A Parable of Compliance issues and their link to EBFM outcomes.

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By John G. Pope[1] and Charlotte T. Weber[2].

This is a scientific parable mostly based on an investigation of Compliance issues and their link to EBFM that arose as part of the MAREFRAME Atlantos CASE STUDY.

Highlights are

- Cost of Compliance is proposed as a useful statistic for assessing any proposed change in management in any fishery.
- Methods of how it might be calculated draws on approaches developed for the MAREFRAME Atlantos Case Study.
- It provides a succinct summary of the proceedings of an important meeting on compliance issues and EBFM held with Atlanterro Stakeholders and the Atlantis Board of Commerce.
- It suggests how its specific techniques could be adapted to other areas and gives an example of the transfer of advanced technical methods from Atlantos Scientists to the (backward) North Sea Case Study.
- It notes the common problems of including Atlanterro and other Stakeholders in the fisheries management process.

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By John G. Pope[1] and Charlotte T. Weber[2].

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Abstract.

Fisheries Stakeholders are understandably most concerned with immediate problems. Often these problems are related to proposed rule changes. This short term focus is in itself a serious problem for introducing Ecosystems Based Fisheries Management (EBFM), which is typically seen as a long-term approach. However, the short-term response of fishers to rule changes may well have long-term consequences by either changing their fishing patterns or by changing the extent to which fishers obey the rules. Either response could have a long-term impact on achieving EBFM.

This is a difficult area to study because it involves fishers' unrecorded behaviour, but it is probably the case that many of the responses of fishers may be influenced by how much it costs them to change their behaviour to comply with new rules. Changes in behaviour may include changes in fishing gear, fishing grounds or fishing effort. To examine these possibilities requires that a short-term area based model is available that can consider the costs and consequences of changes in fishing gear or fishing ground. There can be technical difficulties with doing this, but this paper attempts to show how these might be overcome. However, given the sensitive nature of compliance issues, these approaches are applied to the mythical

fisheries of Atlantis rather than to real life fisheries. Initial results of the model applied to the important Atlantean Fishing fleets are shown, and most importantly how much compliance might cost in these cases is indicated (i.e. the profit forgone by complying). Pursuing this scientific parable further also allows an open discussion of ways to mitigate non compliance. It suggests how stakeholders and managers might be able to improve trust and compliance by adding fishers' information to the scientific information used in models of compliance to increase transparency and by identifying and encouraging responsible behaviours that improve compliance and thus the chances of EBFM being successful. The purpose of the parable is to spark discussion and wider thinking about fisheries management and compliance in an EBFM context.

Key Words: EBFM, Stakeholder views, Fishers' Behaviour, Area Based models, Atlantis Fable, Compliance.

1 Introduction

1.1 Preamble

In 2014 the EU funded a large research project (MareFrame) to remove the barriers that prevent a more widespread use of the EBFM in Europe. At the onset of the MareFrame project North Sea Stakeholders expressed the wish that work should focus on

- The need to achieve Fmsy[1].
- The Landing Obligation.
- The Risks of Incompatible Regulation.

In practice the first of these topics was most congruent with the pre-agreed work plan of MareFrame and thus commanded the bulk of time and resources. However, it was wished in some way to consider the

[1] Fmsy is the level of fishing mortality for a species that will give Maximum Sustainable Yield and is a common limit reference point for fisheries management

41 other two stakeholder concerns. Undoubtedly, it would have been best to base this on a real system and
42 indeed preliminary work was started on this using the small mesh beam trawl fisheries of the Netherlands
43 as an example and work done on this is shown in the results. However, to complete this would have
44 required the ability to visit and have extensive consultations with Dutch Stakeholders and human and travel
45 resources that were not available under MareFrame. Hence such an endeavour has to await another time.
46 Consequently a thought experiment is presented to both demonstrate what might be a first way forward
47 for what is certainly a complex problem and to air some of the opinions, concerns, considerations and
48 opportunities that might come into play when Stakeholders are involved in such a process.

49 Hence in this paper, the authors use a scientific parable that will take the reader to a mythical world—*the*
50 *EU state of Atlantis*. The story revolves around an imaginary fishery placed somewhere in the North
51 Atlantic, which faces 'real-world' issues of a recently introduced discard ban and associated concerns about
52 compliance. The purpose of this 'mythical approach' is to discuss the delicate and sometimes controversial
53 issues of compliance freely. Therefore, despite the (at time) whimsical storyline, all ideas brought forward
54 in this paper are meant earnestly, with the aim to spark discussion and wider thinking about fisheries
55 management and compliance in an EBFM context.

56

57 ## 1.2 Rationale

58 Most proposals for long-term fisheries management suppose that fishers will comply with the proposed
59 regulations. History however suggests that this has not always been the case. Clearly the extent of
60 compliance with regulations will affect their outcomes and therefore the success or failure of measures
61 designed to further Ecosystem Based Fisheries Management (EBFM). The literature suggests that there are
62 multiple factors that influence fishers' willingness to comply with regulations or that tempt them not to
63 comply.

64 Rule compliance is often analysed from an economic perspective and much of today's fisheries
65 management is grounded in such economic theory, where fishers are seen as self-interested, rational
66 agents that strive to maximise their economic utility, while decimating the resource if offered open access
67 (Gordon, 1954). In this case, individuals will comply if the cost of breaking the rule is higher than the utility,
68 while the opposite case will lead to non-compliance. This is in the same line of thought as Hardin's
69 influential piece on the Tragedy of the Commons (Hardin, 1968). Based on these assumptions, the
70 behaviour of individuals is determined by a system of reward and punishment (Raakjær Nielsen, 2003). This
71 understanding narrows down individuals' compliance behaviour to a purely economic incentive which can
72 be controlled through monitoring, surveillance and enforcement. Ostrom's work expanded this
73 understanding and introduced the idea of how reciprocity, reputation, and trust affect people's behaviour
74 (Ostrom, 1998). Further social, cultural, and political factors like norms, perceptions, community,
75 transparency and legitimacy have also been found to impact fishers' behaviour (Hønneland, 1999; Ostrom,
76 1998; Raakjær Nielsen, 2003). Therefore, individuals' decisions to comply can be influenced by both
77 tangible and intangible motivations, like moral obligations and social influence, as suggested by the
78 literature and empirical evidence. In such cases, fishers can show cooperation even though this results in
79 economic loss, just to `do the right thing´, and individuals are more non-compliant the more their
80 community and peers are non-compliant or vice-versa (Sutinen and Kuperan, 1999). This may mean that
81 non-compliance mitigations would have to involve more complex considerations, such as increasing fishers'
82 perceptions of the legitimacy of policies and regulations, introducing equitable procedures for imposing
83 restrictions and empowering participants through co-management, for example (Sutinen and Kuperan,
84 1999). At other times, the issues at hand can be as simple as a lack of understanding of the rules and fishers
85 breaking rules unknowingly.

86 For this reason, the solutions to non-compliance issues are very dependent on the framing of the problem,
87 that is the factors leading to, or preventing, rule compliance (Jagers *et al*., 2012). In return, the diversity of
88 factors potentially influencing compliance exacerbates the development of generalizable and suitable

mitigation and counter measures. So how can we start to understand the costs of compliance—the profit forgone by complying—and its long-term consequences to ecosystem-based fisheries management? Despite the multiple factors, it seems likely that the cost of compliance is potentially the most important factor to consider or at least a first step in the process. However, compliance is often a sensitive and time consuming subject to address for a real fishery. Consequently in this paper, we develop a scientific parable based around the mythical EU state of Atlantis.

1.3 History:- Atlantis Resurgum

Far away and long ago in a parallel universe (that exists as a Riemann surface like extension to the real Earth), Atlantis had slipped below the waves. However, following intense volcanic activity, it rose again from the depths in AD i1850[2]. It is situated in the North Atlantic Ocean on the south Rockall Bank (57.24^{o}+i720N^{o}, 19.36^{o}+i360^{o}W). Ownership of the newly emerged land was initially disputed between the countries of iEurope. But, the Atlantean Government in exile, a covert cabal that had existed since those earlier classical times (with secret HQ on Malta, the Atlanteans being a Phoenician people) laid historical claims to the resurgent land mass. Their claims to sovereignty, perhaps cynically supported by the leading maritime power of the day and backed up by dubious archaeology, were finally accepted and internationally ratified by the Atlantis Treaty. The Government of Atlantis in exile thus claimed and settled the land of Atlantis. Its population subsequently swelled to about 1 million. It is a devotedly Catholic democracy but perhaps not surprisingly given its cabalistic roots, anachronisms remain such as the matriarchally descended High Priestess of Astarte remaining the titular head of state (deemed by many to be of divine origin). Although trading and banking are now the predominant industries of Atlantis, fishing and fish processing were the pioneer industries and are consequently hallowed in the Atlantean psyche.

Background to the Fisheries Management of Atlantis.

[2] Here and elsewhere in the paper a prefix of i indicates an imaginary entity. I.e. i=√-1.

As part of the initial International accommodation, signatories of the Atlantis treaty (signed in St Petersburg i1868) retained rights to share Alantean waters (somewhat like those subsequently granted signatories of the Svalbard Treaty, 1925) and these rights were recognised when Atlantis extended its EEZ under UNLOS in i1997. Atlantis joined the iEU in i1999 and Atlantean waters are fished both by Atlantis based fisheries, by fleets of other iEU countries and by fleets of some non iEU signatories of the Atlantis Treaty. However, in recent years fishing by non Atlantean fisheries has become uncommon but all fishing is subject to the CFP of the iEU. Figure 1 shows the topography of the Atlantean shelf. Fish resources in Atlantean waters, being toward the northern end of the Boreal-Lusitanian province, are not dissimilar to those about the Faroe plateau or the Northern North Sea and the fisheries are conducted with similar fishing methods to those areas.

Traditionally, the Atlatean Fishers, having Mediterranean ancestry, organised their management on a Guild like basis. However, membership of the iEU meant its one size fits all management in the Atlantic has somewhat superseded these earlier approaches though some traditional management rules still persist and these traditional rules are religiously observed by Atlantean fishers. Atlantean fisheries follow a restricted vessel licensing system based on traditional usage rights but this is overlaid with an iEU imposed system of TACs. ITQs have not been adopted in Atlantis.

More recently the iEU has striven to introduce ecosystem-based fisheries management (EBFM) to Atlantis as to other iEU regions. This aims to account for all factors within a fisheries system in a holistic and integrated fashion. The outcomes from this approach are: more precautionary management recommendations, consideration of non-target species, addressing trade-offs among sectors and catch allocation, improved short- and long-term economics for participants, and long-term sustainability (Link, 2010). Of course not all Atlanteans viewed these changes as beneficial but the Government of Atlantis had little choice but to accept this aspect of the iCFP.

Recently, the landing obligation (LO) of the i2013 Common Fisheries Policy, i.e. a discard ban, was introduced into iEU and Atlantean fisheries and will be fully implemented by 2019. With this regulation in place, discarding, i.e. returning catch to the sea, of over-quota, unwanted and undesirable catch will no longer be an option. This has raised concerns of the risk of early closures in fisheries due to what is referred to as the "choke-species" effect, which occurs when the quota of one species is exhausted before those of others. This presents a particular problem for mixed-fisheries, where it can be difficult to target or avoid single species as many are caught together (Mortensen *et al*., 2018). Such a discard ban can have large associated costs in terms of drastic reductions of long-term profits. This could have a strong impact on fishers compliance, as discarding practices have been found to be most closely linked to economic incentives (Simons *et al*., 2015).

Atlantean fisheries are based upon a mixture of Boreal and Lusitanian species. A particular concern is the round fish fisheries for cod, haddock and saithe, which are largely fished by Atlantis based fishers.

In Atlantis, fishers and scientists have a long history of liaising, and it is common practice to address any fisheries issues directly through dialogue between industry and science. The Atlantean traditionally involved in these discussions include The Atlantis Board of Commerce (ABC) and the Atlantis Regional Advisory Council (ARAC). Members of the ARAC include Atlantean (environmental) Non-Governmental Organizations (NGOs), Fishers organizations, fishers unions, the transport federation, the High Priestess of Astarte, fish processors, a few selected consumers, and governmental scientists from the social and natural sciences.

Given the current changes in policy, the Atlantean case study was brought into being as part of the EU-funded MareFrame project, a project aiming to support co-creation processes for ecosystem-based fisheries management solutions. As part of the MareFrame Atlantean case study, the Atlantean stakeholders were invited for an initial consultation regarding the concerns of the newly introduced LO in Atlantis. In the course of the consultation it became clear that:

1. Atlanteans were concerned to achieve EBFM.

2. However, their attention was necessarily focused on short-term issues. In particular they were concerned with the impending Landings Obligation (LO) and its possible effect on compliance.

3. The Atlantis Board of Commerce (ABC), which participated in these consultations, noting that reductions in compliance would have implications for the long-term success of EBFM measures, requested that the MareFrame Atlantean Case Study conduct a preliminary scoping study into the potential extent and cost implications of non-compliance in the context of the Atlantean offshore demersal round-fish fishery.

1.4 Objective

This paper provides the initial response of the MareFrame Atlantean Case Study team to the request by the ABC. It aims:

1) To set out the likely short-term economic scope for non-compliance in the Atlantean round-fish fishery.
2) To record the results of discussions held with ABC and the Atlantis Regional Advisory Council (ARAC) on ways forward to encourage compliance.

2 Materials and Methods

2.1 Approach:

Compliance is a complex amalgam of economic, social and governance factors. However, assuming that non-compliance is driven by economic forces rather than by bad habits or being anti-authority, the cost of compliance (the profit forgone by complying) becomes the measure of the driver that may lead to non-compliant behaviour. In defining this measure no judgment is made as to the likely behaviour of fishers

under the proposed Landings Obligation (LO) in Atlantean waters or elsewhere. Rather it is a way to scale "the wages of sin" for a particular case and thus to appreciate the strength of temptation not to comply.

To predict the size of the cost of compliance (in the short term) with a discard ban (AKA Landing Obligation - LO) requires that the economic consequences of compliant and non-compliant behaviours be calculated. The most obvious behavioural differences between compliant and non-compliant behaviours might be in choice of fishing gear adopted, the areas fished and the amount of fishing effort deployed. Compliant behaviour, which would be landing all fish species caught up to their given quota, might involve the choice of mesh-sizes that reduced the proportion of unwanted sizes of various species and/or avoiding fishing grounds where those sizes of those species are prevalent. Non-compliant behaviours would continue fishing with existing or smaller mesh gears, seek the most profitable grounds and illicitly discard unwanted catch. In the case of the Atlantean fishing grounds the wider and more productive fishing banks are situated off the East Coast, which are more sheltered and more accessible to the main harbour and market at Atlanto Porto (see Fig 1) in the South East Bight of Atlantis. These grounds tend to be more profitable than those on the steeper and more exposed West Coast but are also the nursery grounds of the round-fish species and hence the areas where more unwanted, undersized fish are caught and discarded. The problem for Atlantean fishers is thus somewhat similar to that of the beam trawl flatfish fisheries of the Netherlands and Belgium where the main sole fishing areas overlap with the distribution of undersized plaice and sole and are close to their main harbours.

To model this for Atlantean waters it is necessary first to acquire information on the distribution of fish by area by size. Area distributions of catch by species and effort are available at the STECF website (STECF i2017)[3]. This also provides estimates of total discard weight by species from past years but not their distribution by area. Consequently, not all the information needed for input to a model that operates at a subarea level is available in these existing data; e.g. there are no ICES rectangle data for discards by size

[3] Go to https://stecf.jrc.ec.europa.eu/dd/effort/graphs-annex and for Atlantos data select the LANT Annex.

available by species and by fleet and gear. Hence other means need to be found to generate this information. This can be done by using research vessel survey data to give size distributions by ICES rectangle and by assuming logistic selection and functional forms for discarding for the relevant fleets. Best fits of the operational 50% selection and discarding points may then be estimated by comparing past estimates of overall catches and discards from the fishery with those based on combining survey based catch-rates-at-size and selection patterns with commercial catch and effort distributions. Once these 50% points have been estimated (or guessed), the ratio of discards to catch can then be estimated for each rectangle using the selection pattern and the survey data. Further details of these calculations can be found in Zope, i2016.

In the case of the Atlantean example unwanted catches are those below the earlier EU minimum landing sizes and knife-edged discarding at these sizes was assumed. Fall ground-fish survey estimates of the size distributions of cod, haddock and saithe were available from surveys conducted by R.V. Randomia that are available on the ICES DATRAS database (ICES i2018). Using these data sources it was possible to establish annual average catch-rates-by-size for each rectangle in Atlantean waters for all three species. These were split into three size bands corresponding to unwanted (zero valued and currently discarded) sizes, lower value smaller sizes and more valuable larger sizes. These correspond closely in distribution to the charts of large and small cod, haddock and saithe seen in the Atlantean Annex to the very informative Atlas of Fish (Hessen *et al*, i2015)[4].

Having estimated the areal distributions of the three species by the three size groups (unwanted, small and large fish), an initial very simple spreadsheet model was constructed to optimize profit (under hypothetical compliant or non-compliant behaviours) by modifying fleet fishing distribution over the fishable rectangles and by modifying mesh-size (subject to their being greater or equal the EU mandated 120cm) so as to catch differing proportions of discards, and of small and large commercial fish.

[4] See Section i32 page 186

Catch proportions appropriate to a mesh size were based upon a logistic selection curves using the previous average fish sizes of the catch of each of the three size components for each species. Costs of a day's fishing (the unit of effort adopted) and the average additional costs of steaming to different grounds were ascribed to each rectangle. This enabled the costs to be calculated of expending a given number of days fishing in each rectangle. The catch value of each size of each species was then combined with the calculated catch rates of each size and species in each rectangle. This enabled the catch value of a given number of days fishing at each rectangle to be calculated. Profit for such effort was then calculated as the difference of the calculated fishing costs and catch values for each rectangle and summed to give a total profit. Total catches of each species were also calculated for each rectangle and summed to give the total catch. Fishing effort was also summed across all rectangles.

Optimizations of the fleet effort distribution by rectangle and of the average mesh size that maximized profit were made using the SOLVER optimizing routine of EXCEL . This enabled optimizations to be suitably constrained to the TAC landings of each species and also constrained to limit (in line with Atlantean customs) the total effort per rectangle. Optimizations were made under the two extreme hypotheses of fishers' behaviour. Under the first hypothesis all fishers are compliant while under the second hypothesis all fishers are non-compliant. The simulations were subject to the following rules.

- Under the compliance hypothesis all fish (unwanted and small and large commercial sized fish) are landed and all landed fish count equally towards binding species TAC's.
- Under the non-compliance hypothesis, zero value fish and over quota commercial sized fish are discarded if this allows greater profit. This would be possible because there is presently little at sea inspection. However, the same TACs are still binding on landings as under the compliant hypothesis. This is because all landings pass through Atlanto Porto (Atlantis' only fishing harbour and fish market situated in the South Eastern Bight) where landings are subject to strict monitoring.

- In both cases the fleet, if it wishes, may increase mesh size and change fishing patterns and effort to obtain the most profitable outcome.
- There is a longstanding industry-backed rule that statistical rectangles are closed after a maximum annual effort of 1666[5] days fishing (long supported by religious taboo but now also monitored by satellite).

In both cases the optimization of effort by rectangle and mesh size leads to estimates of overall profit, overall days fishing, species catch and value by size group and actual levels of discards or landed discard sized fish. Overall profit reflects the value of catch and the immediate costs of applying effort and also indirect costs such as increases in steaming time for more distant grounds.

3 Results

Summary of the Initial Report of the MareFrame Atlantean Case Study to the ABC (ABC i2018).

3.1 Areal Distributions.

The report shows the annual fish areal distribution for the mature, immature and juvenile (i.e. below MLS) fish. The full results are available in the report annex tables. For illustrative purposes Figures 2 to 4 are shown here for the immature size group of each species. Distributions of juvenile, immature and mature distributions are available in ABC i2018 - annex 3. Here these are referred to as unwanted catch and as, small and large commercial fish. Figure 2 shows the relative catch-rate per day of small cod. Note that larger cod (not shown) tend to lie further offshore while smaller unwanted sizes (not shown) are found further inshore.

Figure 3 shows the relative catch-rate per day of small haddock. Larger sizes of haddock (not shown) and smaller unwanted sizes (not shown) have very similar distributions to these.

[5] As associated with the mark of the beast linked to the Great Fire of London in that year.

Figure 4 shows the relative catch-rate per day of small saithe. Larger saithe (not shown) tend to lie much deeper while smaller unwanted sizes (not shown) occur very close to the coast.

3.2 Model Results.

More detailed results from the optimization program are shown in (ABC i2018 - annex 4). Here we show Figures 5 and 6 that indicate relative fishing effort by rectangle for the two hypotheses. Note that there are markedly different distributions for the two hypotheses, and that non-compliance allows more fishing days. Table 1 shows the broad differences between the compliant and non-compliant behaviours. The Table shows that with non-compliance the hours fished, the landings value and the profit are all increased by about one third and discarded catch by 43%. The cost of compliance is thus estimated at about €4.4million, i.e. the profit forgone by complying. The implications are that fishing mortality rate would be about 1/3 higher under the non-compliant hypothesis than the compliant hypothesis. Thus if the former is what will actually happen then the EBFM objective of bringing fishing mortality rate on all species down to the Fmsy level would be severely compromised and by extension so would EBFM.

4 Discussion and Conclusions

4.1 Stakeholder Discussions.

On receiving this report the Fisheries Secretary of the ABC convened a meeting with the members of the Atlantis Regional Advisory Council (ARAC) to discuss both the initial report and possible ways forward. The meeting was held under Chatham House rules.

The Mareframe Atlantean Case study leader Dr Zope presented the report and stressed that it in no way claimed that Atlantean fishers engaged in non-compliant behaviour, but it simply tried to estimate the size of the potential driver for non-compliant behaviour under the proposed LO. He noted that under the non-compliant hypothesis:

- There would be a 35% greater fishing effort and presumably concomitant increases in fishing mortality with non-compliance
- Capture of unwanted catch/discards might increase particularly for saithe.
- Profit might be 33% higher.
- That at €4.4million the wages of sin are substantial!
- He also noted the overall increase in profit from non-compliance (33%) was less than expected by some NGO commentators in a year where high haddock discards were anticipated.

Discussions of the report by members of the ARAC were later described as frank and comradely[6]! The main points were:

- There were various accusations by various fleet sectors about other fleet sectors' lack of compliance in the past! This was echoed by the NGO delegates attending, but then denied by all fleet sectors!
- With respect to the report many ARAC members were suspicious of areal distributions of catch rate based upon research vessel data, which did not reflect real fish catch rates by real fishers.
- In particular, changing seasonal distributions of smaller sizes was considered likely to be important. Local fishermen who know their fishing grounds very well were particularly vocal on this point
- These fishermen argued that catch composition varies greatly on a very fine scale in space and time, if you know what you are doing you could thus avoid discarding.
- All the fishermen pointed out they had been shown to be right about such issues in the past.
- Various opinions of the scale of the economic advantage of non-compliance were expressed but most were not wildly dissimilar to those estimated by the model.
- NGOs noted that the non-compliant effort distributions tended to concentrate in areas with sensitive habitats.

[6] Some members subsequently received PTS counselling

- Stakeholders expressed concerns regarding the reliability of the model outcomes and the associated uncertainties.

Dr Zope accepted the more serious criticisms of the report while pointing out that it represented an estimate the worst case scenario for the cost of compliance that was designed as a “straw man” to initiate the discussion.

From his own experience on chartered fishing vessels he had always been in awe of fishers’ ability to catch clean catches when they “chose to”. The important question would be to find ways to encourage them to choose to be compliant with the Landings Obligation. He note that the analysis was designed to provide a worst case scenario for discussion. The non-compliant case of course was based upon the historical behaviour of the fishery and reflected how fishers had chosen to fish in the past. This presumably was the pattern of fishing that was most profitable to them. Discard data confirmed and fishermen themselves acknowledged that extensive discarding had occurred in the past and would presumably still occur in the future if fishers maintained past (short term profitable) patterns of fishing. Thus he said the question should be –“are there patterns of fishing, which based upon the undoubted skills of fishers, would allow compliant fishing to be undertaken in a fashion, which caused less profit to be foregone that that seen in the non-compliant scenario presented?”

Dr Zope stated he would be very willing to improve the input to the model using industry knowledge of fish distributions if these could be provided. He said this would be helpful since RV Randomia was only able to make one Autumn Ground-Fish survey each year and he accepted that its’ young fish catches would not describe annual distributions accurately. Far more importantly such a collaborative study should also help identify behaviours that should be encouraged both by the Government of Atlantis and the fishers themselves in order to decrease discarding, to improve the long term state of the fishery by working “with the grain” of the fishery and by reducing the costs of compliance as far as possible.

The Fisheries Secretary of the ABC thanked Dr Zope for his initial “thought provoking” report and for the offer to improve it using industry knowledge. He proposed a small joint working group formed of Dr Zope and experienced members of ARAC to foster trust and increase transparency. This group would explored the fishers knowledge that could improving both the details of the model and more importantly help come up with proposals for action in the traditional spirit of cooperative fisheries management native to Atlantis. He asked them to provide an interim report for the next meeting in two months’ time. He noted that despite caveats about the inputs there seemed broad agreement about the scale of the economic advantage of non-compliance, at round about 33% extra profit, and that this might constitute a serious temptation to non-compliant behaviour to some. He was concerned to help fishers to resist temptation[7] in the interests of the long-term sustainability of the resource. He asked for suggestions of ways to curb non-compliant behaviour while noting that an increased offshore inspection regime would be expensive and probably ineffective. The ensuing discussion produced (*inter alia*) the following useful suggestions:

- Introduce a targeted inspection of inshore waters.
- Encourage industry reporting of areas of high undersized catch.
- Instigate industry led temporary closures in areas of high discarding.
- Further encourage a social inclusion policy in decision making (this might serve to encourage compliance with the LO).
- Involve women more as at sea observers (perhaps under the aegis of the High Priestess).
- Find ways to compensate the landing of undersized fish with a general levy.
- Improve heavy fines for discarding.
- Empower fishery participants and increase regulation legitimacy by creating ownership and acceptance through co-creation processes (to increase rule uptake).

[7] Noting that some like Oscar Wilde could ”Resist anything except temptation”

- Identify possible other factors leading to non-compliant behaviour and ways to mitigate them through interdisciplinary (i.e. involving natural and social sciences) and trans-disciplinary efforts (i.e. involving academic and non-academic participants).
- Foster the use of decision support frameworks that can highlight alternatives and consequences to stakeholders.
- Build trust through transparency and openness during scientific/planning/decision-making processes.

The Fisheries Secretary thanked the meeting for their suggestions. He noted it was important to reach an early solution to avoid non-compliant behaviour becoming widespread, socially acceptable and entrenched. This is important because non-compliance could increase fishing mortality on these species by 35%, discards would increase by 43% and bottom disturbance would increase on some vulnerable grounds. He advised that he would return next month to discuss practical measures with the ARAC. He stressed that Atlantean traditions lead him to prefer measures that worked "with the grain" of the fishing industry rather than to adopt a command and control approach.

4.2 Back to reality

To conclude: While the Atlantis case study is fabulous[8], it suggests that estimating the cost of compliance (the profit forgone by complying) with any proposed measure would be a useful statistic for any fishery. In regard to non-compliance with the Landing Obligation it should be noted that non-compliance would increase fishing mortality rate on all sizes of fish but particularly undersized fish. The increased fishing mortality rate would mean that EBFM targets such as achieving Fmsy would be compromised. Increases in discards would be a point of concern for any implementation of EBFM. Discarding is directly related to EBFM as it can affect the functioning of ecosystems and reduce long term fisheries profits(Bellido et al., 2011). Moreover, under a Landings Obligation where discarding is illegal it would become far more difficult

[8] *Fabulous* should of course be understood here as *mythical*, from the word *fable*.

384 to monitor discarding accurately and thus it might go largely undetected.

385 Estimating the difference in potential profit between compliant and non-compliant behaviours appears a
386 good place to start in compliance studies in order to get a first impression of the pressure on fishers to
387 evade regulation. At least the initial modelling stages used in Atlantis seem a feasible approach for non-
388 fabulous fisheries. This is demonstrated in Figure 7, showing estimates of potential plaice discard
389 proportions estimated for small mesh beam trawl (BT2) fisheries in the North Sea. These were kindly
390 calculated by Dr Zope pers. comm. following the same procedure used for Atlantean Waters fisheries.

391 Clearly, effective ways to discourage non-compliance are needed since it seems likely that non-compliance
392 would weaken all forms of fisheries management including EBFM. Hence effective measures to reduce or
393 eliminate non-compliance with a Landings Obligation must be an urgent requirement particularly when
394 there is a strong profit motivation in favour of non-compliance with this measure. At sea inspection is costly
395 and may have insufficient deterrent value to eliminate non-compliant behaviour unless it is coupled with
396 punitive fines or confiscation of fishing rights. Moreover it is likely to alienate fishers. Consequently more
397 successful approaches might be those that use social pressures amongst fishers themselves to discourage
398 discarding and/or which use fishers detailed knowledge in ways that finds less unprofitable solutions to
399 avoiding discarding.

400 Such an approach to the problem would be more in tune with EBFM. EBFM aims to improve conventional
401 decision making frameworks by increasing leverage from stakeholders (Link, 2010). This could be achieved
402 by adding active stakeholder involvement and co-creation in the form of working groups (or other similar
403 events) to the process, which offers room for discussion and the inclusion of Stakeholder perspectives.

404 While such processes build trust, they can also provide insights into possible issues of peer pressure,
405 legitimacy, and transparency. In addition, they offer the opportunity to include trade-offs and concerns
406 relevant to stakeholders, which can make the scientific approach more relevant and also increases the
407 likelihood of its acceptance among the participants (Epstein et al., 2018). To achieve this the Stakeholders

involved should be diverse and include fishers, managers, and representatives of other relevant sectors and institutions associated with the resource use to ensure a fair co-creation process (Ballesteros et al., 2018). Subsequently, a combined modelling and stakeholder involvement approach could potentially support resource assessments (e.g. by fishers sharing data with scientists to facilitate model interpretation (Ramírez-Monsalve et al., 2016)) and help to develop appropriate management measures and responses to non-compliant behaviour. The Sustainable Fisheries Resource Advisory Council of Canada (SFRACC)[9], a national arm's-length advisory body designed to offer the Minister broad-based advice and recommendations on fisheries issues might form a useful template for such a body.

For successful EBFM and long-term sustainability for the resource and resource users, further consideration should be given to the complexity of fishers' motivations for non-compliance as well as the socio-ecological context in which they interact. The inclusion of social scientists could help provide the necessary approach together with insights to gain a deeper understanding of the drivers and factors influencing fisher behaviour. However, the necessary extent of such an endeavour would depend on the type and context of the fishery (e.g. geographical location, scale of fishery, gear type, etc.) and the extent of the problem (e.g. high/low compliance). Early stakeholder involvement and consultation would help support the framing of the problem and aid the process of delving deeper into the complexities of fisher's compliance.

[9] See https://www.canada.ca/en/fisheries-oceans/news/2018/07/government-of-canada-announces-new-sustainable-fisheries-resource-advisory-council.html

5 Acknowledgement:

The research leading to these results has received funding from the European Union's Seventh Framework Programme Project MareFrame: Co-creating Ecosystem-based Fisheries Management Solutions under Grant Agreement no. 613571 and from the project SAF21 Social science aspects of fisheries for the 21st century, financed by the EU Horizon 2020 Marie Skłodowska-Curie MSC ITN-ETN Programme under Grant Agreement no. 642080.

Particular thanks are due to Dr Xoh Zope of the Instituto Atlanterro Maritimo (IAM) for making the Atlantean Case Study Report available and for providing the calculations for Figure 7.

In addition, the authors wish to thank three anonymous reviewers for improving earlier version of this paper.

6 References

6.1 Real References

Ballesteros, M., Chapela, R., Raakjaer, J., Ramirez-Monsalve, P., Hegland, T.J., Degnbol,P., Nielsen, K., Rahikainen, M., Baudron, A., Bartolino, V., Colloca, F., Ruiz, J.,Rincón, M.M., Pope, J., Agnarsson, S., Elvarson, B. Stefansson, G., 2018. Who Joins the Table? A Critical Overview of the Co-Creation Approach for the Implementation of an Ecosystem-based Fisheries Management Approach. J. Fish. Res VSI: Advancing EBFM.

Bellido, J.M., Santos, M.B., Pennino, M.G., Valeiras, X., Pierce, G.J., 2011. Fishery discards and bycatch: solutions for an ecosystem approach to fisheries management? Hydrobiologia 670, 317–333. doi:10.1007/s10750-011-0721-5

Epstein, G., Andrews, E., Armitage, D., Foley, P., Pittman, J., Brushett, R., 2018. Human dimensions of ecosystem-based management: Lessons in managing trade-offs from the Northern Shrimp Fishery in

448 Northern Peninsula, Newfoundland. Mar. Policy 97, 10–17. doi:10.1016/j.marpol.2018.08.018

449 Gordon, H.S., 1954. The Economic Theory of a Common-Property Resource: The Fishery. J. Polit. Econ. 62,
450 124–142. doi:10.1086/257497

451 Hardin, G., 1968. The Tragedy of the Commons. Science (80-.). 162, 1243–1248.
452 doi:10.1126/science.162.3859.1243

453 Hønneland, G., 1999. A model of compliance in fisheries: Theoretical foundations and practical application.
454 Ocean Coast. Manag. 42, 699–716. doi:10.1016/S0964-5691(99)00041-1

455 Jagers, S.C., Berlin, D., Jentoft, S., 2012. Why comply? Attitudes towards harvest regulations among
456 Swedish fishers. Mar. Policy 36, 969–976. doi:10.1016/j.marpol.2012.02.004

457 Link, J., 2010. Ecosystem-Based Fisheries Management. Cambridge University Press, Cambridge.
458 doi:10.1017/CBO9780511667091

459 Mortensen, L.O., Ulrich, C., Hansen, J., Hald, R., 2018. Identifying choke species challenges for an individual
460 demersal trawler in the North Sea, lessons from conversations and data analysis. Mar. Policy 87, 1–11.
461 doi:10.1016/j.marpol.2017.09.031

462 Ostrom, E., 1998. A Behavioral Approach to the Rational Choice Theory of Collective Action: Presidential
463 Address, American Political Science Association, 1997. Am. Polit. Sci. Rev. 92, 1–22.
464 doi:10.2307/2585925

465 Raakjær Nielsen, J., 2003. An analytical framework for studying: compliance and legitimacy in fisheries
466 management. Mar. Policy 27, 425–432. doi:10.1016/S0308-597X(03)00022-8

467 Ramírez-Monsalve, P., Raakjær, J., Nielsen, K.N., Santiago, J.L., Ballesteros, M., Laksá, U., Degnbol, P., 2016.
468 Ecosystem Approach to Fisheries Management (EAFM) in the EU - Current science-policy-society
469 interfaces and emerging requirements. Mar. Policy 66, 83–92. doi:10.1016/j.marpol.2015.12.030

Simons, S.L., Döring, R., Temming, A., 2015. Modelling fishers' response to discard prevention strategies: The case of the North Sea saithe fishery. ICES J. Mar. Sci. 72, 1530–1544. doi:10.1093/icesjms/fsu229

Sutinen, J.G., Kuperan, K., 1999. A socio-economic theory of regulatory compliance. Int. J. Soc. Econ. 26, 174–193. doi:10.1108/03068299910229569

6.2 iReferences

ABC. i2018. ABC internal report 2018 no 6. pp62, ABC publications. Astartia.

Heessen, H.J.L., Daan, N. and Ellis, J.R. i2015. Fish Atlas of the Celtic Sea, North Sea and Baltic Sea with an Annex on Atlantean Waters. Based upon International research-vessel surveys. i2015. Wageningen Academic Publishers. 725pp.

ICES DATRAS Data base. i2018. http://ices.dk/marine-data/data-portals/Pages/DATRAS.aspx

STECF i2017. https://stecf.jrc.ec.europa.eu/dd/effort/graphs-annex

Zope, X. i2016. Calculating areal distribution of unwanted catch of cod, haddock and saithe in Atlantos Waters. Proc Atlat. Acad. Sci. Vol. 45. P134-146.

7 Tables

Table 1 Main results of the preliminary Mareframe Case Study into compliance costs. (Results from ABC i2018 reproduced by kind permission of ABC.)

Behaviour	Compliant	Non-compliant	% increase
total days fished	4610	6240	35%
landed wt. 1000 Tonnes	39	37	-4%
landed value million€	39	52	34%
costs million€	25	34	35%
profit million€	14	18	33%
total discards 1000 Tonnes	12	17	43%
Cod discards 1000 T.	4	5	45%
Haddock discards 1000T.	6	7	22%
Saithe discards 1000T.	2	4	71%

8 Figure Headings

Figure 1. The lid off Atlantis topography and bathymetry. View from South East.

Figure 2. The spatial distribution of relative catch per day of small cod. (Figure from Zope i2016)

Figure 3. Relative catch per day of small haddock. (Figure from Zope i2016)

Figure 4. Relative catch per day of small saithe. (Figure from Zope i2016)

Figure 5. Relative days fished per rectangle with compliance with the landing obligation. (Results from ABC i2018 reproduced by kind permission of ABC.)

497 Figure 6. Relative days fished per rectangle with non-compliance with the landing obligation. (Results from
498 ABC i2018 reproduced by kind permission of ABC.)

499 Figure 7. Estimates of potential plaice discard proportions estimated for small mesh beam trawl fisheries in
500 the North Sea. Kindly calculated by Dr Zope pers comm. following the same the procedure used for Atlantis
501 fisheries.

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Figures for A Fabulous attempt to link the cost of Compliance to EBFM.

Figure 1 The Lid off Atlantis: Topology and Bathymetry.

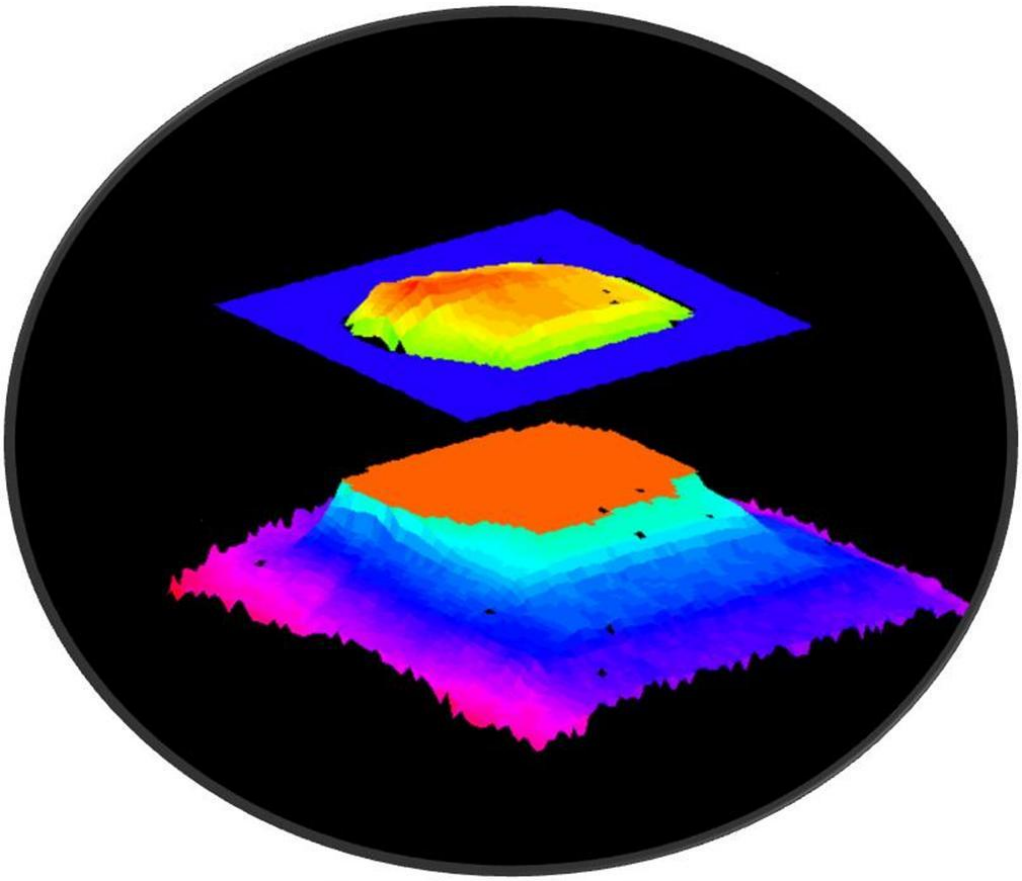
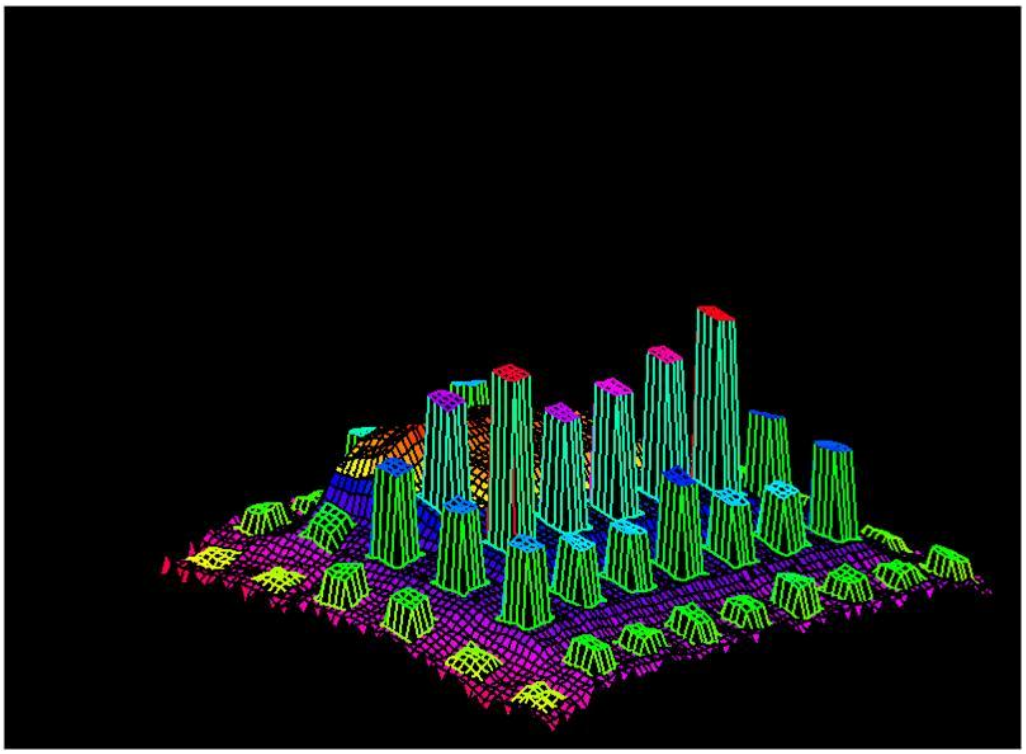


Figure 2



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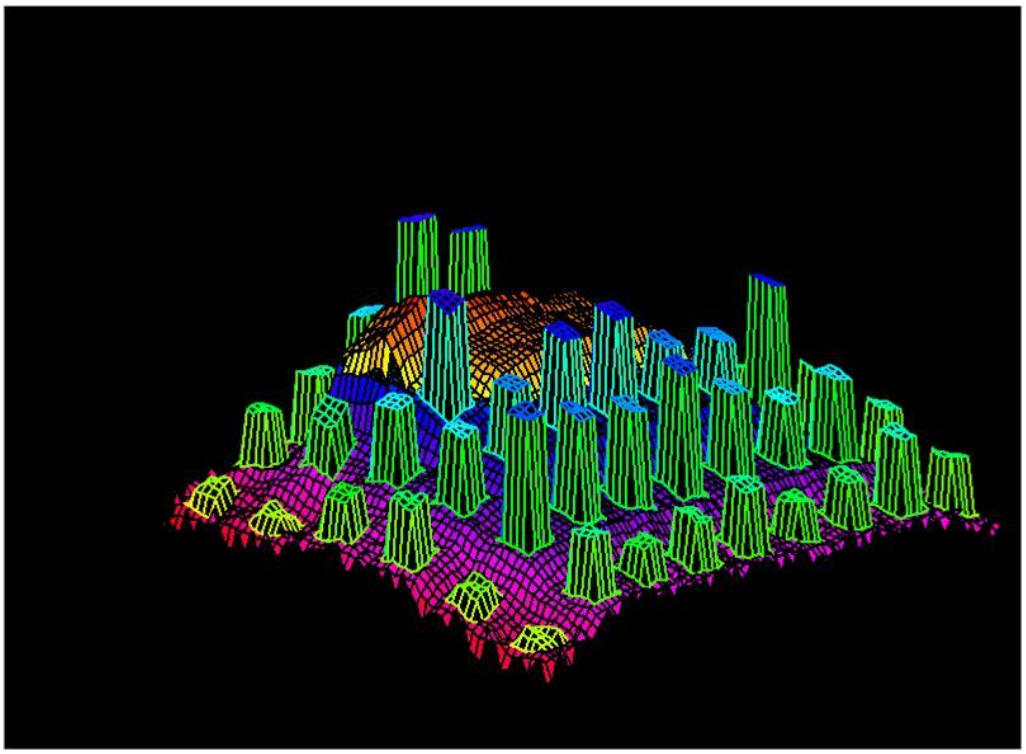


Figure 4

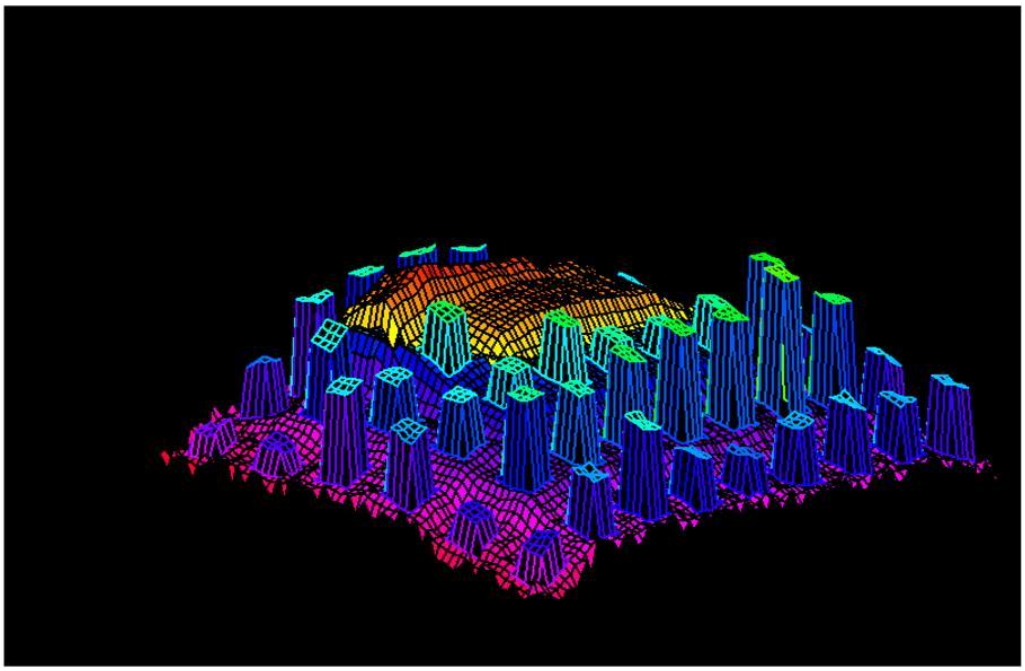
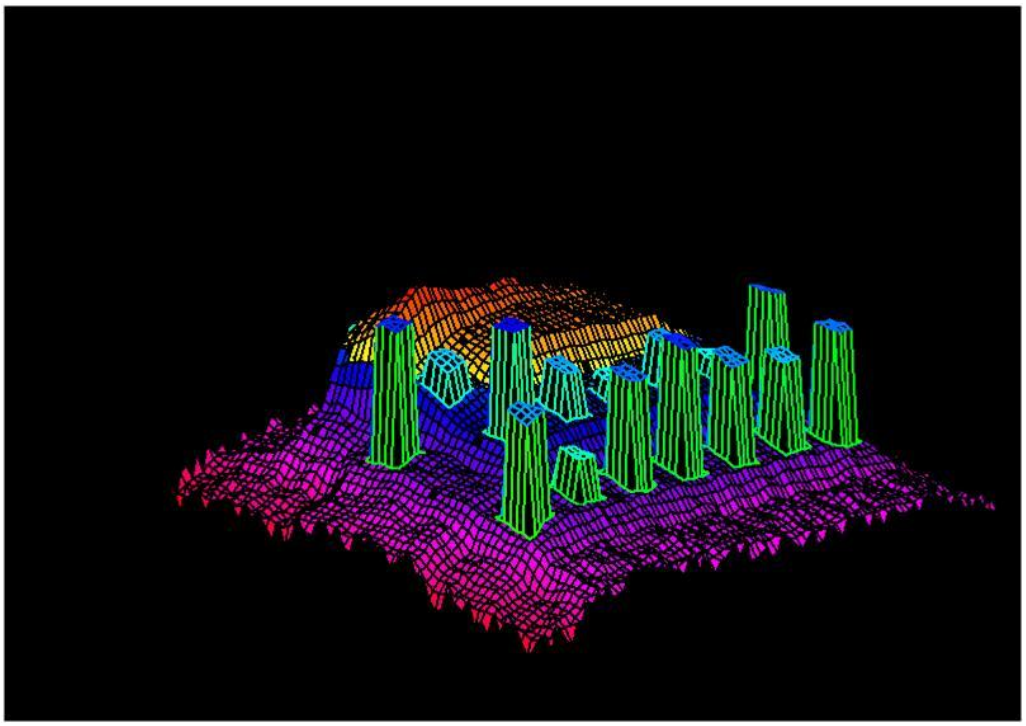


Figure 5



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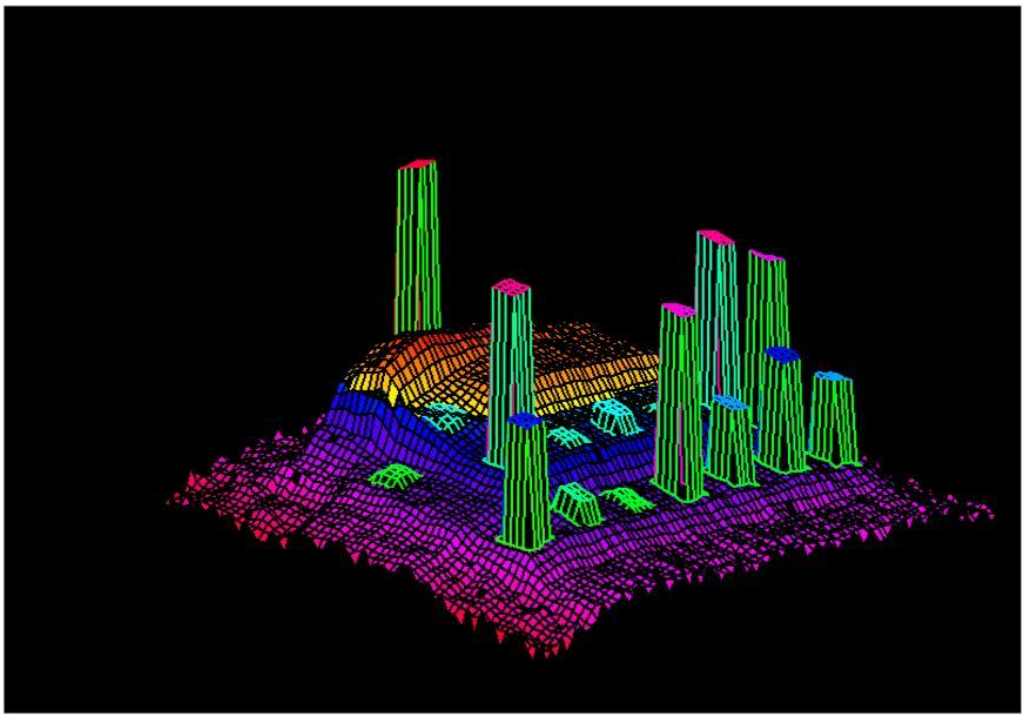
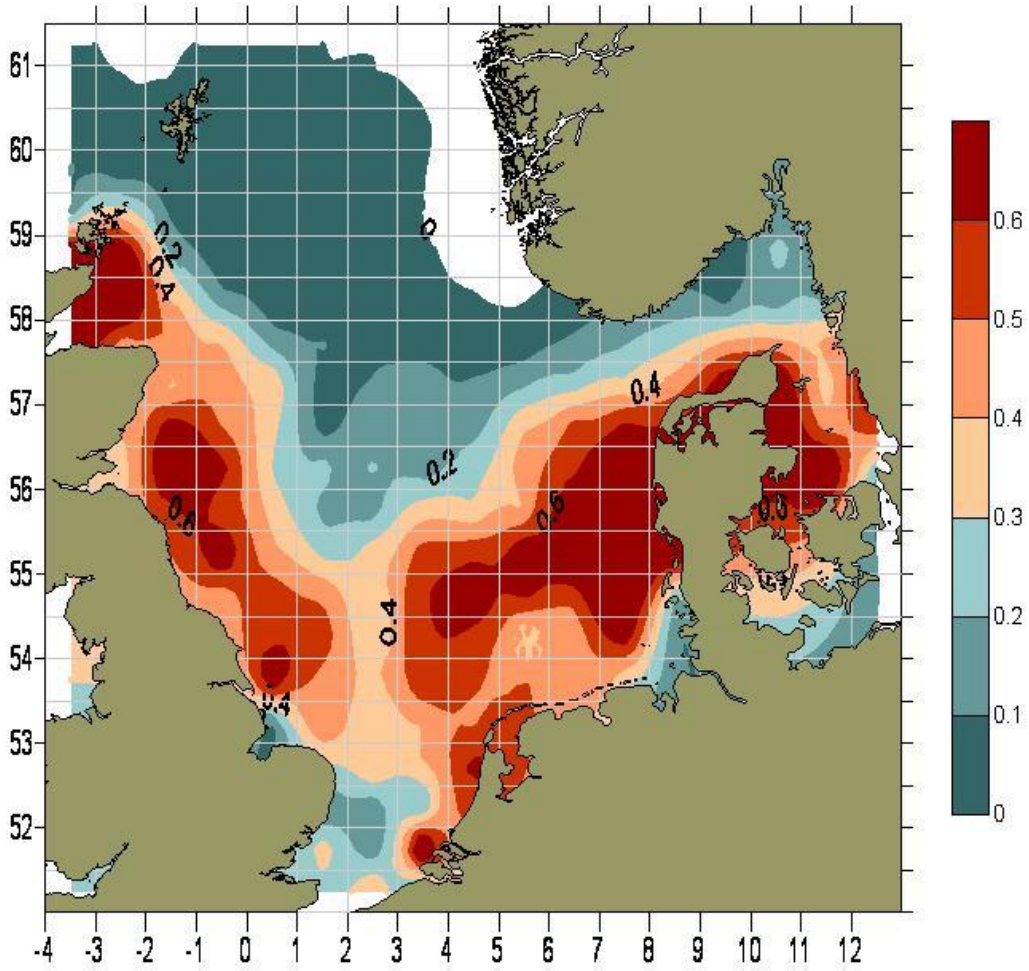


Figure 7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