Int. Symposium: Drivers of dynamics of small pelagic fish resources, Victoria, BC, Canada,

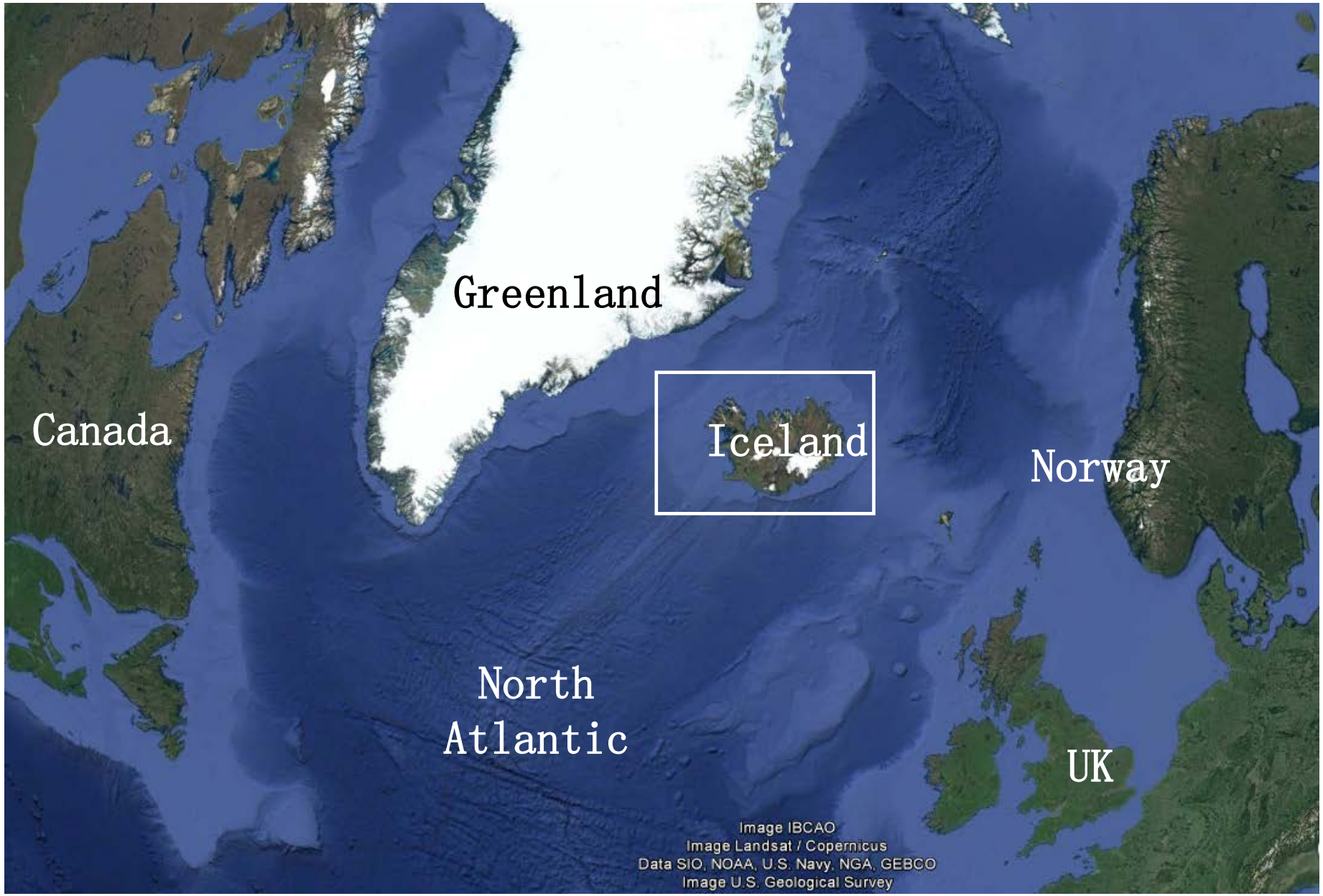
March 6-11, 2017

Development, nature and impacts of widespread and long-lasting *Ichthyophonus* sp. outbreak in Icelandic summer-spawning herring

Guðmundur J. Óskarsson, Jónbjörn Pálsson and Ásta Guðmundsdóttir

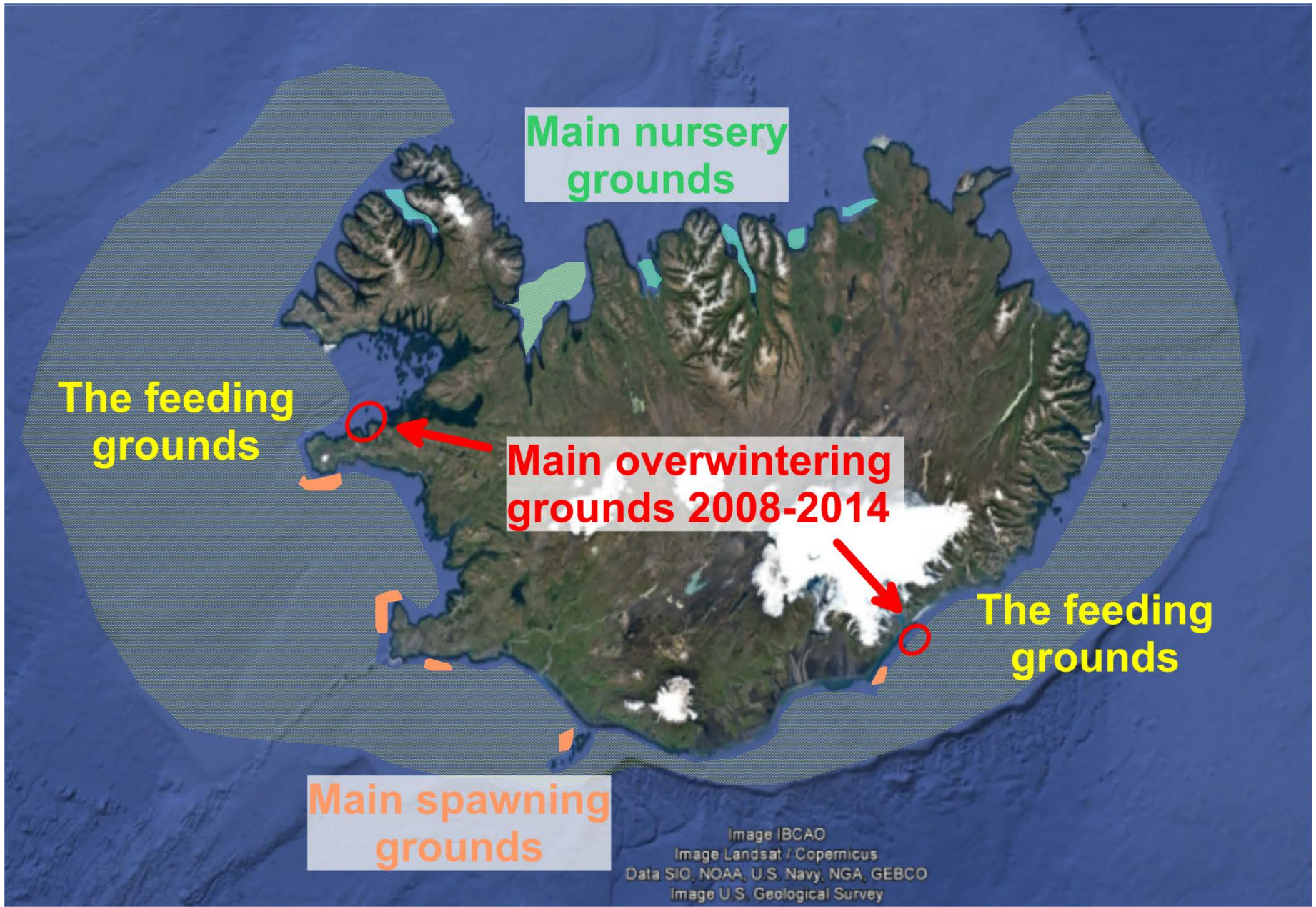
HAFRANNSÓKNASTOFNUN
Rannsókna- og ráðgjafarstofnun hafs og vatna
MARINE & FRESHWATER RESEARCH INSTITUTE

Biography of Icelandic summer-spawning herring



Biography of Icelandic summer-spawning herring

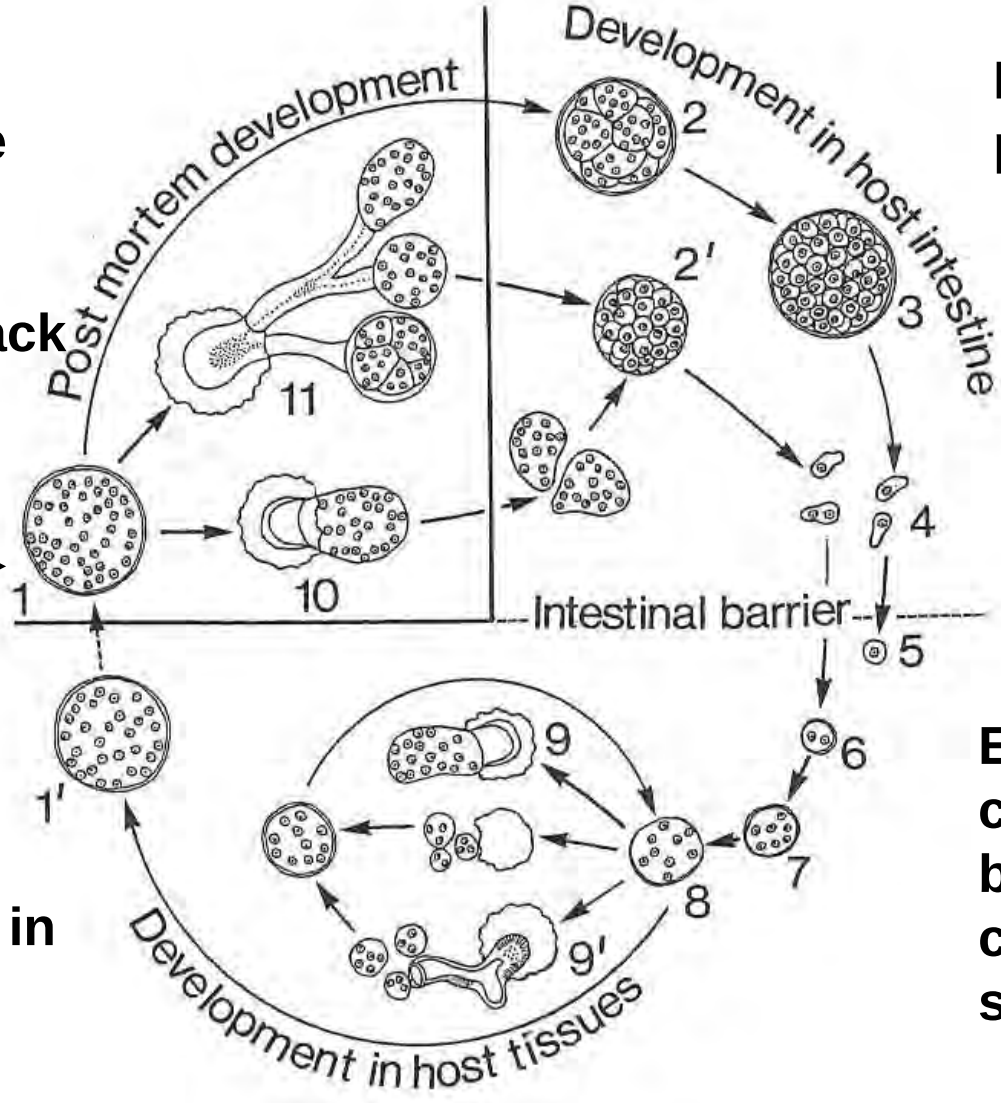
Biography of Icelandic summer-spawning herring



The protozoa, *Ichthyophonus* sp. in the host:

Amoeba like form grows through the digestive track

Resting spores ingested by herring –activated in the stomach



Endospores produced

Endospores carried by the blood circulatory system

An escalation in the infection

Source: Kinne 1984

Known *Ichthyophonus* outbreaks in Atlantic herring:

Stock	Period	Infection prevalence	Source
Gulf of Maine	1930-31	70%	Lauckner 1984
---	1947		Sindermann 1963
Gulf of St. Lawrence	1898		Sindermann 1963
---	1912-14		Sindermann 1963
---	~1940		Sindermann 1963
---	1954-55	50%	Lauckner 1984
North Sea	1991	~10%	Patterson 1996
Norwegian spring-sp.	1991-92	~10%	Kramer-Schadt *et al.* 2010

Seems to be common conception that *Ichthyophonus* infected herring dies within 100 days (max. 6 months) (Sinderman 1958; McVicar 1981).

Background and objective

- The infection outbreak in the Icelandic stock first observed and identified in November 2008.
- A research program was launched right away to study the infection (i.e. surveys and increased sampling effort).
- The objective here is to show the main results of these studies for **2008-2014** with respect to the **prevalence of the infection** and **development of the infection**, both with the overall goal to **estimate the mortality imposed by the outbreak**.

Material and methods

Overview of herring samples collected during 2008-2014 for inspection of *Ichthyophonus* infection

Origin of samples	All areas		West Iceland (Breiðafjörður)		
	# samples	# herring examined	# samples		# herring examined
			Bottom trawl	Purse seine	
Catches	407	28539	0	322	21981
Surveys	165	12929	56	6	3972
Total	572	41468	56	328	25953

From the whole year (development of the infection)

From the overwintering grounds (severity of infection)

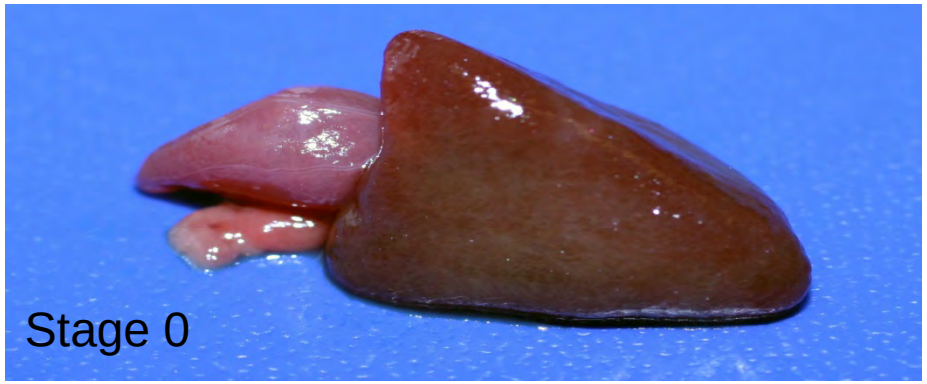
Material and methods

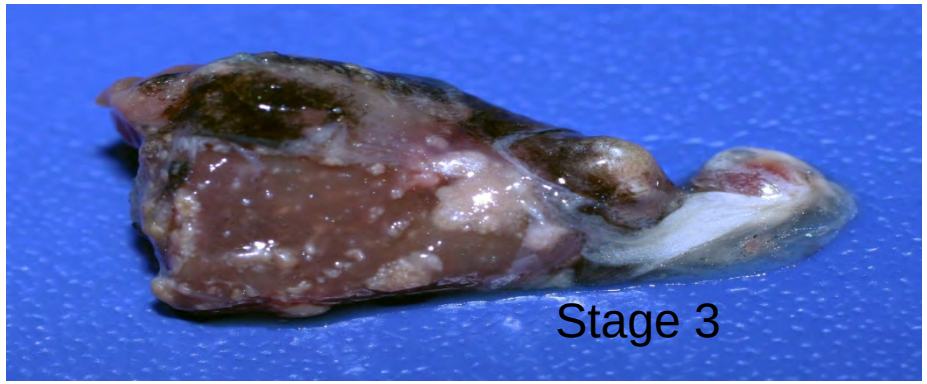
The following determinations were done for all fish sampled

- Total length (1.0 cm)
- Whole body weight (0.1 g)
- Gonad weight (0.1 g)
- Sex
- Maturity stage (1-8)
- Age (from fish scales)
- Infection stage (from hearts)

Material and methods

- The parasite accumulates in blood rich tissues like hearts.
- Thus the hearts were examined macroscopically under a dissecting microscope (ICES 1993), and the severity of infection classified:





Photos:
J. Pálsson

Validation of infection mortality

Use suite of runs with the standard assessment tool used for the stock (VPA/ADAPT version 3.3.0 NOAA Fisheries Toolbox) to estimate the likely level of infection mortality (the model with the minimum sum of squares):

Estimated from samples and acoustic

$$M_{total,\ year} = M_{fixed} + M_{infection,\ year} \times k$$

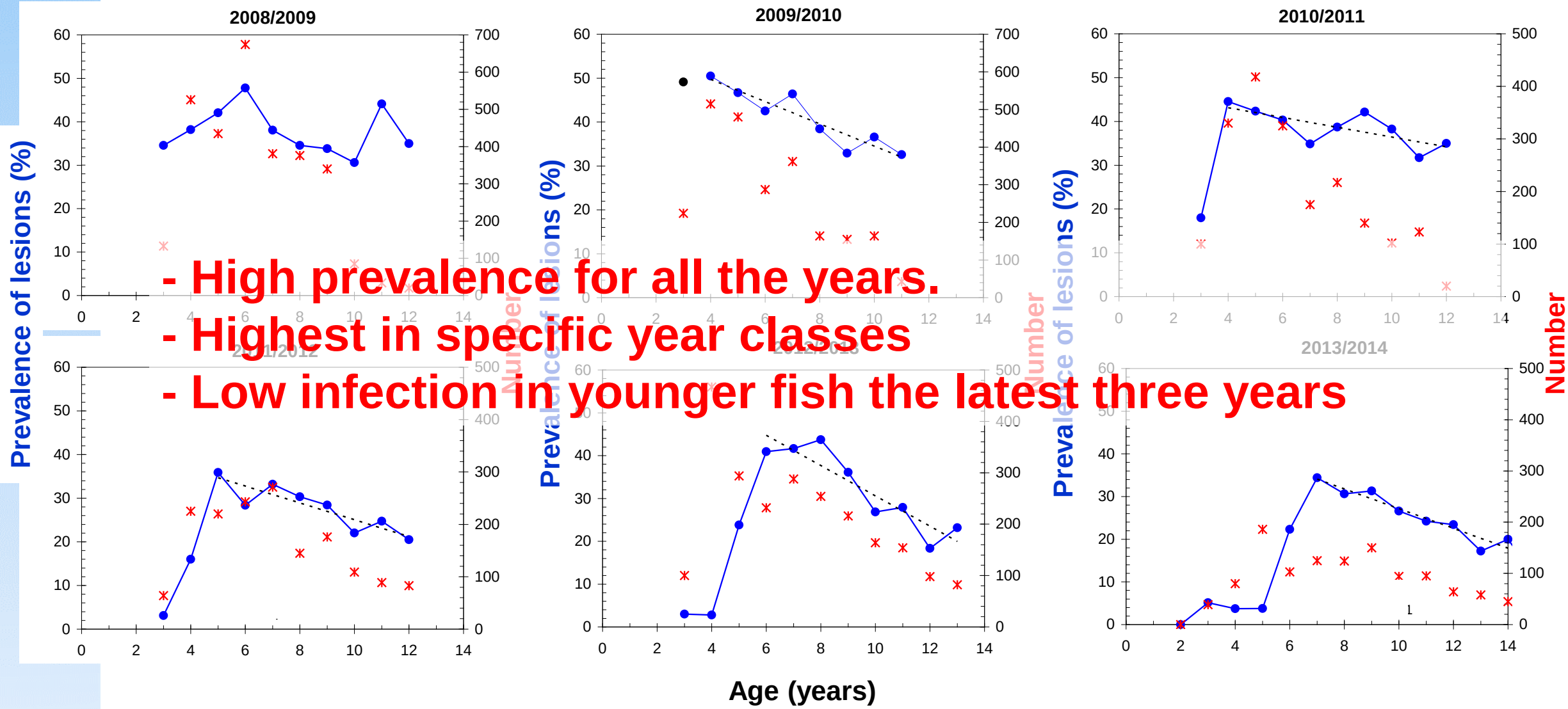
= 0.1

VPA runs made with k ranging from 0 to 1

This is comparable to approaches used by Patterson (1996) and Marty et al. (2010).

Results

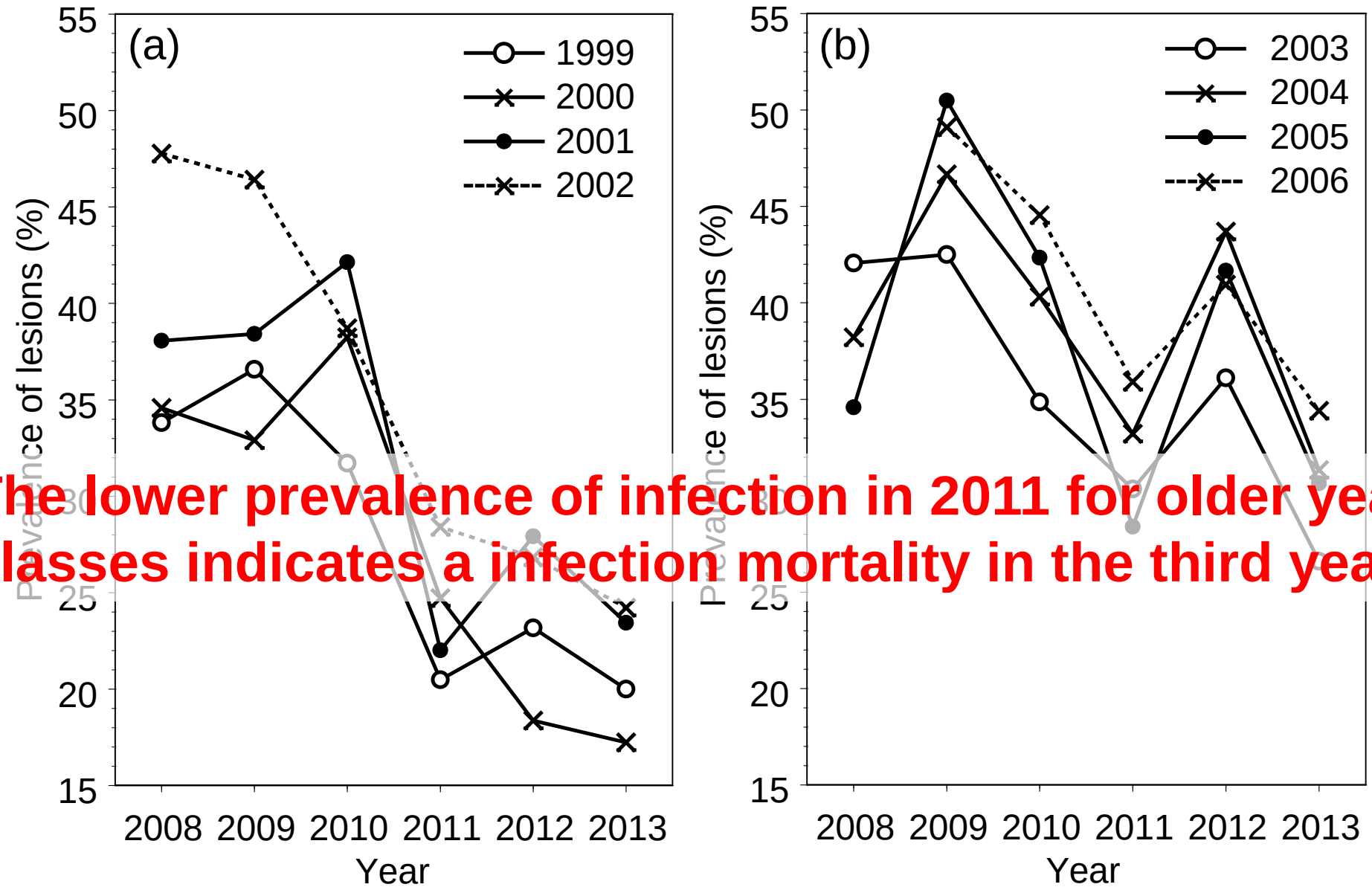
Prevalence of heart lesions (%) vs. age in the main overwintering area in the west



- High prevalence for all the years.
- Highest in specific year classes
- Low infection in younger fish the latest three years

Results

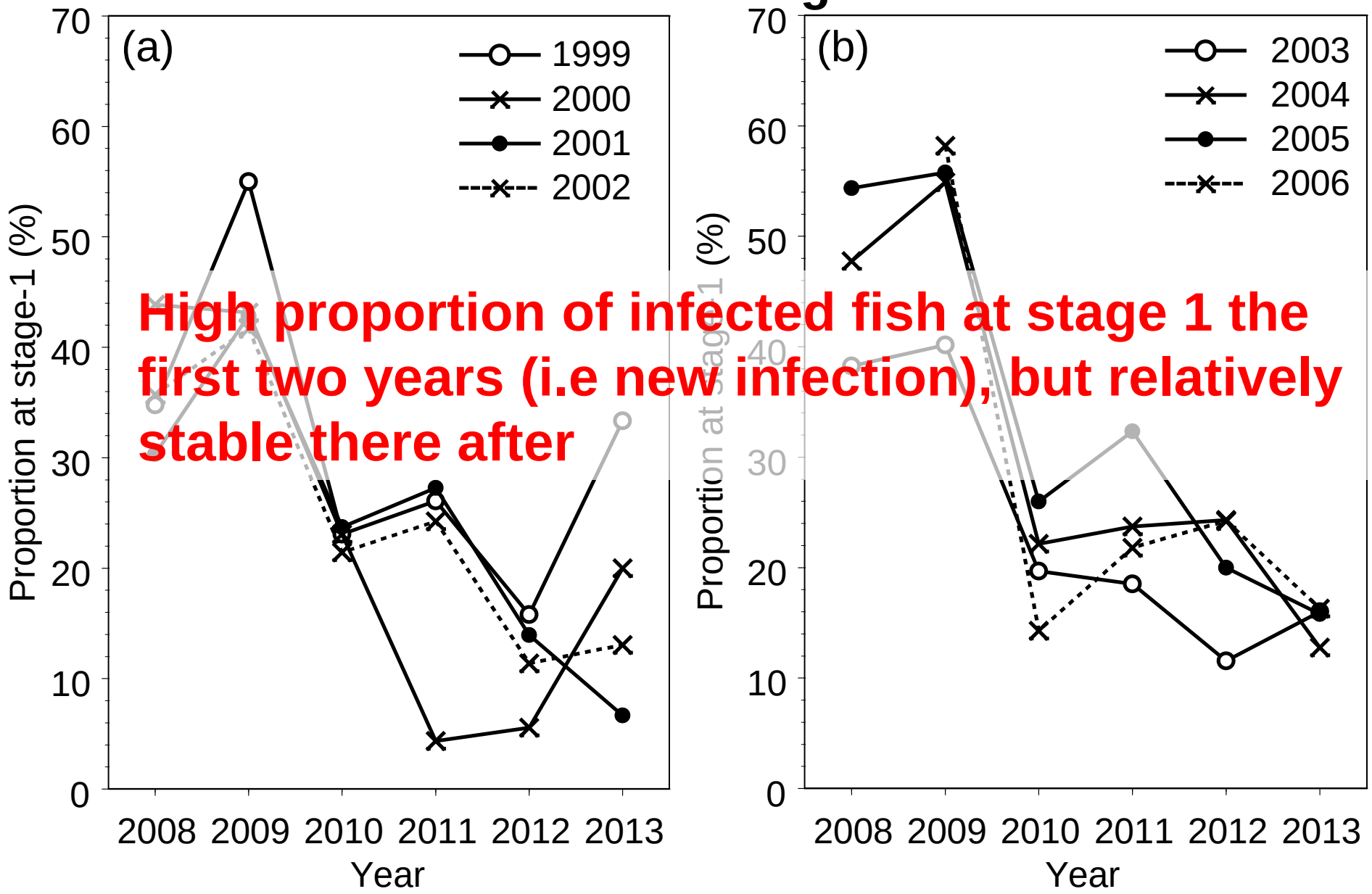
Prevalence for year classes ´99-´02 (left) and ´03-´06 (right) in the main overwintering area in the west



The lower prevalence of infection in 2011 for older year classes indicates a infection mortality in the third year!

Results

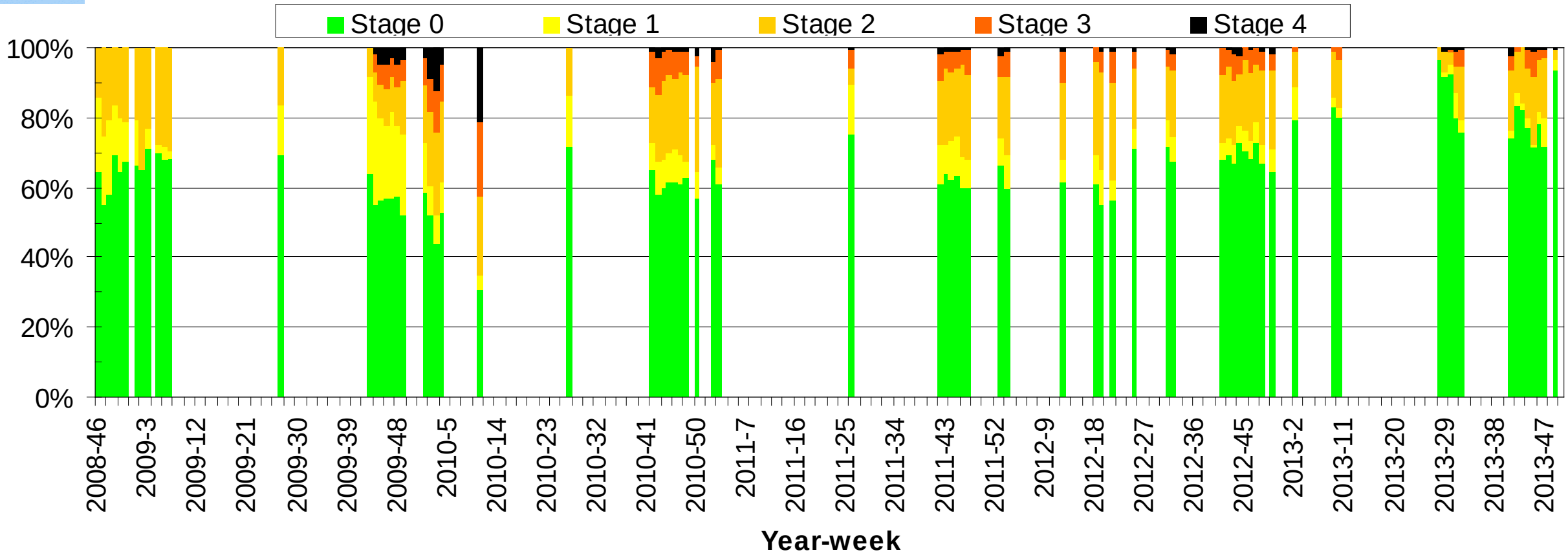
% stage-1 for year classes ´99-´02 (left) and ´03-´06 (right) in the main overwintering area in the west



High proportion of infected fish at stage 1 the first two years (i.e new infection), but relatively stable there after

Development of the infection severity

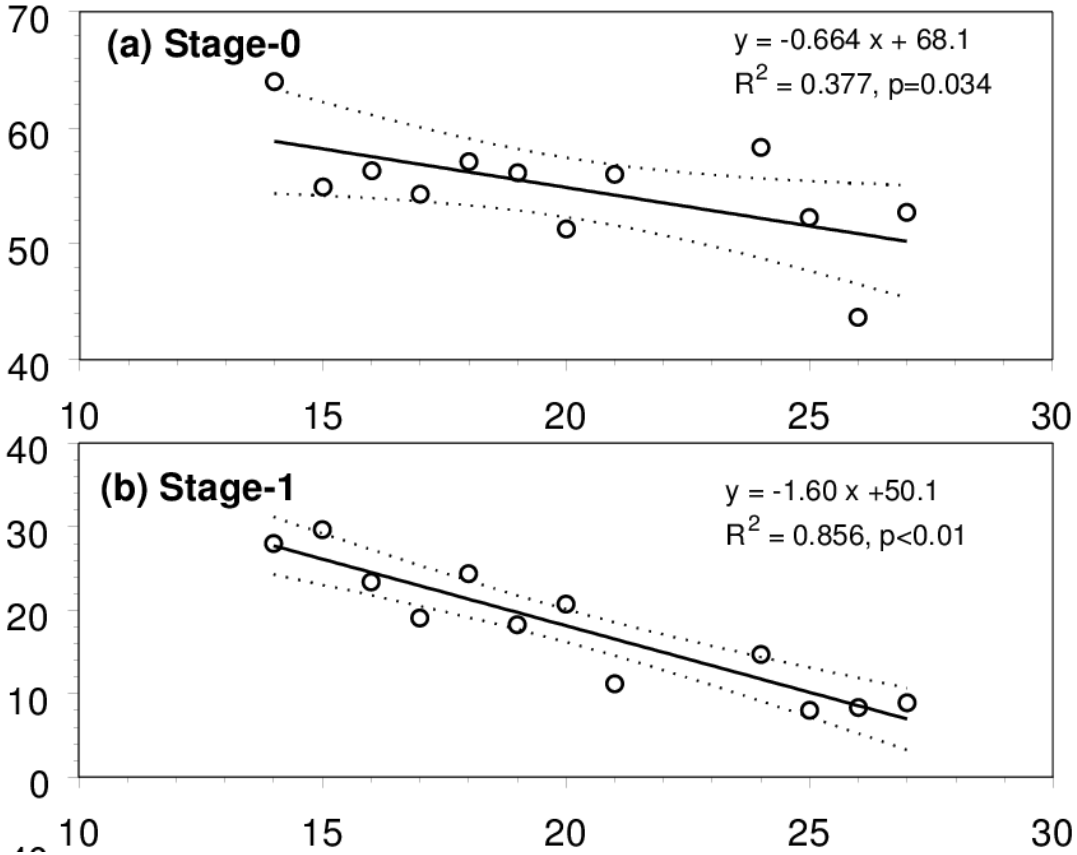
on weekly basis over 2008-2014 in all areas

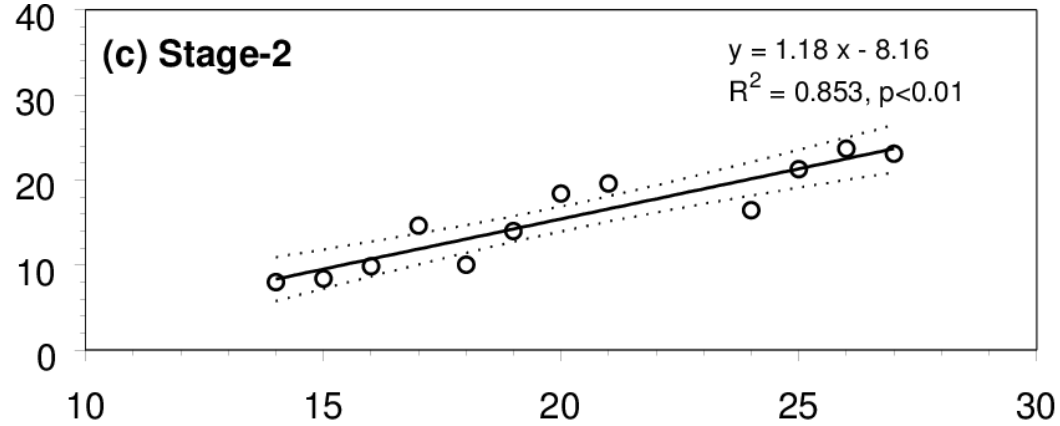


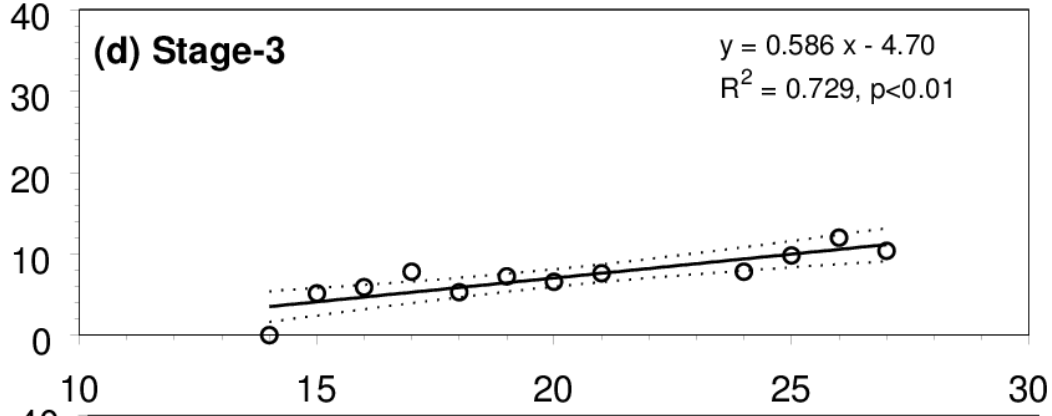
The lesions apparently progressing from stage-1 to stage-2 in the first two years …, indicating mortality

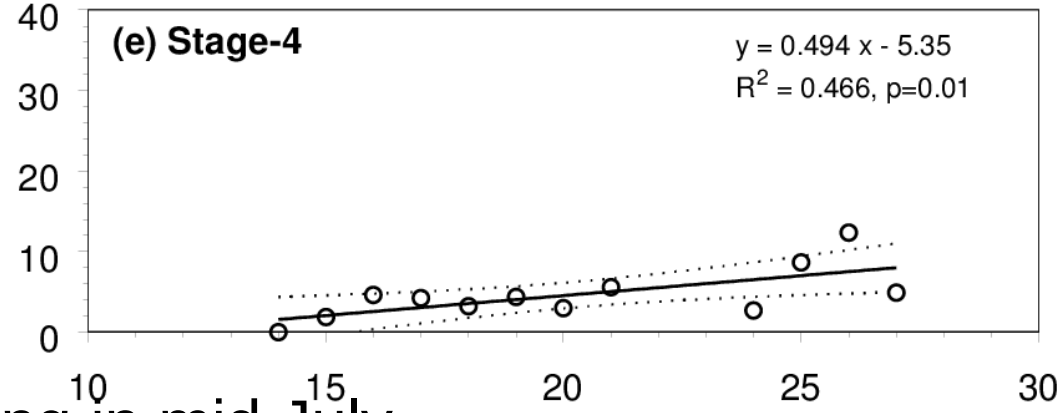
Results

Development of the infection severity in 2009/2010









Weeks from spawning in mid July

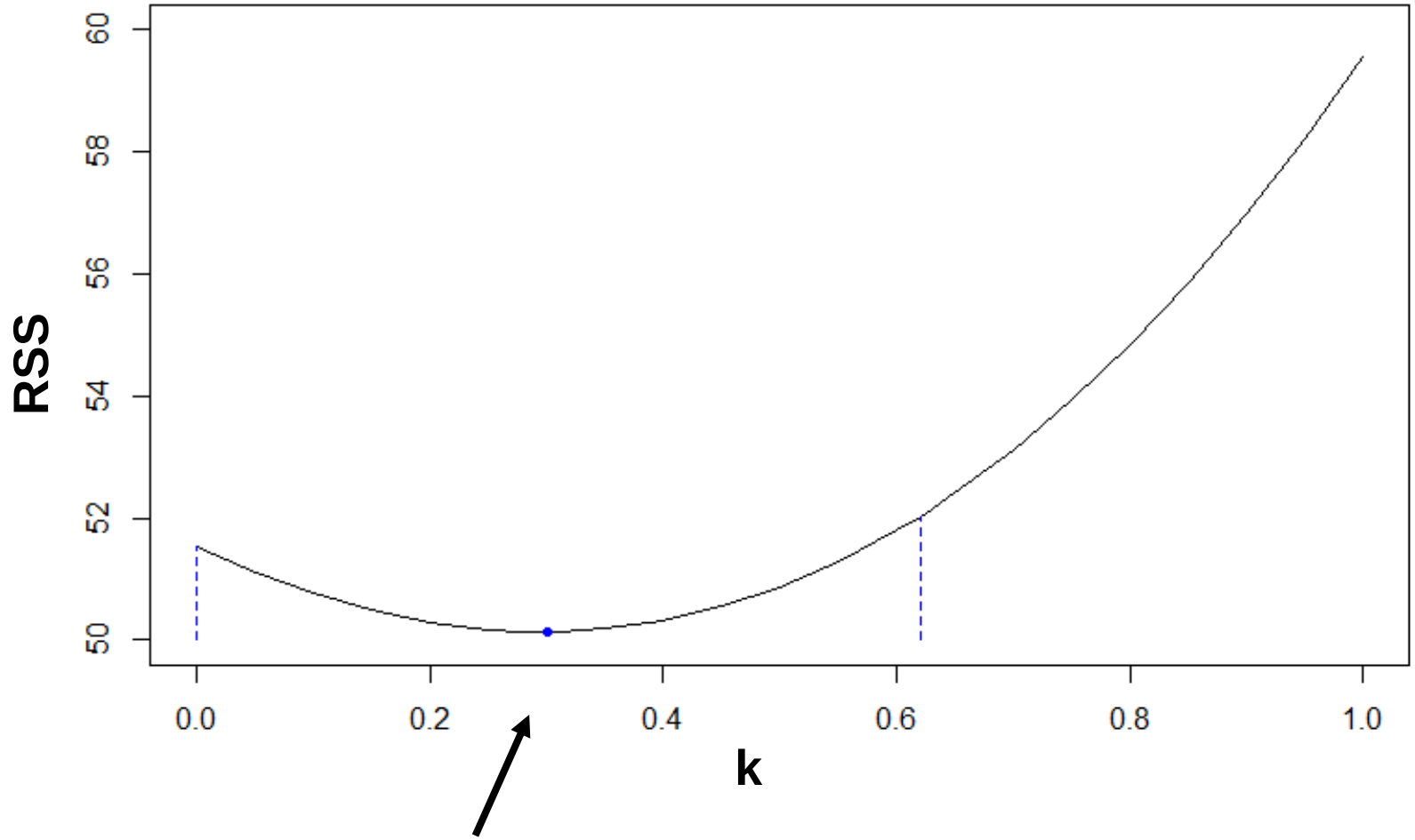
Logical interpretations of the results above

- **The stock went through significant infection mortality in first three winters but apparently insignificant thereafter.**
- **Thus, we estimated k (i.e. infection mortality) for the <u>first three years</u> only.**
- **We assume that k is the same for all these three years!**

$$M_{total,\ year} = M_{fixed} + M_{infection,\ year} \times k$$

Results

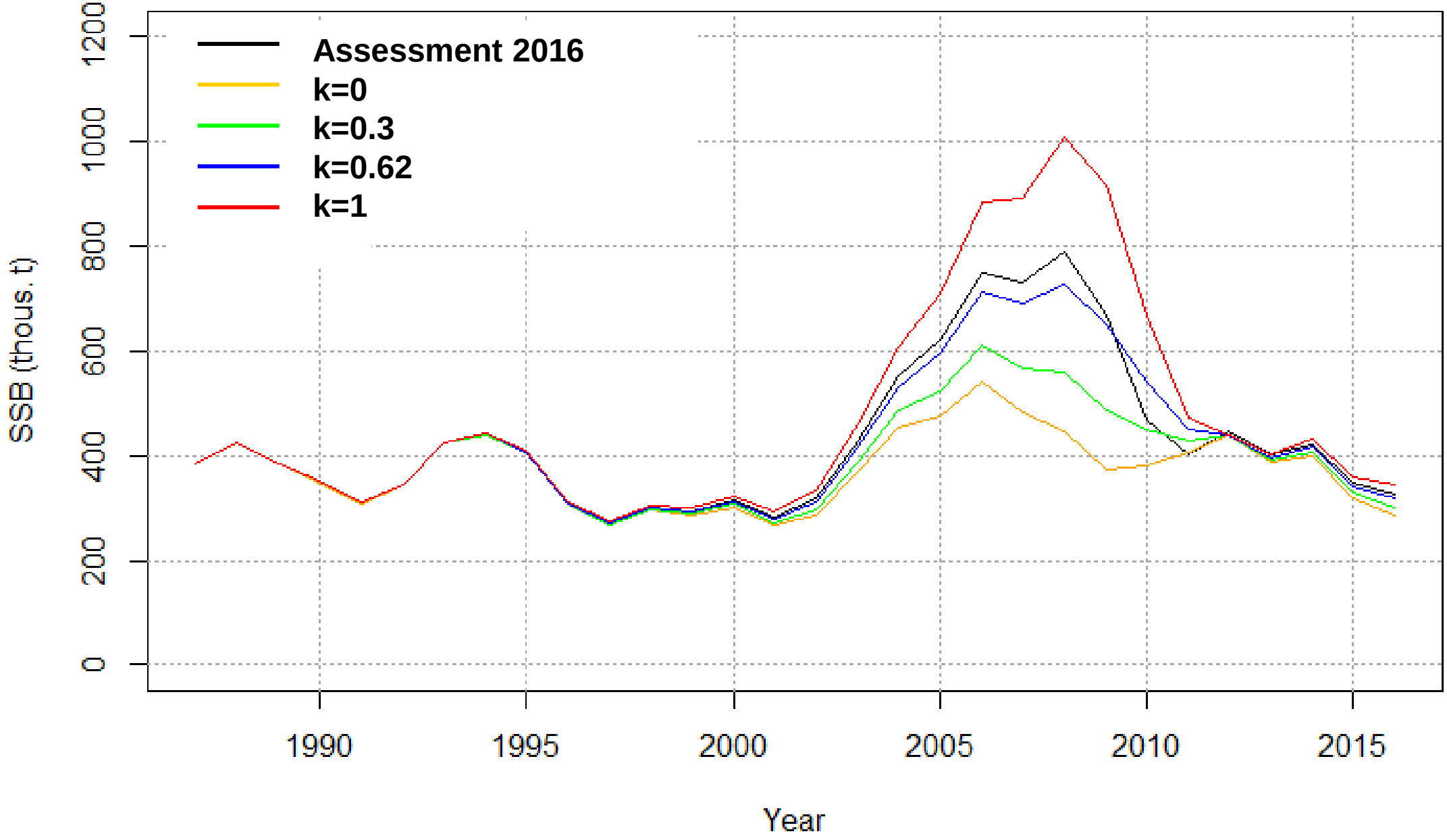
Residual Sum of Squares (RSS) from VPA runs with varying k



Minimum RSS at k=0.3 (95% CI: 0-0.65), indicates that 30% of infected herring died each year for the first three years.

Results

Spawning stock biomass from different VPA runs:



Concluding remarks

- The prevalence of heart lesions high for 6 years (13-42%).
- Apparently insignificant infection mortality the last 3 years.
- During the first 3 years, around 30% of the infected herring died.
- The infection is less lethal for herring than generally assumed – further studies ongoing (e.g. histological studies)
- The infection had a huge impact on the stock size development.
- New infection, and increasing prevalence observed in the autumns 2015 and 2016.
- More effort needed to study the distribution of *Ichthyophonus* in the ecosystem to explore the causes of these kind of outbreaks

Thanks to all the colleagues at MFRI for the cooperation!

Thanks!