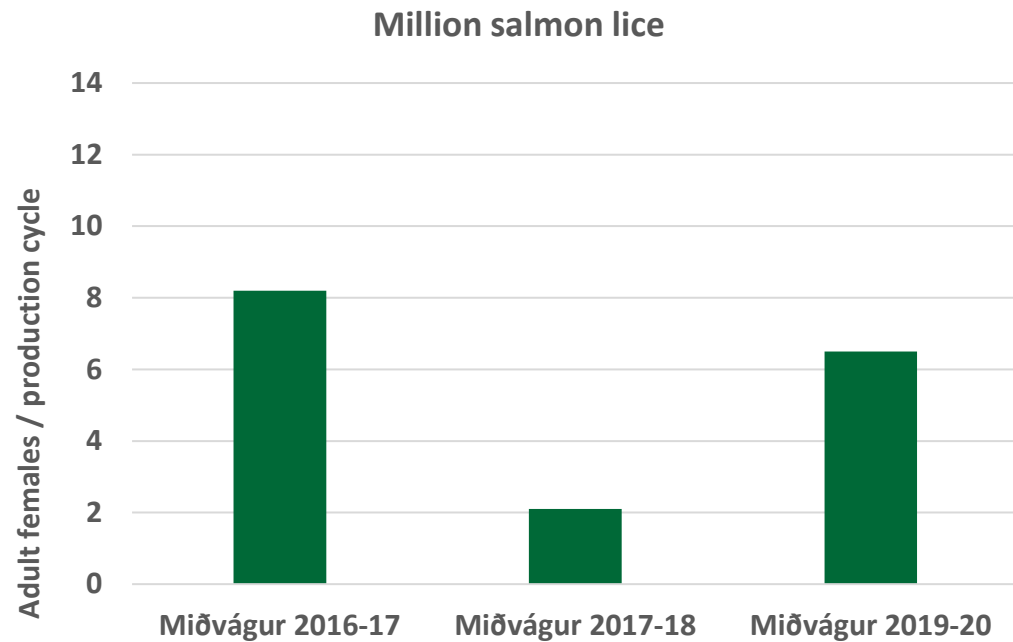
# Vestmanna



Production cycle	Stocked salmon	Sea lice	Weight	Mortality >90dg	Deloused pens						
					Slice	Salmosan	Diflu	Combi	Alphamax	Mechanic	Total
Vestmanna 2015-16	1.2 mill	8.7 mill	6,2 kg	4,5%				10			10
Vestmanna 2017-18	1.8 mill	3.4 mill	5,7 kg	5,1%	12				5		17
Vestmanna 2018-19	1.5 mill	2.7 mill	6,4 kg	3,9%							0
Vestmanna 2020-21	1.5 mill	4.8 mill	7,6 kg	2,0%	14	2					16



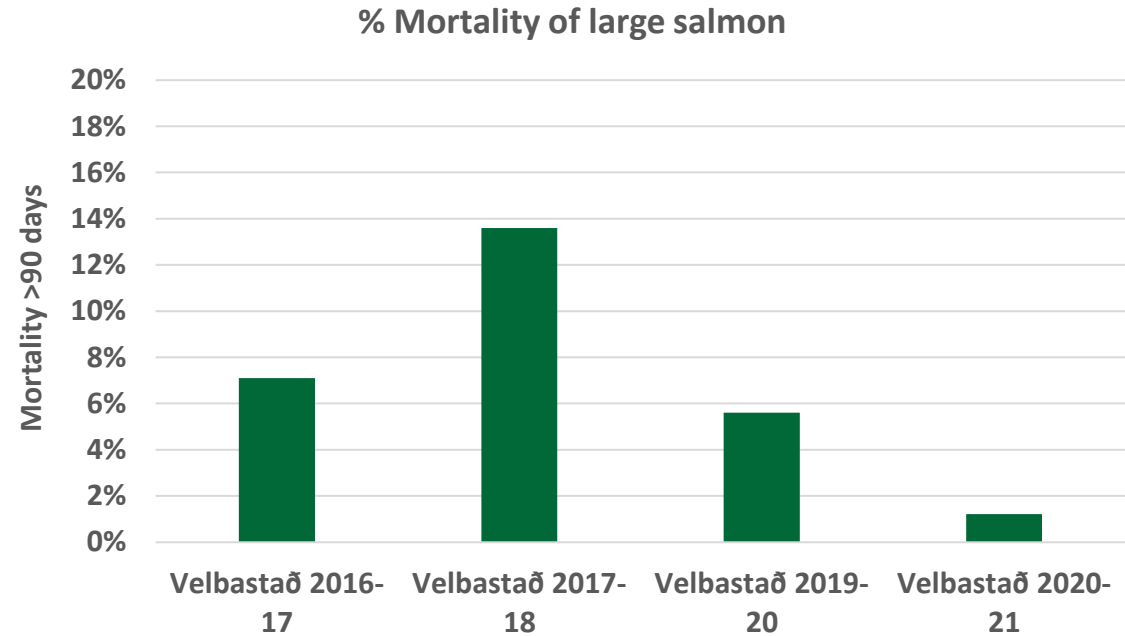
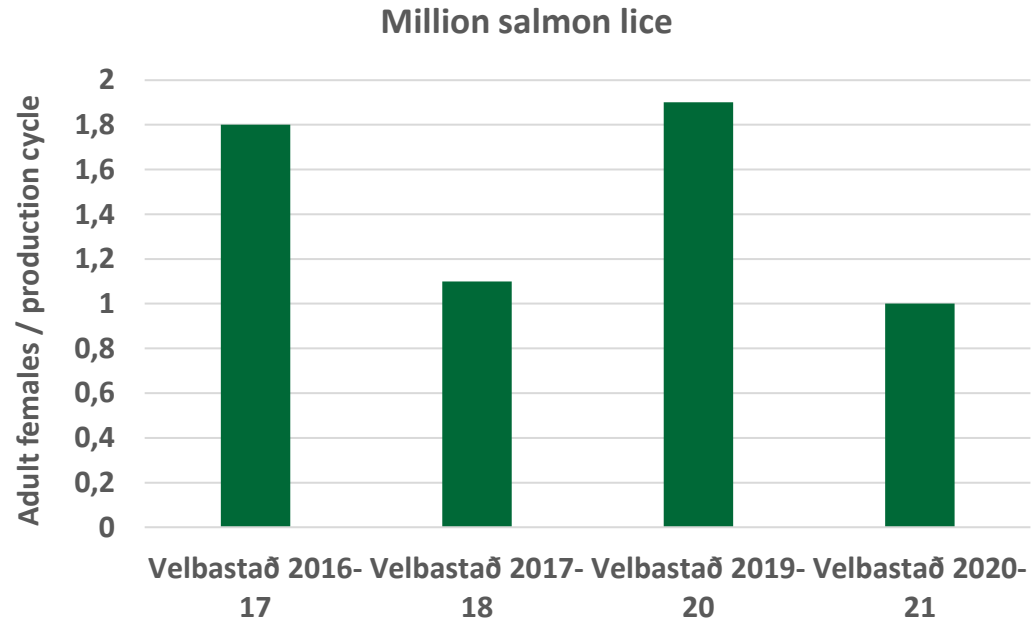
# Miðvágur



Production cycle	Stocked salmon	Sea lice	Weight	Mortality >90dg	Deloused pens						Total
					Slice	Salmosan	Diflu	Combi	Alphamax	Mechanic	
Miðvágur 2016-17	1.8 mill	8.2 mill	5,4 kg	5,6%					7		7
Miðvágur 2017-18	1.6 mill	2.1 mill	5,2 kg	8,9%							0
Miðvágur 2019-20	1.5 mill	6.5 mill	5,9 kg	4,5%	12	6					18



# Velbastað



Production cycle	Stocked salmon	Sea lice	Weight	Mortality >90dg	Deloused pens						
					Slice	Salmosan	Diflu	Combi	Alphamax	Mechanic	Total
Velbastað 2016-17	0.3 mill	1.8 mill	5,9 kg	<b>7,1%</b>						3	<b>3</b>
Velbastað 2017-18	0.5 mill	1.1 mill	5,5 kg	<b>13,6%</b>	10		10				<b>20</b>
Velbastað 2019-20	0.5 mill	1.9 mill	6,0 kg	<b>5,6%</b>	5			5			<b>10</b>
Velbastað 2020-21	0.5 mill	1.0 mill	6,2 kg	<b>1,2%</b>	10	5					<b>15</b>



# Sea lice Hiddenfjord

## 2018:

19,3 % of production  
8,3 % of the sea lice

## 2019:

18,6 % of production  
11 % of the sea lice

## 2020:

18,7 % of production  
9,8 % of the sea lice

## 2021 so far:

18,9 % of production  
6,6 % of the sea lice



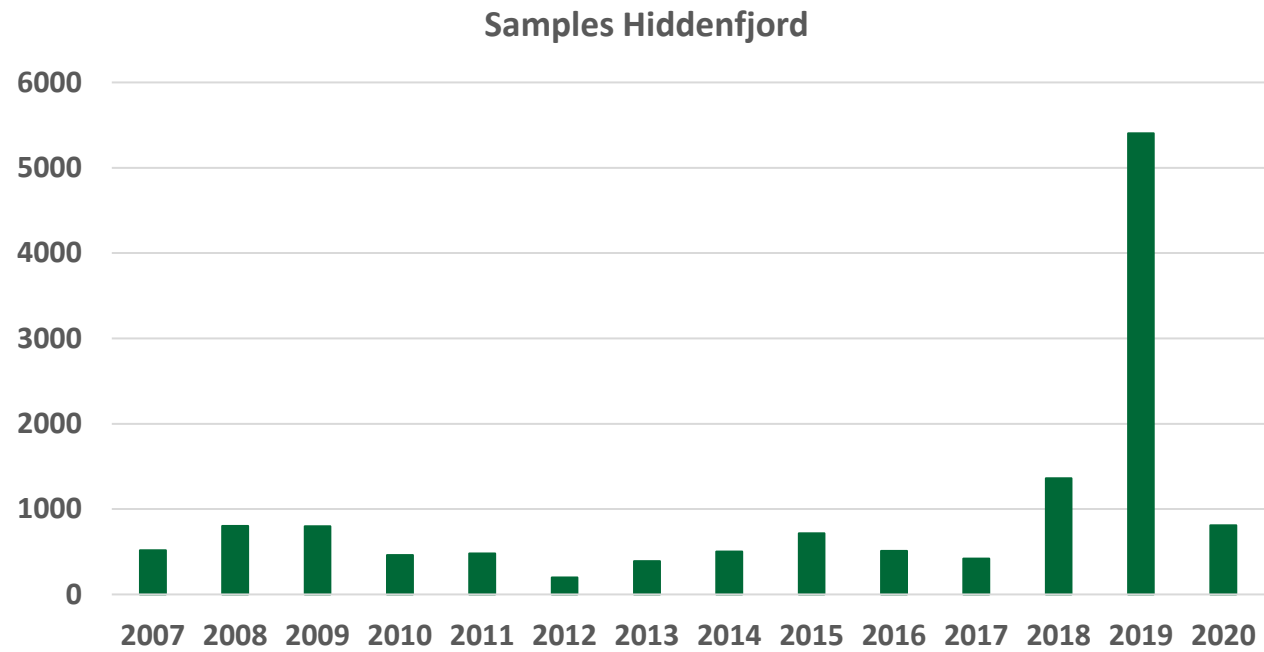
**HIDDENFJORD**  
RAISED IN THE WILD

# Disease surveillance



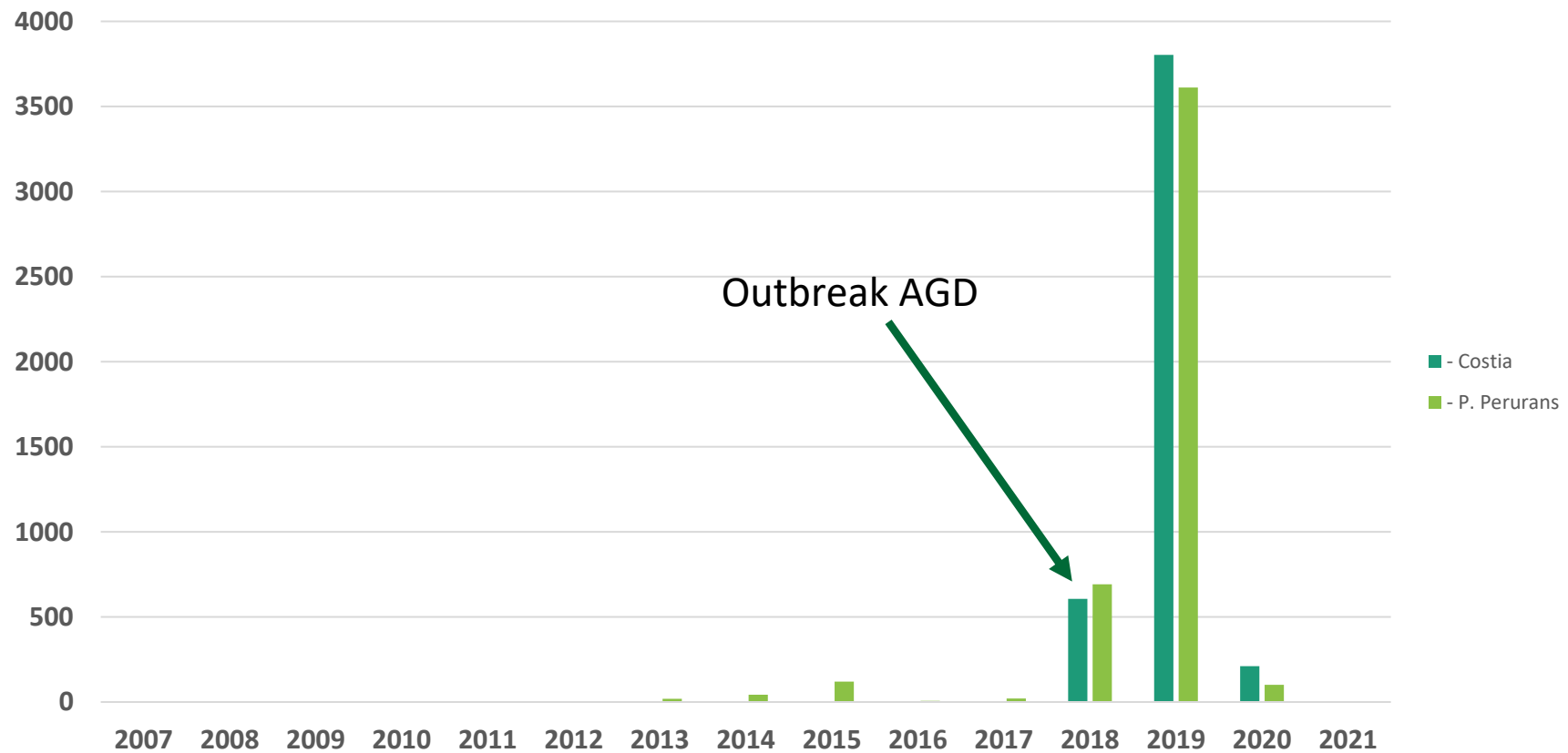
HIDDENFJORD  
RAISED IN THE WILD

# Disease surveillance





# Detections and outbreaks

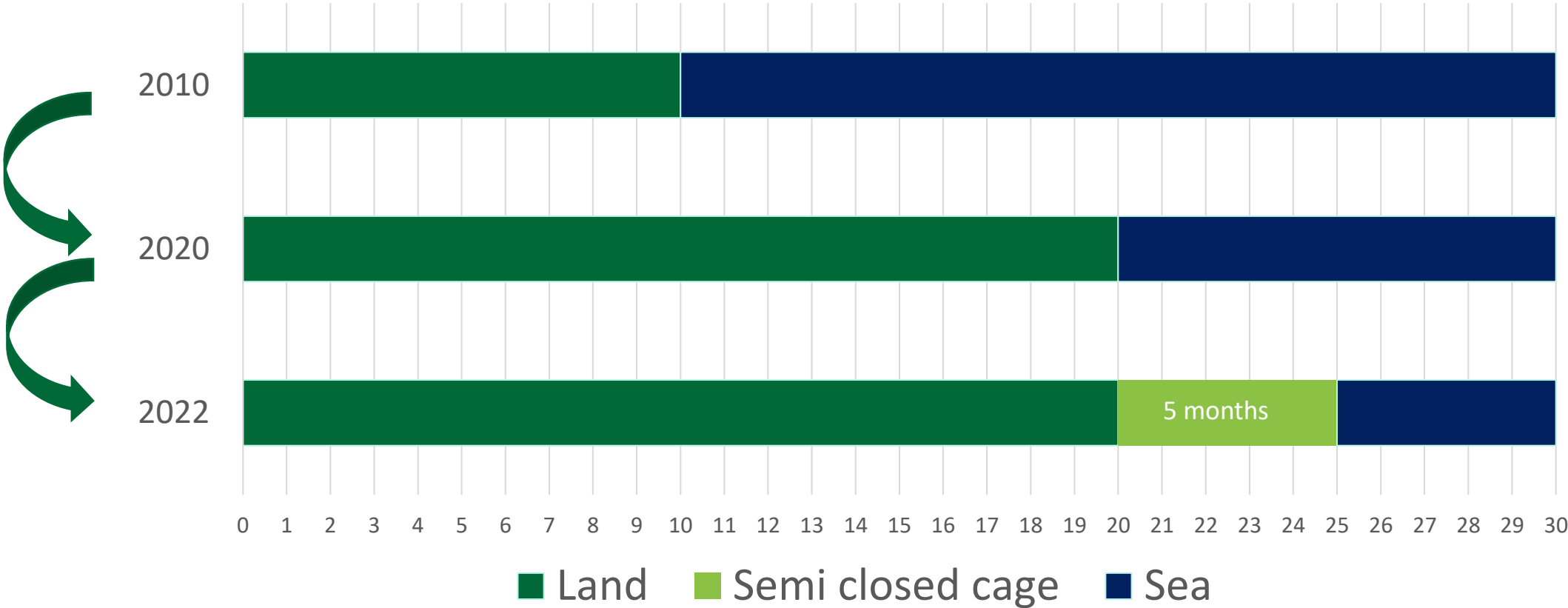




# Semi Closed Containment System



# Production time



# The future

Continue with moving to exposed sites and/or expanding exposed sites  
- Current barrier Suður í bug

Semi-closed-containment systems

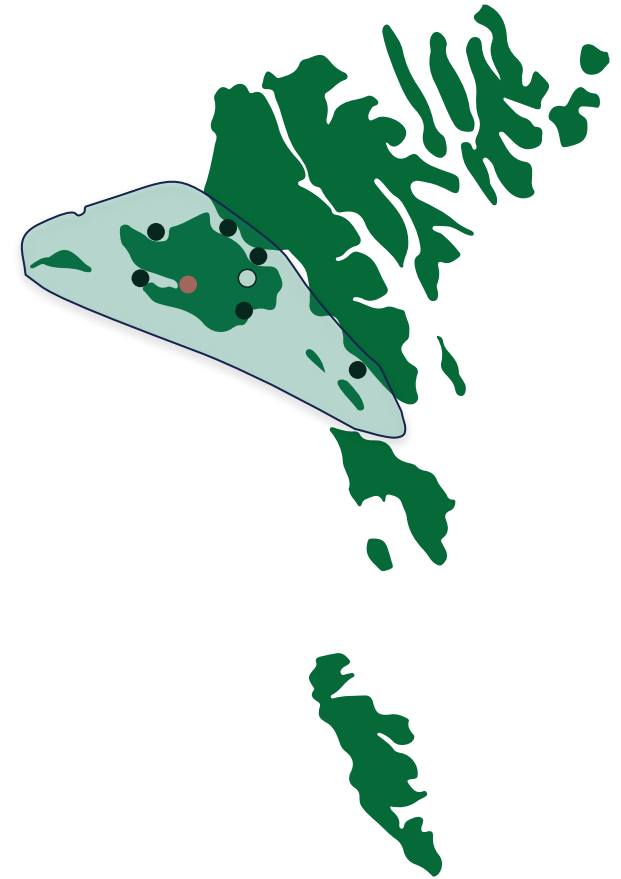
Stricter regulations

Goal -> No handling and no chemical treatments

**Salmon farming in the Faroes is under pressure**

Too many sea lice – too high mortalities – **160** times above sea lice limit (1,0 adult females) since okt'17!  
**Hiddenfjord 7 times**

Too many diseases -> Sea temperature increases -> AGD, other diseases?



**HIDDENFJORD**  
RAISED IN THE WILD

# Opinion – What should the industry focus on?

- Large smolts of good quality
- Fewer/equal number of smolts
- Fast growth on sea
- Lumpfish research – focus on getting mortality down!
- Genetics
- Sea lice modelling
- Strict sea lice regulations – **Hiddenfjord** wants 0,2 adult female limit
- Exposed farming
- Semi closed containment systems?



Takk fyri



**HIDDENFJORD**  
RAISED IN THE WILD