Commentary on the MB0102 Sensitivity Matrix Assessment of Sensitivity of Seagrass Beds to Physical Damage
by Michael Simons, July 2014, for the Boat Owners’ Response Group

Definitions:


Seagrass Beds: we interpret these to be specifically of the species Zostera marina, as this is the species named in the MCZ site feature descriptions.

Physical Damage Assessments: this document refers to the pressure described in the Matrix as “Shallow abrasion/penetration: damage to seabed surface and penetration < 25mm”, also “Penetration and/or disturbance of the substrate below the surface of the seabed > 25 mm.”

1.1 Objection 1:

The existing MarLIN assessment is of Moderate Resistance and Moderate Resilience. However, the MB0102 Assessment takes an extreme position and assigns the lowest possible Resistance (None) and the lowest possible Resilience (Low) without

(a) presenting any reasons or evidence whatsoever,

(b) without identifying the people whose opinions formed this Assessment, and

(c) without indicating whether the “experts” on whose opinion the Assessment was based did indeed have a high level of expertise in the subject area

The process thus appears secretive, opaque (totally non-transparent) and unverifiable. It flouts all the norms of scientific procedure and ignores the guidance within the document (Tillin, Hull & Tyler-Walters 2010, or MB0102/3A/22, p 29) that “5.21 It is desirable that any approach used, and the sensitivity categorisations that are assigned to features, can be justified to stakeholders”.

This mysterious and unattributable process makes, I submit, the Assessment unsuitable to inform public policy – especially policy which can impact public freedoms.

1.2 Evidence

Paragraph 5.21 of MB0102/3A/22 continues: “The basis of sensitivity decisions made by experts or those based on published evidence are recorded in proformas for each feature (Annex G) by recorders that had been briefed by the contractor and supplied with standard recording sheets.”
The relevant proforma is reproduced above. The shallow abrasion/penetration assessment seems entirely dependent on “expert judgement from workshop 2”, while the > 25 mm assessment has expert judgements from Workshops 1 and 2, and cites Domacini et al 2002. This is listed in the references section at the end of Annex G as follows:

“Domacini et al 2002 - reference supplied at workshop but could not be sourced”

Nor did a Google search find any paper by a Domacini on Zostera marina. The reference would seem to be invalid.

Thus the basis of the decisions made by “experts” is not recorded at all, all that is recorded is an untraceable reference and that the assessments were a result of “expert judgements from workshops 1 and 2”.

Annex H of MB0102/3A/22 does give MarLIN information:

**2.23 Seagrass IMS.Zmar**
*Pressure Evidence/Justification (e.g. supporting references, info on resistance resilience etc from MarLIN)*

Heavy abrasion, primarily at the seabed surface, and Light abrasion at the surface only:

Small scale sediment disturbance may stimulate growth and removal of small patches of sediment allows recolonization by seedlings (Davison & Hughes, 1998). However seagrasses are not physically robust, so activities such as trampling, anchoring, digging, dredging, power boat and jet-ski wash are likely to damage rhizomes and cause seeds to be buried too deeply to germinate (Fonseca, 1992). Suction dredging for cockles in the Solway Firth removed Zostera in affected areas while Zostera was abundant in undredged areas (Perkins, 1988). Physical disturbance and removal of plants can lead to increased patchiness and destabilization of the seagrass bed, which in turn can lead to reduced sedimentation within the seagrass bed, increased erosion, and loss of larger areas of Zostera (Davison & Hughes, 1998). Therefore, the impact from a scallop dredge is likely to remove a proportion of the population and result in increased erosion of the bed. Hence, intolerance has been recorded as intermediate. Grazing gastropods and other epifauna are small but likely to be displaced or removed attached to the leaves of Zostera. Reduction in numbers of grazers may potentially result in smothering by growth of epiphytes and other algae, especially in the spring and summer months. Recovery is dependant on the size of the size of the area affected, so is set as moderate, yielding a moderate sensitivity rating.

(emphasis in bold applied by myself)

This does not support the “expert” assessment of No Resistance (= high intolerance) and Low Resilience (= low recovery). The MarLIN assessment used the benchmark pressure of a single pass of a scallop dredge, which would seem a much greater pressure than a 10 kg leisure boat anchor – leisure boat anchoring is one of the pressures under consideration in the MCZ process, and the Assessments under discussion here are, I believe, intended to be applied to that (anchoring) pressure.

**1.3 “Experts”**

*Who were the “experts”?*

Following my earlier enquiries, I did receive the following information from Carole Kelly of Defra:

“The number of experts involved in Workshops 1 and 3 were 49 and there were 48 participants for Workshop 2. In some cases publishing participants names alongside affiliations can deter people
from participating in future workshops and can even lead to the participants receiving unwarranted attention. Attendees participated on the understanding that names would not be released. So in order to release names we would have to seek permission from each one which is not feasible. I therefore cannot release names from the expert workshops as we don’t have the participants permission. Many were invited as representatives of their organisations and it was clearly stated in the reports who these organisations were.*

I have tried to find out a bit more information around the MB0102 seagrass classification and as I understand it was made by consensus of at least 7 experts with MarLIN involvement, as along with ABPmer they were the contractors for the sensitivity matrix, so MarLIN attended/facilitated all the meetings and drafted the report. I appreciate that this does not explain the differences between what is in the MB0102 report and on the MarLIN website, I know MarLIN are currently refreshing their website and updating their business plan, so I would suggest you ask MarLIN the reason for this difference. “

This sheds little more light on the matter.

It is not known who these “experts” were, nor what was their level of expertise. How many papers on eelgrass had they published, for instance? If we are asked to accept someone as a true expert, it is reasonable to expect them to have a significant portfolio of publications in the relevant area.

1.4 So, to repeat, no evidence or reasons are given, no names are given so nothing is attributable, no indication of the actual expertise of the “experts” is given, and the only supporting documentation actually contradicts the assessment. This is not science, nor is it fit for the purpose of informing public policy. This slipshod approach is particularly regrettable when there are thousands of published papers on *Zostera marina* in the worldwide scientific literature, some of which could have been used to inform the assessment. Some examples are cited in the next and following sections.

1.5 *Footnote: Lists of organisations attending workshops:* *

**Workshop 1 Representatives**
- ABPmer
- Bangor University
- Centre for Environment, Fisheries and Aquaculture Science (CEFAS)
- Countryside Council for Wales (CCW)
- Environment Agency (EA)
- Heriot Watt University
- Joint Nature Conservation Committee (JNCC)
- Marine Biological Association (MBA)
- Marine Scotland
- Natural England (NE)
- Natural History Museum
- Northern Ireland Environment Agency
- Scottish Association for Marine Science (SAMS)
- Scottish Environment Protection Agency (SEPA)

**Workshop 2 Representatives**
- ABPmer
- British Marine Aggregate Producers Association
- British Marine Federation
- British Shipping
- CCW
- Centrica
- International Power plc
- Joint Nature Conservation Committee (JNCC)
- Mainstream
- MALSF
- Marine Ecological Surveys Ltd
- Marine Management Organisation
- MarLIN
- Maritime and coastguard agency
Workshop 2 made the majority of the relevant assessments. It is notable that most of the organisations did not seem particularly suited to assessing eelgrass resistance and resilience, as delegates recognised:

“Following breakout session 1 a number of delegates felt that they were unable to contribute further to the sensitivity matrices, due to lack of knowledge of the resistance and resilience of features, and subsequently left the workshop. The remaining delegates were invited to remain and contribute to further sensitivity assessments if they felt they had sufficient expert knowledge of the feature, or were invited to join a discussion group on pressure benchmarks (specifically physical abrasion), which delegates had indicated that they wished to discuss.”

(Annex F, section 3)

2.1 Objection 2

“The MB0102 Assessment of No Resistance, Very Low Resilience and High Sensitivity is not compatible with published evidence in at least 12 scientific papers.”

To develop this point we need first to draw attention to the criteria for the different levels of assessment, as set out in the MB0102 document, Tillin, Hull & Tyler-Walters 2010, and then to compare the Assessments against reported observed data in the scientific literature.

2.2 Resistance and Resilience

Levels of Resistance and Resilience are defined in the MB0102 document, pp 25 – 29.

Although para 5.2 is entitled “Assessment of the Feature’s Resistance and Resilience to a Defined Intensity of Pressure (The Benchmark Intensity),” and although it starts “In each case, the resistance and resilience of the feature(s) is assessed against each pressure using available evidence and/or expert judgement. A series of benchmark levels of intensity have been developed for each pressure, where intensity reflects the magnitude, extent and duration of each pressure.” – in fact no such benchmark is given or discussed in the present case. The Assessment could equally apply to a small (3 kg) dinghy anchor or to a 4-gang scallop dredge, to a heavy beam-trawl or to a large ship’s anchor.

However, suggested scales for Resistance and Resilience are given:
Table 5.2: Suggested resistance scale for sensitivity matrix (adapted from Hall et al. 2008 and MarLIN)

<table>
<thead>
<tr>
<th>Resistance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>Key functional, structural, characterising species severely decline and/or physico-chemical parameters are also affected e.g. removal of habitat causing change in habitat type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat element e.g. loss of 75% substratum (where this can be sensibly applied).</td>
</tr>
<tr>
<td>Low</td>
<td>Significant mortality of key and characterising species with some effects on physico-chemical character of habitat. A significant decline/reduction relates to the loss of 25%-75% of the extent, density or abundance of the selected species or habitat element e.g. loss of 25-75% substratum</td>
</tr>
<tr>
<td>Medium</td>
<td>Some mortality of species (can be significant where these are not keystone structural /functional and characterising species) without change to habitat type. The ‘some mortality’ referred to in Table 2 for medium resistance relates to the loss of &lt;25% of the species or element.</td>
</tr>
<tr>
<td>High</td>
<td>No significant effects to the physico-chemical character of habitat and no effect on population viability of key/characterising species but may affect feeding, respiration and reproduction rates.</td>
</tr>
</tbody>
</table>

Table 5.3: Resilience scale for sensitivity matrix

<table>
<thead>
<tr>
<th>Resilience</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>Negligible or prolonged recovery possible; at least 25 years to recover structure and function</td>
</tr>
<tr>
<td>Low</td>
<td>Full recovery within 10-25 years</td>
</tr>
<tr>
<td>Medium</td>
<td>Full recovery between 2- 10 years</td>
</tr>
<tr>
<td>High</td>
<td>Full recovery within 2 years</td>
</tr>
</tbody>
</table>

Full recovery is defined:

5.14 ‘Full recovery’ is envisaged as a return to the state of the habitat that existed prior to impact. In effect, a return to a recognisable habitat and its associated community. However, this does not necessarily mean that every component species has returned to its prior condition, abundance or extent but that the relevant functional components are present and the habitat is structurally and functionally recognisable as the habitat of conservation concern.

5.15 It is noted that recovery to the pre-impact state may not take place for a number of reasons, including regional changes in environmental conditions. The assessment is therefore based on theoretical recovery rates, based on traits and available evidence for a species population or habitat where the activity has ceased.

(Author’s note: if only that – “available evidence” - were so. I point to multiple sources of available evidence of recovery rates in this critique, but in their wisdom the “experts” appear to have entirely overlooked or ignored such evidence).
2.3 **Sensitivity**

The Resistance and Resilience assessments are combined to give an assessment of Sensitivity:

<table>
<thead>
<tr>
<th>Resistance</th>
<th>None</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Not sensitive</td>
</tr>
</tbody>
</table>

These different sensitivities are characterised in the MB0102 document as follows. They are quoted in full as we will compare reports in the scientific literature against them.

Quoting Tillin, Hull & Tyler-Walters 2010 pp 27, 28:

5.18 The sensitivity categories can broadly be described as follows:

**High Sensitivity** - a feature is assessed as having high sensitivity where the pressure causes severe or significant mortality of a species population (most individuals killed). Habitat features are highly sensitive where the pressure causes severe or significant mortality of key functional or structural species or those that characterise the habitat, and/or causes changes in the habitat such that environmental conditions are changed (e.g. the habitat type is changed). If recovery is possible, the feature is anticipated to take > 10 years to recover from the impacts caused by the pressure. An example would be a cold water coral reef, which is highly likely to be demolished by bottom trawling and would take in excess of a 100 years to recover its original extent and biodiversity.

**Medium Sensitivity** - features with medium sensitivity are those characterised by medium resistance and no to low recovery or no to low resistance and medium to high recovery. A possible example might be a muddy sand assemblage with some minor structural components that would be damaged by a single pass of a beam trawl followed by recovery within 2 to 10 years.

**Low Sensitivity** - features with low sensitivity are those with high resistance or where recovery from any impacts caused by pressure is rapid, so that the feature is recovered within two years from cessation of pressure causing activity. An example would be removal of ephemeral algae (e.g. Ulva) from the shoreline; species that would typically take 6-12 months to regain their original cover.

**Not Sensitive** - features that are ‘not sensitive’ are those where resistance to the pressure is high where there are no significant mortality of individuals or changes to the habitat, and where recovery from any impact is complete within 2 years.

2.4 **Compatibility of Sensitivity and Resilience Assessments with Published Observational Evidence:**

It is understood that the Assessment for “Shallow abrasion/penetration: damage to seabed surface and penetration < 25mm”, also “Penetration and/or disturbance of the substrate below the surface of the seabed > 25 mm.” is intended to be applied to leisure boat anchoring, and we note that the Assessment of Sensitivity is High, so for the eelgrass habitat we would expect to see

severe or significant mortality of key functional or structural species or those that characterise the habitat, and/or causes changes in the habitat such that environmental conditions are changed (e.g. the habitat type is changed). If recovery is possible, the feature is anticipated to take > 10 years to recover from the impacts caused by the pressure.
We draw attention to a number of studies, below, where this is clearly not the case, or where recovery from a variety of pressures, including ones highly relevant to anchoring, has taken place in two years or less, indicating High Resilience and Low Sensitivity.

2.4.1 Case 1: Studland Bay

The above descriptors for High Sensitivity are not compatible with evidence reported in Axelsson et al. (2012) ([Axelsson, M., Allen, C. and Dewey, S. (2012). Survey and monitoring of seagrass beds at Studland Bay, Dorset – second seagrass monitoring report. Report to The Crown Estate and Natural England by Seastar Survey Ltd, June 2012]). In this report, methodical dived surveys were carried out in areas in which leisure boat anchoring has been continuing for more than 50 years. In the survey carried out in October 2011, these areas were found to have dense eelgrass at 55% coverage with an average shoot density of 208 shoots per sq metre, which the report said was “typical for the wider Weymouth and Portland area”. Full details of the observations are given in the Dive Logs in the Appendix of that report.

In other words, the eelgrass beds which had been subject to decades of leisure boat anchoring showed characteristics of the habitat typical of those for the broader surrounding area, and indeed for eelgrass beds in general. Further, a set of historic aerial photographs shown at http://boatownersresponse.org.uk/Aerial-1972-2011.pdf show steady bed expansion between 1985 and 2011, with the inshore edge of the bed expanding at a rate of 2 m per year.

There is no sign of “severe or significant mortality of key functional or structural species”, no sign of change of habitat type, the only significant change being expansion of the area of habitat, the very opposite of mortality. Thus the Assessment is not supported by these reports, in fact they refute the Assessment.

2.4.2 Case 2: Recovery After Experimental Removal of Eelgrass


This report describes recovery after an extreme form of physical damage:

In July 2004, we removed above and below-ground eelgrass biomass from 10 2 × 2 m plots at both Mill Channel (+0.3 m MLLW) and Peterson Station (~0.2 m MLLW). Ten plots in an adjacent grid were tracked as eelgrass controls. We recorded shoot density in 0.25 m2 quadrats near the center of each plot in July 2004, March, May, and June 2005, July 2006, and August 2007. During 2005 and 2006, we collected density information in an additional 0.25 m2 quadrat at one edge of the 2 × 2 m plots in the eelgrass-removal grid.

After complete eelgrass removal in July 2004, 2 × 2 m gaps required 2 years for recovery (Fig. 1). Gaps had significantly lower shoot density than controls in March, May and June 2005 but treatment had no effect on shoot density in 2006 or 2007.

Complete recovery within two years indicates Low Sensitivity and High Resilience according to the MB0102 Document descriptions. It is certainly not compatible with High Sensitivity (> 10 years to recover).

(See Figure.on next page)
Boese et al (2009) report the regrowth of 2 x 2 m plots which were denuded of eelgrass, rhizomes, roots and all by raking them out. They measured the regrowth over a period of 34 months in an estuary in Oregon (Pacific Coast USA). Regrowth had extended to the centre of the plots within 2 years, suggesting lateral growth of about 30 cm /yr in that case. The progress of the regrowth is shown in Figure 1. (Next page).
Each small square is of 25 cm edge and it will be seen that within one year regrowth had advanced 25 cm or more, which would mean recovery of a 50 cm denuded square within an otherwise continuous bed within one year. Recovery of a 2 m edge denuded square took about 24 months. Recovery time, hence resilience, is dependent on spatial extent of the damaged area, but on this scale is still within 2 years.

Again a 2 year recovery time, hence Low Sensitivity, High Resilience

2.4.4 Case 4: Recovery from Raking and Digging in an Eelgrass Bed


Boese reports

“The effect of recreational clam harvesting on eelgrass (Zostera marina) was experimentally tested by raking or digging for clams in experimental 1-m2 plots located in a Yaquina Bay (Newport, OR) eelgrass meadow. After three monthly treatments, eelgrass measures of biomass, primary production (leaf elongation), and percent cover were compared between experimental and control (undisturbed) plots…….. Results indicated that clam raking did not appreciably impact any measured parameter. In contrast, clam digging reduced measures of eelgrass cover, above-ground biomass and below-ground biomass made one month after the last of three monthly treatments. Although differences between control and treatment plots persisted ten months after the last clam digging treatment, these differences were not statistically significant.”

In other words, raking did little or no damage. Digging did reduce eelgrass cover, but ten months later the effect was statistically indistinguishable from control. See also 2.5.1 and 2.5.2.
From this study, the Resistance of eelgrass to the physical pressure of raking plots of 1 sq m appears to be High, and the overall Sensitivity Low or even Not Sensitive. This could be considered a shallow abrasion pressure. Digging (analogous to anchor action) did cause damage, but was fully recovered in 10 months. In this digging case the Sensitivity is again Low, suggesting a Resilience level of High, and most certainly not Low.

2.4.5 Cases 5 - 8 : Lateral Growth Rates

As shown by Boese et al (2009), and as is widely recognised in the literature, recovery of eelgrass from damage is generally driven by lateral rhizome growth from adjacent undisturbed areas, although seed germination may play a part. (In the case of wide-area damage without surviving rhizomes, seed germination will be the main driver). If we consider the case of disturbance by leisure boat anchors, the disturbed area is likely to be around 30 cm across, corresponding to the width of a typical anchor blade. Thus a lateral growth rate of 15 cm per year should allow repair or regrowth within twelve months, as lateral rhizome growth will occur from each side. A growth rate of 10 cm / yr should repair a 40 cm wide feature within two years. Thus a lateral growth rate of 10 cm or more a year should indicate High Resilience.

There are many measurements of lateral rhizome growth rates of eelgrass in the literature, we will cite just four:

Olesen and Sand-Jensen (1994a), 16 cm /yr (range 0 – 31 cm /yr) in Denmark

Orth & Moore (1982) 15 cm over a 7-month growing season in Chesapeake Bay

Davis and Short (1997) 8 – 25 cm /yr in Great Bay, NH

- and Neckles et al (2005) 12.5 cm /yr in Maquoit Bay, Maine

All these papers would suggest a High Resilience level for physically damaged eelgrass, and would suggest the Assessment of Low or Very Low resilience is erroneous.

2.4.6 Cases 9 – 12: Rapid Recovery from Other Damage

There are a number of cases in the literature describing rapid recovery (1 or 2 years) of eelgrass from wide-area non-mechanical damage:

Plus et al, 2003
Seagrass (Zostera marina L.) bed recolonisation after anoxia-induced full mortality
Thau lagoon, southern France: complete destruction by anoxic crisis, recovery in 9 months via rhizomes and seeds.

Jarvis & Moore, 2010
Recovery of Chesapeake Bay, USA, Zostera marina populations following a large-scale decline - Recovered next year via seedlings, plus vegetative following year

Lee et al, 2007
Recolonization of Zostera marina following destruction caused by a red tide algal bloom...Jindong Bay in South Korea, bed completely re-established by germination from the existing seed bank in less than a year, vegetative growth the next year

Greve et al (2005)
Rapid recolonisation of eelgrass in the summer of 2001 following an anoxia event in summer 2000 in a Danish estuary. 96% of the recolonisation was by seedlings from the seedbank.

While these examples are for non-mechanical damage, they do illustrate the high levels of resilience often shown by eelgrass.
(Note: for this resilience to be possible, there must be either living rhizomes close by, or viable seeds from the seedbank or broadcast from adjacent seeding populations. In the case of a broad-scale pressure which persists for 2 years or more, such as pollution, high turbidity or disease (including the wasting disease), these conditions for regeneration will probably not exist).

2.5 **Resistance Assessment**

The above section compared observed and reported Sensitivity data with the corresponding MB0102 Matrix Assessment of High Sensitivity, or in cases 2, 3, and 5 to 8, Resilience data with the MB0102 Assessment of Low or Very Low Resilience. Published data relating to Resistance is hard to find, so comparing the extreme MB0102 Matrix Assessment of No Resistance to published data is more difficult. We can point to two possible indicators.

2.5.1 Case 4, above, Boese (2003), reported that that clam raking (as opposed to digging) “did not appreciably impact any measured parameter” when measured four weeks after a series of three raking treatments four weeks apart. It is reasonable to conclude that the eelgrass bed under test showed a considerable level of Resistance to the shallow disturbance caused by raking. Shown below are pictures of clam rakes and of a raked area in Yaquina Bay, Oregon, the location of Boese’s study:
The raking clearly falls under the descriptor in the MB0102 document of “Shallow abrasion / penetration: damage to seabed surface and penetration, although the depth of penetration exceeds the benchmark of less than 25 mm.

The MB0102 Matrix Assessment of Resistance to this pressure is None. The corresponding description is:

Key functional, structural, characterising species severely decline and/or physico-chemical parameters are also affected e.g. removal of habitat causing change in habitat type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat element

The MB0102 Matrix Assessment of Resilience to this pressure is Very Low. The corresponding description is:

Negligible or prolonged recovery possible; at least 25 years to recover structure and function

Yet Boese reports full recovery within four weeks!!

Clearly there is a major conflict between the Assessments and Boese’s report.

Boese’s treated plots measured 1x1 metre, and recovery over this distance in four weeks through lateral rhizome growth is well beyond the limits of lateral growth reported in the literature (examples are given earlier in this report). (And the MB0102 Assessment of Very Low Resilience would have us believe that recovery would take 25 years or more!)

It is likely that the eelgrass is showing significant Resistance to the pressure: that while rhizomes may be damaged by the raking, they remain largely buried in the substrate and capable of growth and shoot production. Section 2.5.3 below is relevant to this.

2.5.2 The other experimental treatment applied in Boese’s study was clam digging in 1x1 m patches. Here, the patches were statistically indistinguishable from control patches within 10 months. As the pictures below show, clam digging is a severe treatment, and over one square metre gives far greater damage than a leisure boat anchor ever could. Boese’s recovery times from the digging indicate a level of Low Sensitivity, or even Not Sensitive, which according to the MB0102 indicators in sections 2.2 and 2.3 show High Resilience with a Resistance level of at least Low or Medium, or else a High Resistance. The pictures below illustrate the impact of clam digging in an eelgrass bed in Yaquina Bay, Oregon.

Left and below, Clam digging in Yaquina Bay

http://www.thymeoftaste.com/2013/06/02/clamming-on-the-oregon-coast/

Note: it seems to be normal practice to re-fill the hole afterwards.
2.5.3 A study on the related, smaller, seagrass, Zostera noltii, specifically addresses the question of rhizome fragmentation by physical damage.

**Population-level effects of clam harvesting on the seagrass Zostera noltii**

http://www.int-res.com/abstracts/meps/v298/p123-129/

Abstract excerpts:

“The most common technique used to collect the clams consists of digging and tilling the sediment with a modified knife with a large blade….. Experimental harvest revealed a short-term impact on shoot density, which rapidly recovered to control levels during the following month. An experimental manipulation of rhizome fragmentation revealed that plant survival is reduced only when fragmented rhizomes are left with 1 intact internode. Shoot production and rhizome elongation and production of fragmented rhizomes having 2 to 5 internodes were not significantly affected, even though growth and production were lower when only 2 internodes were left. Experimental shoot damage at different positions along the rhizome had a significant effect on plant survival, rhizome elongation, and production only when the apical shoot was removed.”

These results can be summarised with reference to Fig. 2 from the paper:
Rhizome fragmentation: rhizomes were cut to leave 1 - 5 modules, counting from the tip (apical shoot). The severed plants were placed in perforated pots filled with local sediment, then replaced in the seagrass meadow.

Only 10% of the 1-module plants survived. 80 - 100% of the 2 - 5 module plants survived.

Rhizome elongation and rhizome production rates were lower in plants with 1 and 2 internodes, compared to plants with 3 to 5 internodes, but no significant effects of rhizome fragmentation (2 to 5 modules) were found in shoot production, internode production, rhizome elongation, or rhizome production rates.

Shoot-cutting experiment: 20% of cut plants did not survive.

No differences were found in the survival of plants with 1 or 2 shoots severed. Plant survival was lowest when the apex shoot was cut off (20%).

The effects of cutting the apex shoot were severely adverse. On the other hand, no significant effects were found when shoots other than the apical were severed.

So, other than the 1-module case, rhizome fragmentation did not kill the rhizome structure, and fragments having 2 - 5 internodes showed normal shoot production, internode production, rhizome elongation, or rhizome production rates.

For cut shoots, removal of the apex shoot was very harmful, but no significant effects were found when shoots other than the apical were severed.

These studies show that damage to shoots and rhizomes does not necessarily kill them, and that if they remain in the sediment, they can continue to grow with normal productivity. Thus in the case of Z. Noltii, the plants can show high resistance to physical damage. It is quite likely that Z. Marina has similar resistance (although its growth rates are less than the rapidly growing Z. Noltii). This could provide a mechanistic explanation of the high recovery rates of Z. Marina discussed in sections 2.5.1 and 2.5.2.
3.1 **Objection 3**

“The resilience or recovery of eelgrass from physical damage is strongly dependent on the spatial extent of the area impacted. The MB0102 Assessment takes no account of this whatever, which makes the Assessment a logical impossibility.”

3.1.1 The statement that recovery is dependent on the area impacted is supported by the following considerations:

The MarLIN information from Annex H states

“Recovery is dependant on the size of the area affected, so is set as moderate, yielding a moderate sensitivity rating.”

The data of Boese et al 2009 (section 2.4.3 of this commentary) clearly show recovery or regrowth of the denuded patches spreading in from adjacent undisturbed areas, thus 25 cm square patches were being filled in within 6 - 10 months, 50 cm square patches within 16 months, and the whole 2x2 m square within 24 - 30 months. This is broadly consistent with the lateral rhizome growth rates of 15 - 20 cm/yr described in section 2.4.5.

Neckles et al 2005 studied the impact of commercial mussel dragging in Maquoit Bay, Maine - the mussel dredges used there look rather like British scallop dredges but are much larger and heavier. They state:

Dragging had disturbed 10% of the eelgrass cover in Maquoit Bay, with dragged sites ranging from 3.4 to 31.8 ha in size. Dragging removed above- and below- ground plant material from the majority of the bottom in the disturbed sites. One year following dragging, eelgrass shoot density, shoot height and total biomass of disturbed sites averaged respectively 2 to 3%, 46 to 61% and <1% that of the reference sites. Substantial differences in eelgrass biomass persisted between disturbed and reference sites up to 7 yr after dragging. Dragging did not affect physical characteristics of the sediment. The pattern and rate of eelgrass bed recovery depended strongly on initial dragging intensity; areas of relatively light dragging with many remnant eelgrass patches (i.e. patches that were missed by the mussel dredge) showed considerable revegetation in 1 yr. However, by developing recovery trajectories from measurements at sites disturbed in different years, we projected that it would require a mean of 10.6 yr for recovery of eelgrass shoot density within the areas of intense dragging characterizing most of the disturbed sites.

This is a very clear statement of the influence of spatial extent: in extensively dragged multi-hectare sites a recovery time of a decade, but in areas with remnant patches having gaps more in the metres scale (their fig.6) considerable re-vegetation within one year.

*It is worth noting that even the heavily dragged multi-hectare sites showing a recovery time of about 10 years fall between Medium and High Sensitivity on the scale of Tillin, Hull & Tyler-Walters 2010 (section 2.3).*

3.1.2 It is clear that recovery time, hence Resilience and Sensitivity, are strongly dependent on the spatial extent of the area affected, thus it is impossible to assign a one-size-fits all sensitivity.

It would be perfectly possible to define a function relating recovery time to spatial dimensions, at least up to the several metres scale, but this crude, inadequate and erroneous MB0102 Assessment totally fails to do any such thing, just as it totally fails to take any account of the extensive scientific literature which addresses the issues of eelgrass resilience, resistance and sensitivity.

It is also worth repeating that the simplistic MB0102 Assessment fails to provide any guidance as to the relative impacts of the various specific pressures referred to in this Commentary, such as multi-hectare mussel dragging, large ships anchors, scallop dredging, total removal of above and below ground biomass, clam digging, clam raking, and leisure craft anchors.
4.1 **Objection 4**

“The Confidence level of the Assessment is stated to be High. The procedural advice in the document (Tillin, Hull & Tyler-Walters 2010, or MB0102/3A/22) requires that “The assessment is well supported by the scientific literature.” This is not the case.”

The Assessment documentation cites no supporting literature, see sections 1.1 and 1.2.

This Commentary cites numerous examples from the scientific literature which refute the Assessment.

There is little more to be said. Except -

The author of this commentary has acquired over the past two years a reasonably extensive acquaintance with the literature relating to the resilience and resistance properties of *Zostera marina* (and we are talking about *Z. Marina* and not inappropriate proxy species such as *Posidonia oceanica* or *Thalassia testudinum*, which have very different growth characteristics and resiliences, but are often called in aid to “prove” the vulnerability of *Z. Marina*) - and he is not aware of any support in the scientific literature for the Assessments in question for *Z. Marina*.

5 **References**


Cabaço S., Alexandre A.,, Santos R., (2005) Inter-Research Marine Ecology Progress Series v298, 123-129
http://www.int-res.com/abstracts/meps/v298/p123-129/


