FARMED FISH HEALTH FRAMEWORK – CLIMATE CHANGE WORKSTREAM

HARMFUL PLANKTON BLOOMS – WHERE, WHEN AND HOW ARE THEY IMPACTING THE SCOTTISH INDUSTRY, AND WHAT CAN WE DO TO MANAGE THE RISKS THEY POSE?

PROPOSED OUTLINE FOR 2 WORKSHOPS

Purpose:

Workshop 1 – to establish what current monitoring takes place across Scotland

"what do we know"

Workshop 2 – to explore what applied research might enhance current understanding of the risks and improved control or mitigation of those risks

"**how can that shared knowledge be used to improve management and mitigation?**"

Timing:

Workshop 1 – 2 hours, Zoom or MS Teams; ideally second half of June 2021, date to be identified via Doodle poll to maximise attendance

Workshop 2 – details to be informed by workshop 1; ideally mid-August to early September 2021, date to be identified via Doodle poll to maximise attendance

Participants:

Workshop 1 – environment personnel from across the salmon and trout sector in Scotland, with some knowledge, expertise or awareness in monitoring aspects of the environment and/or Harmful Algal Blooms (HABs) and Jellyfish; ditto experts from MSS and SEPA

Workshop 2 – as above possibly also with (a) hand-picked selected academics with knowledge of cutting edge academic know-how on HABs and jellyfish spread, modelling and management; (b) technical specialists and suppliers of novel solutions to the market in the mitigation of HABs and jellyfish risks

Expected Outputs:

Workshop 1 – a clear picture emerging of current monitoring practice in terms of:

a. what monitoring is currently done? (time frequency – hour, day, week, month)
b. where is that monitoring taking place? (physical locations – pens, sites, lochs, area management areas, regional scale)
c. what methods are used to do that monitoring? (sampling protocols etc)
d. what is the variation or consistency within and between companies and geographies, if any?
e. what types of data does the sampling and monitoring generate?
f. How much inter-organisation co-ordination is already taking place?
g. How much co-ordination between different aquaculture producers is already taking place, e.g. between salmon farmers and mussels farmers.

Follow up to workshop 1 – review available data; identify opportunities for utilising that data; conversely identifying significant data gaps and needs for standardised protocols on sampling, data collection and data analysis

Workshop 2 – to consider how data might be shared, how analysis of the available data may inform future research, what mitigation activities may be possible, modelling to create reliable forecasts etc and to invite bids for applied research projects involving industry and academic know-how, potentially administered and managed by SAIC

Follow up to workshop 2 – inform future projects directed at enhancing knowledge of HABs and jellyfish risks and improved mitigation measures

Workshop organisation:

Planning, administration and delivery – SAIC

Selecting named attendees – SSPO, BTA, MSS, SEPA

Deciding on next steps, including funding of proposed actions – FFHF Steering Group

FARMED FISH HEALTH FRAMEWORK – CLIMATE CHANGE WORKSTREAM UPDATE
Harmful Plankton Blooms – where, when and how are they impacting the Scottish industry, and what can we do to manage the risks they pose?

The climate change workstream met on 12 May to develop further proposals on how climate change impacts on HABs and jellyfish can best be addressed. The purpose of our discussions was to identify work necessary to support the industry in managing and mitigating the risks of HABs.

Action to date

SSPO has undertaken a survey across its members of the measures used to monitor and manage the prevalence of HABs and jellyfish. Whilst that survey is incomplete, and all member companies of the SSPO are encouraged to collaborate in this project. The industry analysis shows what sampling is done, what mitigation measures are adopted, and what modelling or other research would be valued by industry.

Proposed Workshops

We propose therefore that two 2 hour workshops are held over the next 3 months, as set out in the attached proposal document. These will support better understanding of the current position, and identify research or other needs that can be addressed through the FFHF, through the pooling of industry, Government and academic knowledge.

Further Action

Anticipated next steps from these workshops would be to consider (a) how data might be shared and how analysis of the available data may inform future research; (b) what mitigation activities may be possible, and if any emerging good practice could be shared; (c) what modelling to create reliable forecasts would be most valued by industry; and thereafter (d) to invite bids for collaborative applied research projects.

Resourcing

The workshops will be arranged by the members of the climate change workstream. Once the need for future applied research projects has been established, and their specific focus identified, a programme of work can be commissioned. This is not currently funded.

Recommendation

The FFHF is invited **to endorse** this plan of action and that future actions around applied research may incur a cost, which is currently unfunded. The FFHF is invited **to record** that collaborative actions to address the threat of HABs and jellyfish requires to be resourced, with input likely to be required from both Government and industry.

Heather Jones on behalf of: [Redacted - reg 11(2) personal data]**,** [Redacted - reg 11(2) personal data]**,** [Redacted - reg 11(2) personal data]**,** [Redacted - reg 11(2) personal data]

3 June 2021

Species of Interest (From Current Knowledge)

HABs	Toxin Producing	1	Haptophytes	*Chrysochromulina leadbeateri*
		2		*Prymnesium parvum*
		3		*Prymnesium polylepis*
		4	Raphidophytes	*Fibrocapsa japonica*
		5		*Heterosigma akashiwo*
		6		*Chattonella antiqua*
		7		*Chattonella marina*
		8		*Chattonella ovata*
		9		*Chattonella subsalsa*
		10	Dictyophytes	*Pseudochattonella farcimen*
		11		*Pseudochattonella verruculosa*
		12		*Vicicitus globosus*
		13	Dinoflagellates	*Karlodinium veneficum*
		14		*Karenia mikimotoi*
	Physical Damage	15	Diatoms	*Chaetoceros* spp.
Gelatinous Zooplankton	Toxins Net Clogging	16	Cnidarians (including siphonophores)	
		17	Ctenophores	
High Biomass	Gill Clogging Oxygen Depletion		All bloom-forming phytoplankton species	

The majority of phytoplankton (except *Karenia, Karlodinium* and *Chaetoceros*) difficult to identify in routine samples and their ecology in Scottish waters is unknown
A survey of industry might change this species list
Note *Alexandrium* and *Pseudo-nitszia* not on list at moment

Points to Note

Current Monitoring

- Full phyto and zooplankton communities (all species) monitored weekly at L. Ewe and Stonehaven (large gelatinous zooplankton not monitored)
- FSS monitor shellfish toxin-related species in shellfish growing waters round coast (Mar - Sept)

Changing Baselines

- If fish kills increasing, what is causing the problem – gelatinous zooplankton or HABs?
- Are levels at which HABs/gelatinous plankton have lethal effect decreasing?
- e.g. If Amoebic Gill Disease is increasing on Scottish fin fish farms, the associated treatments might lower tolerance to HABs/gelatinous plankton?
- What are the levels at which HABs/gelatinous plankton produce lethal effects?

Information needed from industry

- When and where are fish kills happening?
- Does industry have in situ plankton data that identifies which species/groups are causing problems?
- All year, or seasonal?
- Regional differences? Locational differences?

Molecular methods e.g. qPCR

- Being developed by several groups internationally (e.g. Norway)
- No kits can be taken straight “off the shelf”
- Often developed to work in mono-species cultures. Possibility of false-positives in real mixed communities from different countries.
- Methods need 2-3 years development
- Validation in Scottish conditions needed for target species

Traditional Monitoring (Taxonomist / Microscope)

- For 17 species of interest
- Up to 2 days per plankton sample
- Many species of interest difficult to monitor because of small size and preservation issues
- Separate analysis needed for small gelatinous zooplankton
- Early warning implies the need to detect species at low concentrations (i.e. BEFORE problems arise)

New Technology Monitoring

- FlowCam
- IFCB (Imaging FlowCytoBot)
- Both need 2-3 years development time, incl. “training” of systems and validation.
- SAMS have just purchased an IFCB NAFC will be getting one during 2021
- IFCB needs IT infrastructure for data capture / analysis

MSS Top 4 Projects (in order of priority)

1. **Survey of the Problem:** Where, when are problems occurring? Gather all existing data, plankton observations, personal observations – all from industry. (Use contractor. Anonymise results)

[1 person, 1 year]

2. High Risk Farm Case Study: Study one farm intensively where fish kills occur. Monitor environment, plankton, fish health simultaneously through 2 years.

[3 people, 3 years]

3. Target Species Molecular methods e.g. q-PCR Development: Develop and validate q-PCR in Scottish waters for 7 target species.

[2 people, 3 years]

4. Novel Monitoring Network: Link SAMS and NAFC IFCB development. Add a third instrument with MSS. Develop associated IT and data analysis. Validate. Develop operational warning system.

[3 people, 3 years, £250k capital, £100k for IT infrastructure development]

Remote Sensing

- Can indicate areas of high biomass, but can not in general give species
- Remote sensing is not great for gelatinous zooplankton

Modelling

- Physical models of bloom transport well developed
- Biological models of bloom initiation / species development very much in infancy

PML Service – "Scottish Karenia Watch"

- Uses weekly mosaics to overcome cloud cover. April – Oct. 300m resolution.
- Uses ocean colour to predict probability of Karenia – add simplified "traffic light" interpretation
- Four Scottish company groups pay to receive weekly emailed alerts

PML Research – "PRIMROSE"

- Linking physical models and remote sensing
- Images "seed" particle tracking models – these predict how blooms may move

Remote Sensing – Their Priorities for the Future

1) **Increase Species of Relevance:** More work on the spectral signature of species of interest. **[1 person, 3 years]**

2) **Hyper-Spectral Satellites:** Due in 2023, 100s of colours (now 7-8 colours). Different pigments / different species. Could start looking at spectral signatures now. **[2 people, 3 years]**

From: Voas S (Sheila) < [Redacted - reg 11(2) personal data]@gov.scot>
Sent: Tuesday, August 24, 2021 6:00 PM
To: Heather Jones < [Redacted - reg 11(2) personal data]@sustainableaquaculture.com>; < [Redacted - reg 11(2) personal data]@scottishseafarms.com>; [Redacted - reg 11(2) personal data] < [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]< [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]@scottishsalmon.co.uk>; [Redacted - reg 11(2) personal data]@britishtrout.co.uk; [Redacted - reg 11(2) personal data]@btinternet.com; [Redacted - reg 11(2) personal data]@scottishseafarms.com>; [Redacted - reg 11(2) personal data]@dawnfresh.co.uk; [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]@vmd.gov.uk; [Redacted - reg 11(2) personal data]@SEPA.org.uk; [Redacted - reg 11(2) personal data]@vmd.gov.uk; [Redacted - reg 11(2) personal data]@mowi.com; [Redacted - reg 11(2) personal data]@gov.scot>; [Redacted - reg 11(2) personal data]@gov.scot>
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Subject: RE: FFHF - Priority CC projects

Thanks Heather. Sounds like a positive step forwards to me.
[Redacted - reg 11(2) personal data]will be better able to answer on budgets, but to be aware that there are limited funds for all the FFHF work so we all need to make sure we prioritise their use appropriately. Im not suggesting that anyone doesn't already know that but always best to be upfront about the challenges
S

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Subject: RE: FFHF - Priority CC projects

Dear All

Thanks to [Redacted - reg 11(2) personal data] and [Redacted - reg 11(2) personal data]for their comments.

We agreed at the meeting to follow up the HABs workshop 1 with a second HABS workshop at which all participants can contribute their ideas and indicate their willingness for industry data to be shared and used with full consent of contributing parties, and for SAIC and Marine Scotland to have further discussions on the possibility of funding to support approved projects.

I suggest we bring back an updated report to the whole FFHF once that second workshop has taken place, and once we know if – and if so how much – money Marine Scotland can contribute to this important work.

Kind regards,

Heather Jones

CEO

Sustainable Aquaculture Innovation Centre

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Subject: RE: FFHF - Priority CC projects

I'm inclined to agree with that conclusion.

For me, the real issue is that we see, either from gross examination of fish or histopathology, evidence of damage to gills without clear identification of the culprit. We assume an environmental factor has caused damage but we often don't know what it is – "environmental insult" is the default diagnosis when no gill pathogen is identified. We therefore don't know when to introduce mitigation measures (leaving aside the fact that we have limited mitigation measures available).

I think an analysis of data which might show what was happening in the environment when negative gill health incidents occurred would potentially be of most immediate value. I think that's what [Redacted - reg 11(2) personal data] is suggesting and therefore support the action, although I have my doubts that even the wider dataset will be adequate.

[Redacted - reg 11(2) personal data]

From [Redacted - reg 11(2) personal data]@gov.scot>
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Subject: FFHF - Priority CC projects

Dear SG member,

At the FFHF steering group, Heather proposed one priority research topic could be to investigate trigger levels for specific plankton species, i.e. the plankton concentrations which result in lethal or sub-lethal effects in adult fish. My concerns are as follows:

- I am not so sure there is a one-to-one match between plankton concentrations and harmful effect in a simplistic way.

- At the Climate Change workshop we heard reports from the sector environmental experts of a complex picture, with temperature, salinity and DO varying alongside plankton concentrations. Lethal and sub-lethal effects resulted from what sounded like fairly normal concentrations of plankton, of species that would not normally be associated with harmful effects. Thus we can hypothesise that in the Scottish context there are interactions between T, S, DO, multiple plankton species within the community and variable fish health that result in additional lethal or sub-lethal effects in farmed fish.

- For me the priority is to take the wealth of data that already exists (albeit collected using different protocols – but it is good enough probably to start with), along with the records of fish health, and examine the above hypothesis and try to pin down patterns in the data which will then inform future work.

- Lets consider going straight into challenge experiments using experimental fish. We might consider two temperatures (warm and cold), two salinities (salty and fresh), two DO values (good and not so good), and four plankton species at say 6 different concentrations, and for say 4 different levels of fish health. That gives a total of 768 combinations of conditions. For each one we will need say 20 fish in triplicate, with a control - say a bare minimum of 80 fish. For the 768 combinations that is 61,440 fish. I suspect they should all come from the same brood stock to eliminate biological variability, and I suspect fish age might be yet another variable to consider, as well as feeding status. I am also not too sure it would be ethical to manufacture fish with different degrees of gill ill-health. Even with this quite extensive experiment I think there would be challenges over the statistical validity, plus the fish will be in extremely unnatural conditions away from other stressors that fish in real farms experience. This is an expensive, resource heavy and time consuming study.

- Hence for me a fairly cheap desk study of real data is by far a better option at the moment than a challenge experiment to determine trigger levels of plankton. (and as an aside, I think the in situ data collected by the industry will be a much better dataset to use in order to analyse the SRUC dataset than satellite data).

[Redacted - reg 11(2) personal data]