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*Editors*

# Imagine Maths 5

Between Culture and Mathematics



Istituto Veneto  
di Scienze Lettere  
ed Arti

*To*

*Umberto Eco*

*Giorgio Israel*

*Luca Ronconi*

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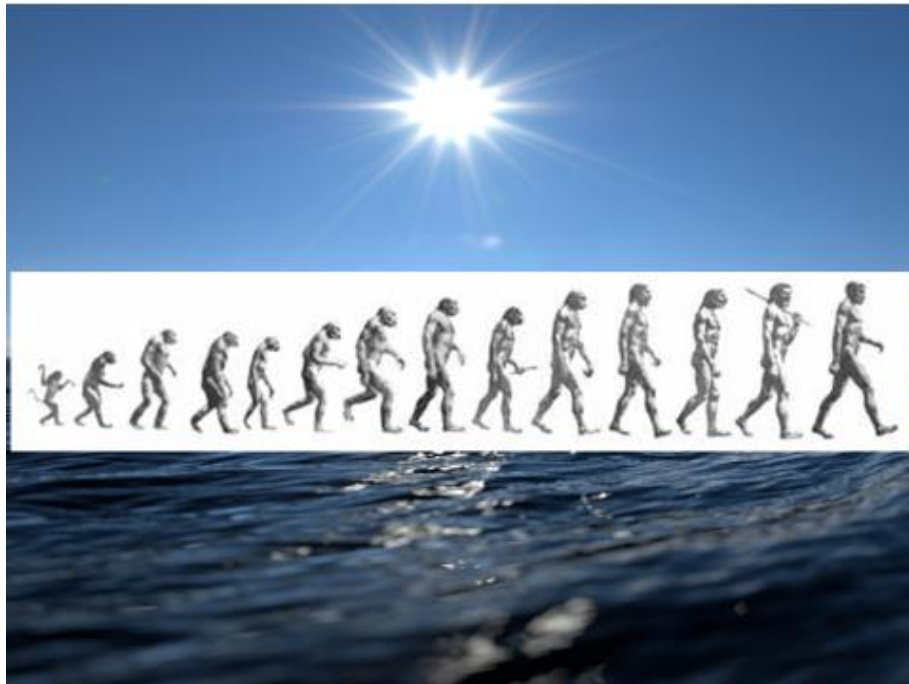
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## “La vita è baccalà”

### Fisheries and Aquaculture: A Way of Life or a Science?

#### The Origins of Fishing and Fish Farming

Fishing is an ancient practice possibly dating back to the ages before our own species *Homo sapiens sapiens* even appeared on the global scene to the time of *Homo habilis* 1 900 000 to 800 000 years ago. To put this timeline in perspective *Homo sapiens* appeared 200 000 years ago and by this time we had started to wear cloths, moved away from home, that is out of Africa and further afield. Fishing was certainly quite well advanced 40 000 years ago but agriculture didn't start until 20 000 years later and by that time trade in fish had certainly been established. However, there were still some very interesting beasts around during this period like woolly rhinos, mammoths and sabre toothed cats. In addition, a lot of climate change was still to be experienced. Fishing techniques were very simple to begin with, hand gathering, spearing, possibly angling, and netting and trapping came later<sup>1</sup>.



Fishing then developed steadily through the ages and became basically an important part of most ancient societies and is accredited in China to folklore hero Fu Xi<sup>2</sup>, Europe has its own champion in the Greco-Roman God Neptune with his fishing trident and, as everybody knows, fish and fishermen have their important place in the Bible.

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<sup>1</sup> Pitcher, T.J. & Lam, M.E. 2015. Fish commoditization and the historical origins of catching fish for profit. *Maritime Studies*, 14(2): doi:10.1186/s40152-014-0014-5 [online]: [Cited 14 January 2016].  
[www.maritimestudiesjournal.com/content/14/1/2](http://www.maritimestudiesjournal.com/content/14/1/2)

<sup>2</sup> Wikipedia, the Free Encyclopedia



It is also clear that trade in general developed early and to a large extent around fishing and the trade in fish was also often linked to and related to the trade in salt<sup>3</sup>. This is not surprising since when permanent settlements started to appear fishing communities were perhaps less self-sufficient than others for many items and therefore needed to trade more than others. This is not at all at odds with their still hunter-gatherer nature since they are known to trade extensively with outside communities<sup>4</sup>.

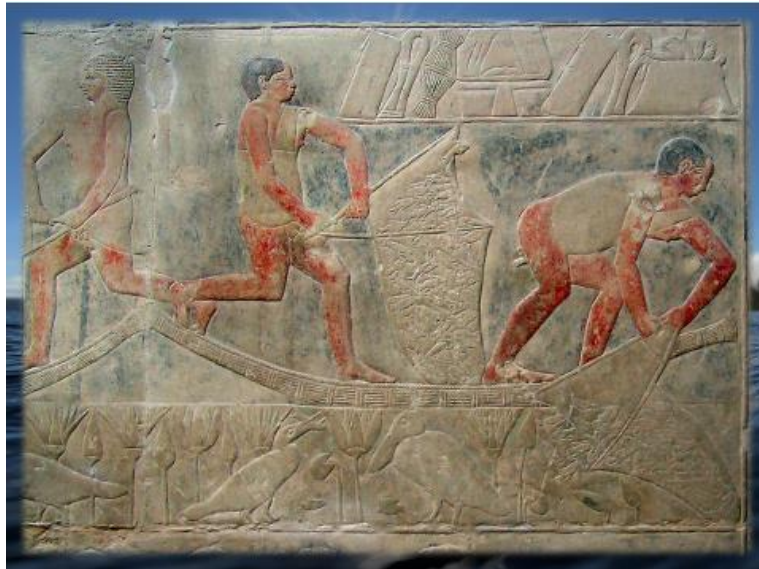


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<sup>3</sup> heritageofjapan.wordpress.com, Amazing Jomon Japan

<sup>4</sup> Encyclopedia.com, SALanoue, 2002

One can say that fishing was an integral part of all the Mediterranean societies and their culture and trade in the period 1 000-500 BC, and later extending further north. Such was the extent of the activities that changes in stock productivity were seen as early as the first century AD and at the beginning of the second millennium AD local sources could not supply growing cities of Europe like London for example<sup>5</sup>. In fact trade in certain products and trade-links in these products that still exist today can be over a thousand years old as is the case in the trade between the Nordic Countries and Italy in dried cod, the stock-fish<sup>6</sup>.



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<sup>5</sup> Pitcher, T.J. & Lam, M.E. 2015. Fish commoditization and the historical origins of catching fish for profit. *Maritime Studies*, 14(2): doi:10.1186/s40152-014-0014-5 [online]: [Cited 14 January 2016].

[www.maritimestudiesjournal.com/content/14/1/2](http://www.maritimestudiesjournal.com/content/14/1/2)

<sup>6</sup> Wikipedia, the Free Encyclopedia

Aquaculture is much younger than capture fisheries and much younger than agriculture. The cradle is undoubtedly in China and in the second millennium BCE even though eels may have been raised as early as 6 000 BCE in Australia. Farming is thought to have started when fish, probably the common carp ended up accidentally in flooded rice paddies after bad weather. A fortunate genetic mutation later during the Tang dynasty led to the emergence of gold fish. However, aquaculture was known in various areas of the world such as Japan and Hawaii, and the Romans also bred fish in ponds. This tradition migrated to monasteries in central Europe which in that way kept themselves stocked with fish, kept alive in ponds, in spite of the long distance from the ocean. Aquaculture as we know it today has however evolved from the late 19<sup>th</sup> century, but the production levels we know today only started appearing after 1950. In spite of great production strides in salmonids in western countries China is the by far the greatest aquaculture producer in a global aquaculture production which now totals half the fish supplied for human consumption.<sup>789</sup>



## A way of life or a science?

There are interesting questions that arise when considering the history and development of fisheries and aquaculture through the ages. When did this activity change from a way of life to the science based industry we know today or indeed has that change happened or to what extent has that change taken place today?

<sup>7</sup> FAO. 2015. *Food Outlook: biannual report on global food markets, October 2015*. Rome. 131 pp. (also available at [www.fao.org/fileadmin/user\\_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf)).

<sup>8</sup> Rabanal, H.R. 1988. *History of aquaculture*. Manila, FAO. (also available at [www.fao.org/3/contents/0edbf87f-b553-5e23-9645-9913009b964c/ag158e00.htm](http://www.fao.org/3/contents/0edbf87f-b553-5e23-9645-9913009b964c/ag158e00.htm)).

<sup>9</sup> Wikipedia, the Free Encyclopedia

What do I mean by a way of life and what do I mean by science? I must admit that I don't use these terms in a very precise way but I ask for your indulgence.

A way of life is the manner in which a person lives<sup>10</sup>. In my considerations of fisheries and aquaculture it is a life which is forced upon one due to circumstances largely beyond ones control, in fact a life without choices or careers at such. The surroundings dictate more or less, what you have to do, possibly generation after generation. There may be some variety or choice but the main path and purpose is clear and simple. In our case, fisheries and later aquaculture. This is not at all the same situation as many modern people find themselves in when they have a choice of careers and lifestyles that has in it, in many cases a life stance<sup>11</sup> position based on ideological or religious positions.

What do I mean by science? Here again I am a little confused since I am talking both in the older sense about the body of knowledge and about the more recent sense of the scientific process or scientific method<sup>12</sup>. I believe that it is necessary to think about it in this way since we span quite a long period in my discussion. It is also interesting, perhaps inevitable, when pondering the question "Fisheries and Aquaculture: A Way of Life or a Science?", to pay particular attention to mathematics and how they have influenced and shaped the developments of fisheries and aquaculture over time and their present situation.

A great respect for mathematics and its importance was instilled in me from a very early age. This respect was so strong that I studied as much mathematics at school as possible without eventually studying at university anything that required a strong mathematical background and opted instead for veterinary medicine. The story goes that my great-great-great-great grandmother who was widowed in the late eighteenth century, taught her second and much younger husband to read, write and calculate. Together they subsequently became successful entrepreneurs in fishing and all things linked to fishing and trade in fish. This included re-establishing shipbuilding in Iceland, including the use of decked vessels and operating a trading fleet of their own. In general they transformed the industry in the country at the time. He, a sign of that era, was eventually knighted for various services to his king and country especially during the Napoleonic wars and is considered the Father of my home town of Hafnarfjörður in Iceland<sup>13</sup>. Such is the power of education and arithmetic.

## Observations and Using Numbers

In the beginning, all fishermen were in my belief fishermen as a way of life. It probably doesn't take fantastic deduction skills to come to that conclusion. Utilizing nature however is not an easy thing; it is in fact a very tricky thing. This, the first settler in Iceland a Norwegian called Hrafna-Flóki, found out when during his first winter in Iceland all his stock starved since he had not taken care to harvest during the summer to have fodder to last through the winter and maintain his stock on. He thus found himself early in the spring devoid of food, perched high on a mountain watching and waiting for the ice-floats to move out of the firths so he could sail straight back to Norway. However, whilst waiting for the ice to clear he gave the country its name, Iceland, which stuck. At least that is what our history tradition tells us<sup>14</sup>.

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<sup>10</sup> Cambridge Dictionaries Online, Cambridge University Press 2016

<sup>11</sup> Wikipedia, the Free Encyclopedia

<sup>12</sup> Wikipedia, the Free Encyclopedia

<sup>13</sup> Saga verslunar og kaupmennsku í Hafnarfirð by Lúðvík Geirsson

<sup>14</sup> Landnámabók manuscript

Utilizing nature takes a lot of deduction power. Repeated observations, trial and error, getting results, repeating your actions, refining your actions. Accumulating and recording knowledge to use it again and survive. Rudimentary numeracy must have been involved. Particularly when trading started, approximates will not have been enough. I feel sure that precision must have been demanded quite early in trade between communities, which was in fact an interaction between strangers.

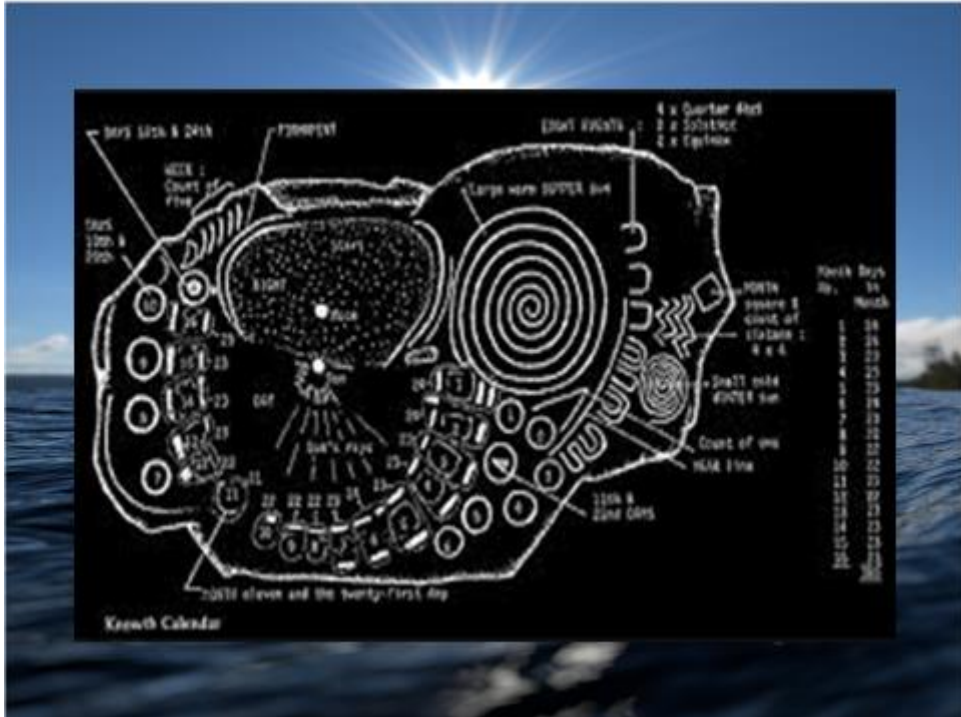


For the information observed and collected to be used appropriately, events needed to be recorded against time in one way or another. How to create a calendar and use it to register an early type of an almanac with experienced and expected events must have been something that was developed early on. The very word al-manakh is even hypothesized as being Arabic and meaning climate<sup>15</sup>. To read the calendar and the almanac therefore required the understanding of figures and mathematics. The oldest calendar is in fact thought to be an 8000 years old lunar calendar in Aberdeen shire in Scotland<sup>16</sup>. Modular arithmetic, right?

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<sup>15</sup> Wikipedia, the Free Encyclppedia

<sup>16</sup> Gaffney, V. *et al.* 2013. Time and a place: a luni-solar 'time-reckoner' from 8th millennium BC Scotland. *Internet Archaeology*, 34 [online]. [Cited 14 January 2016]. <http://dx.doi.org/10.11141/ia.34.1>



Knowing how many fish constituted a good fishing and where and when it was to be had was the insurance for continued existence for fishermen more so than for others. In addition, how much it was worth in bartering, was very important information.



## Going Beyond the Shore-Line

I do not know much about boat building but I am sure that however simple the craft is you want to build you will need to do some measurements. Simple arithmetic will help you along. However, by the time you reach the size of a modern trawler you will need the help of a few centuries of thinkers and engineers.



I don't know much about navigation either but when the vessels were big enough to take you across to the Grand Banks, and I am certain that happened long before Columbus ventured across the pond further south, you needed a compass and a sextant. In addition you needed charts with longitudes and latitudes not only to sail by but also to find the right spot again where you caught all that big cod last season. That is in fact what made your success, to find the right spot repeatedly or to deduce where the cod would go next if circumstances changed. The Vikings did not have this kind of sailing equipment during their time and they therefore were a bit hit and miss in their voyages.



## Approaching Our Times.

As we approach our times our technologies and our mathematics make us more and more efficient in utilizing the fisheries resources. In addition to collecting information about behavior, patterns, places, connections, we come closer and closer to actually seeing the fish. First through sonar and later underwater cameras. There is no end in sight to the physics and the mathematics involved in this and it involves both capture fisheries and aquaculture.

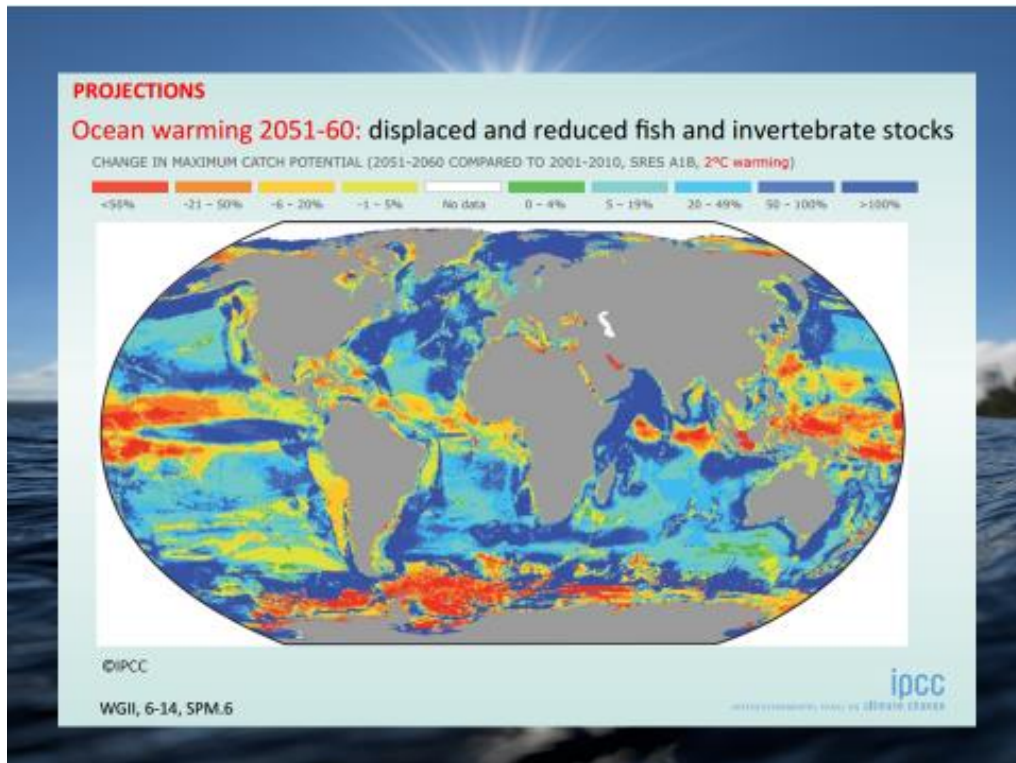
Horsepowers play an enormous role in this since, as we know water is heavy in spite of displacement. We then find ourselves in the situation where our stocks are mostly either fully exploited or overexploited. This calls for very careful management based on the best available science regarding stock size and developments. Fantastic advances have been made in population biology and for a large part of the global fisheries; we now have the biological, mathematical and management tools to handle the situation. Stock assessment involves the use of various biological parameters (growth, maturity, fecundity etc.), fishery data (catch, fishing effort, gear selectivity etc.) and mathematical calculations. To make quantitative assessments about the past and current status of a fish stock, answer questions about the size and productivity of the stock, and make predictions about how a fishery will respond to current and future management measures<sup>17</sup>. A wide range of models can be used for the mathematical calculations and the selection of a specific model depends on the data available, the characteristics of the fishery and the questions to be answered<sup>18</sup>. Modern stock assessment has evolved greatly to multispecies assessments, which consider interactions between targeted and associated species and between different gears and fisheries, and to including social and economic aspects because fishery management decisions are often made on social and economic grounds.

However, these fantastic advances have not reached all and we need to improve particularly in data poor fisheries in the developing world, the so called small scale fisheries which are not so small scale since the bulk of those involved in fisheries in the world are involved in this type of fisheries. In this, we will need some pretty good mathematics.

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<sup>17</sup> Hilborn, R. & Walters, C. 1992. *Quantitative fisheries stock assessment: choice, dynamics & uncertainty*. New York, USA, Chapman & Hall.

<sup>18</sup> Quinn II, T.J. & Deriso, R.B. 1999. *Quantitative fish dynamics*. New York, USA, Oxford University Press.



However, where are the highest-level mathematics being used in regards to fisheries today? The figure above shows a prediction of how the distribution of fish stocks will change with increased ocean temperature (IPCC). I am not a very well qualified person to explain how they were mathematically derived at but I am trying to help people prepare and to respond to these predictions and therefore appreciate very much being able to have this information even though I know they are predictions and can be inaccurate.

## The Present Situation of Fisheries and Aquaculture.

Fish has, as we have seen above, since time immemorial been an important local source of food and nutrition. New technologies and increased affluence have over time made fishing and trading in fish more attractive in terms of employment and investment. Additionally, the positive health effects recognized from consuming fish<sup>19</sup> have led to a demand that makes fish today the world's most traded international food commodity. The developing world counts for more than half of the trade, with the net trading value now higher than that of all other food commodities combined<sup>20</sup>. Almost one billion people or 12% of the global population depend on fish for their livelihoods and the world population depends on fish for 15-25% of its animal protein intake<sup>21</sup>. As mentioned before, half coming now from aquaculture. However, the

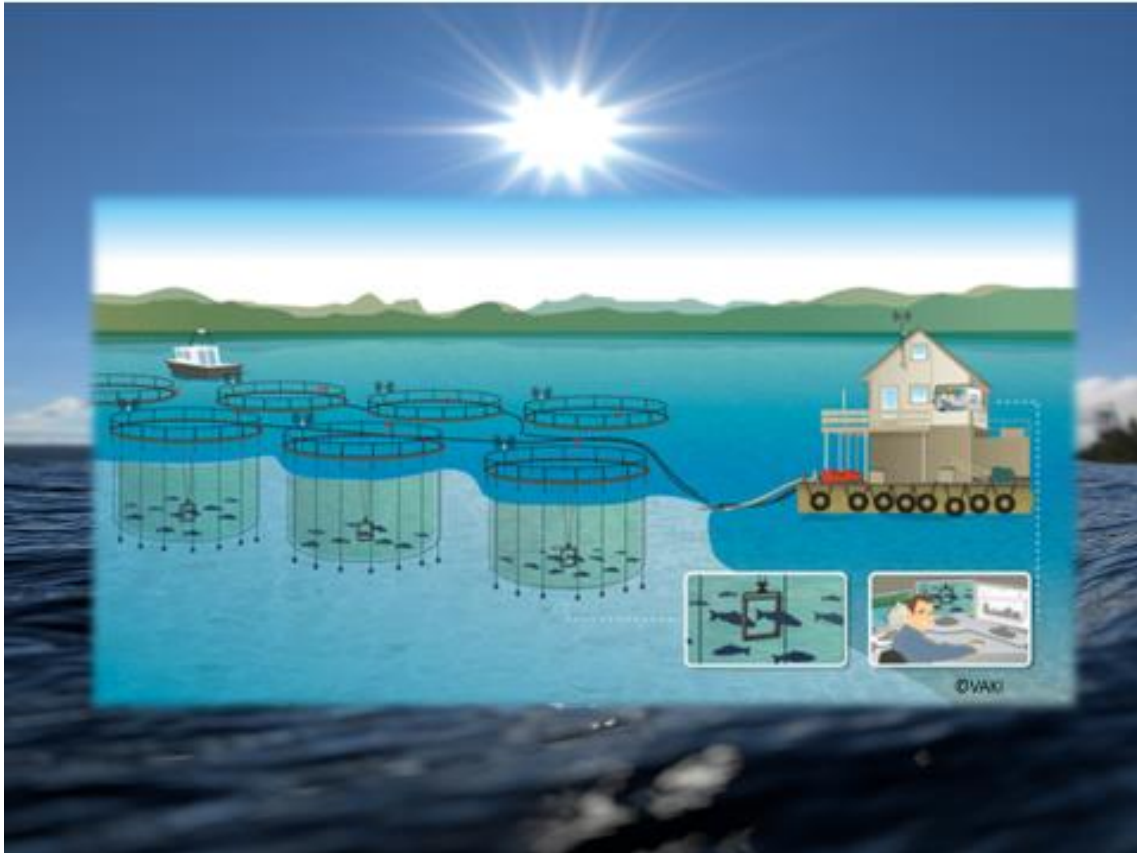
<sup>19</sup> FAO/WHO. 2011. *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption*. FAO Fisheries and Aquaculture Report No. 978. Rome, FAO. 50 pp. (also available at [www.fao.org/docrep/014/ba0136e/ba0136e00.pdf](http://www.fao.org/docrep/014/ba0136e/ba0136e00.pdf)).

<sup>20</sup> FAO. 2015. FAOSTAT, Trade domain. In: *FAO Statistics Division* [online]. Rome. [Cited 14 January 2016]. <http://faostat3.fao.org/download/T/TP/E>

FAO. 2015. *Food Outlook: biannual report on global food markets, October 2015*. Rome. 131 pp. (also available at [www.fao.org/fileadmin/user\\_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf)).

<sup>21</sup> FAO. 2014. *The State of World Fisheries and Aquaculture 2014*. Rome. 223 pp. (also available at: [www.fao.org/3/a-i3720e/index.html](http://www.fao.org/3/a-i3720e/index.html)).

resulting competition has led to over-capacity to fish and to over-fished stocks. Presently 61% of the world stocks are fully fished and about 10% under-fished.



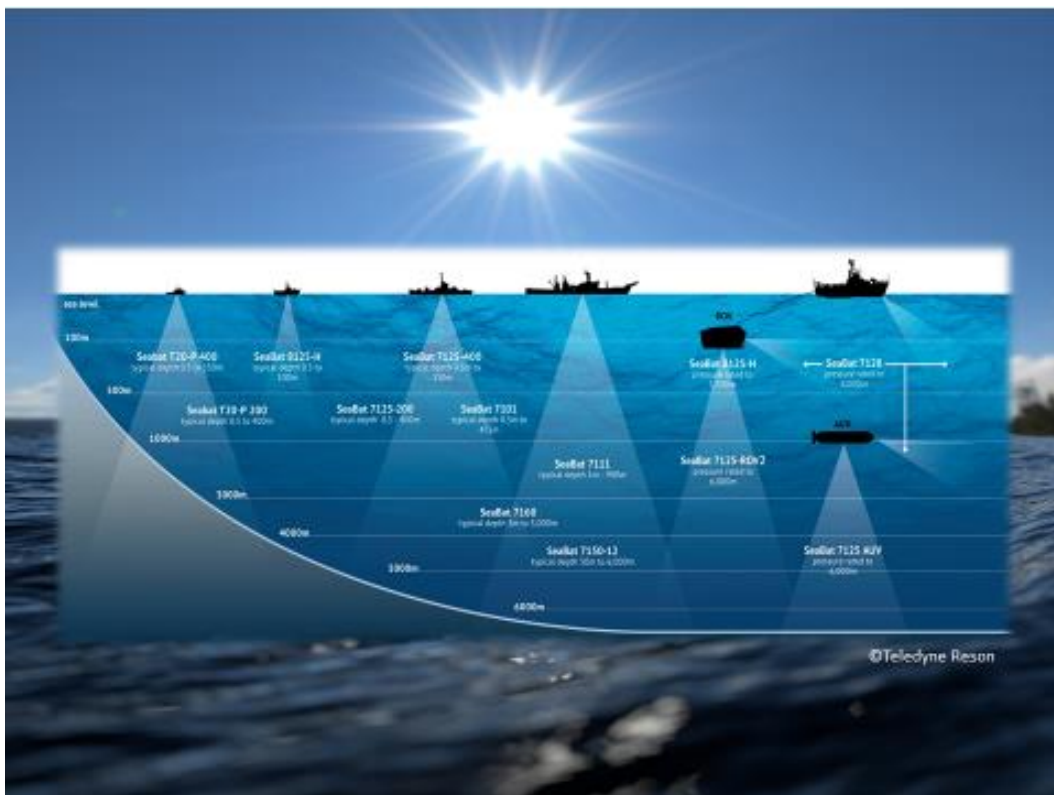
Unfortunately, about 29% are overfished<sup>22</sup> in spite of the international commitment from Johannesburg in 2002 to restore them to sustainable levels by 2015. In fact, the proportion of overfished stocks has increased since then. This is the crux of the problem and we need to do something about it.

Traditionally, fisheries were open to all. However, increased capacity and catches required a new type of governance, fisheries governance calling for restrictions on catches and fishing activities. Typically, decisions like this are controversial, unpopular and difficult to make and therefore, often neither easy to enforce nor successful since they affect people's livelihoods as well as the wellbeing of the communities concerned. Hence, we find ourselves in the present situation regardless of commitments. Fortunately, all is not lost and we can do much to improve the stocks. Some governance and management structures have nevertheless been successful. These systems are characterized by two main elements: reliance on sound information and science as well as an understanding by businesses and communities that their future prosperity depends on the sustainability of the fish stocks. In the developed world this has often happened through rights-based systems of various kinds. Some, but not all, have even been characterized by tradable rights, and as controversial as they may be for their effects on communities, have probably been the most economically successful.

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<sup>22</sup> FAO. 2014. *The State of World Fisheries and Aquaculture 2014*. Rome. 223 pp. (also available at: [www.fao.org/3/a-i3720e/index.html](http://www.fao.org/3/a-i3720e/index.html)).

In the developing world the challenges can be quite different, especially where fishing communities are amongst the poorest. In these cases fishing rights, including community rights, can also be useful and even required from another point of view, namely to secure traditional livelihoods and incomes under perilous conditions of population migration to the coast from inland, drawn by the open-access fishery. Long-distance fleets encroaching on the fishery from the ocean side, often illegally, can also be a threat. With over two-thirds of the global catch and over 95% of the global fisheries workforce coming from the developing world and over 90% of that workforce working in small-scale fisheries. How to develop fair, tenure-secure, sustainable and economic fisheries management systems in this part of the sector becomes the greatest challenge the industry faces.



These challenges are not easily met. However, we have already taken many important steps in that direction. The FAO Code of Conduct for Responsible Fisheries, the Ecosystem Approach to Fisheries and most recently, the CFS Voluntary Guidelines for Tenure in Land, Fisheries and Forests, as well as the FAO Blue Growth Initiative, all laid a very important foundation for the Small-Scale Fisheries Guidelines. Now all this and more needs to be put into practice, employing the practical experience we have gained on how to improve science and link decision-making to the sustainable interests of industry and communities. This we all need to do together: fishermen, communities, the industry along the whole value chain, governments, regional and international organizations, as well as civil society. We need to set aside our prejudice, remove our blinkers and avoid fighting yesterday's battles today. We need to examine what we have done well and what mistakes we need to avoid repeating when designing

the future solutions to our challenges. If we are successful, many of the difficulties we now face in by-catch, illegal fishing, certification criteria, etc. will be reduced and even cease to exist. Above all, however, we must let the countries and the communities concerned lead and make the decisions. For it is their future that is at stake.

This is why we are reaching out for increased cooperation and partnerships. The goal is sustainability of all fish stocks through science, (based on mathematics), fair, tenure-secure and economic management systems. At stake are the fish stocks themselves and the livelihoods of communities. The prize, if we succeed, could be a sustainable increase in global fisheries' net income of USD 50 billion annually as suggested in *The Sunken Billions*, the FAO/world Bank study<sup>23</sup>. That would be the single largest contribution to poverty alleviation we have seen in a long time.

### **A Way of Life or a Science?**

The original question was: Is fisheries and aquaculture a way of life or a science? Before we answer that question let's examine the information I mentioned above that over two thirds of the world catch is caught by the developing countries and almost a third is caught by the developed countries<sup>24</sup>. The third caught by the developed countries is caught by 5% of those involved in fisheries in the world. They use the highest technology available, are highly trained, highly skilled and highly professional in a western scientific sense. They are sought after and therefore have career choices. The developing countries two-thirds are caught by the other 95% of fishermen. The bulk of these 95% are small scale fishermen which are often the poorest of the poor in their own countries<sup>25</sup>. They in general don't have a choice. Being a fisherman is their way of life, the only one they have, the only one they know, the only one they are likely to get and they in fact need support to protect it. This is why working directly with these communities is so important.

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<sup>23</sup> World Bank & FAO. 2009. *The sunken billions: the economic justification for fisheries reform*. Washington, DC, The World Bank, and Rome, FAO. 100 pp.

<sup>24</sup> World Bank. 2012. *Hidden harvest: the global contribution of capture fisheries*. Washington, DC. 69 pp. (also available at <https://openknowledge.worldbank.org/handle/10986/11873>)

<sup>25</sup> World Bank. 2012. *Hidden harvest: the global contribution of capture fisheries*. Washington, DC. 69 pp. (also available at <https://openknowledge.worldbank.org/handle/10986/11873>)



## Conclusion

I come from Iceland where fisheries through the ages were so dominant that they say “lífið er saltfiskur” (Icelandic) or “la vita è baccalà” (Italian) or in English “life is salted cod”<sup>26</sup>. My own background is very much in that direction. One of my ancestors was a Governor of Iceland during the reign of the Kalmar Union. When he sailed from my home town Hafnarfjörður, in the early 15<sup>th</sup> century into a self-imposed exile in England, after having probably been involved in fisheries disputes between the English and the Hanseatic League, he had a King’s ransom worth of stock-fish on aboard his ship<sup>27</sup>. Another ancestor, mentioned earlier, owned, built and operated the first decked schooners in Iceland virtually starting the Industrial revolution in the country during the Napoleonic era.<sup>28</sup> Later my great grand- father bought and operated the first Icelandic trawler 111 years ago<sup>29</sup>. In spite of this background, it did not occur to me at all when I was deciding what to study at university to study anything remotely related to fisheries. It was my love of horses that drew me to veterinary medicine. However, during the time of my studies I acquired an interest in aquaculture and the last thing I did before leaving Scotland after graduation was to apply for a Masters course a year later in fish pathology.

After that I went and worked on fish diseases and aquaculture during a very active aquaculture period in Iceland. That type of industry development work drew me in to politics and I was elected to the Icelandic parliament. However, 8 years later when I joined the Cabinet, I joined as the Minister of Fisheries. Leaving the Cabinet and politics ten years later I went back into

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<sup>26</sup> Salka Valka by Halldór Kiljan Laxnes

<sup>27</sup> Öldin fimmtánda by Óskar Guðmundsson

<sup>28</sup> Saga verslunar og kaupmennsku í Hafnarfirð by Lúðvík Geirsson

<sup>29</sup> Hafnarfjarðarjarlinn: Einars saga Þorgilssonar by Ásgeir Jakobsson, 1987

practicing veterinary medicine. That did not last long since by 2010 I was in Rome and again in charge of both fisheries and aquaculture. Now at FAO.

This tells me that fish, fisheries, aquaculture and the Oceans in general have an enormous draw. A magic draw similar to Schiller's Lorelei but hopefully more constructive. Many of my compatriots feel this as well and I think you can even sense this in the national psyche. If you talk about fisheries everybody is an expert, everybody has an opinion and no wonder half of our external earnings come from fish. In Iceland the technology is all there, the science is all there and the mathematics are all there contrary to how it is in many of the communities that rely on fisheries and aquaculture for their subsistence. However, in spite of the mathematics and the science as well as all the modern career choices the country has to offer, in Iceland fisheries is whether we like it or not the same as in these small communities in the developing countries, still a way of life. Fisheries are in our blood.

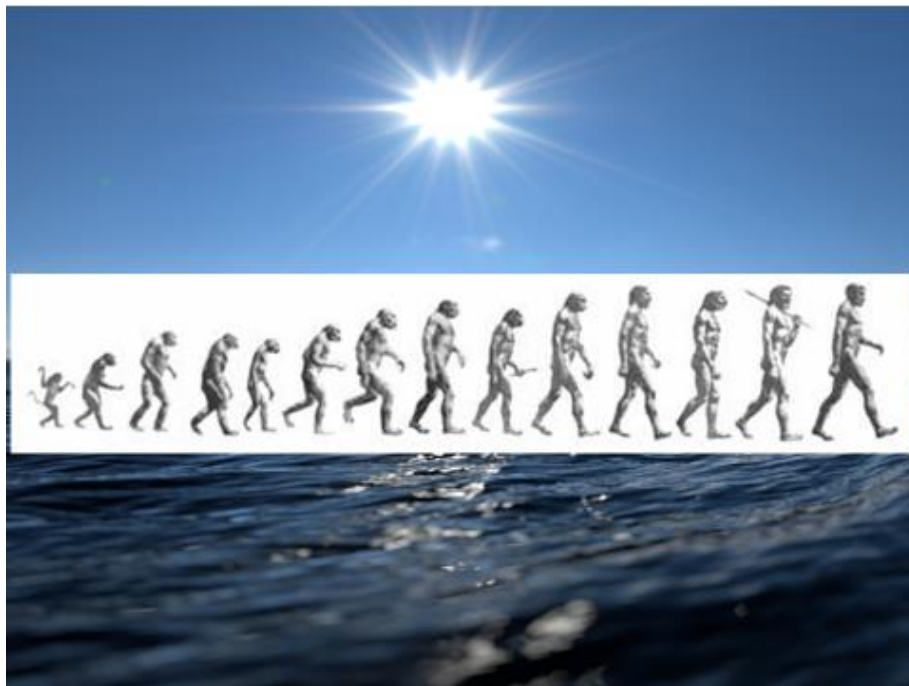


## “La vita è baccalà”

### Fisheries and Aquaculture: A Way of Life or a Science?

#### The Origins of Fishing and Fish Farming

Fishing is an ancient practice possibly dating back to the ages before our own species *Homo sapiens sapiens* even appeared on the global scene to the time of *Homo habilis* 1 900 000 to 800 000 years ago. To put this timeline in perspective *Homo sapiens* appeared 200 000 years ago and by this time we had started to wear cloths, moved away from home, that is out of Africa and further afield. Fishing was certainly quite well advanced 40 000 years ago but agriculture didn't start until 20 000 years later and by that time trade in fish had certainly been established. However, there were still some very interesting beasts around during this period like woolly rhinos, mammoths and sabre toothed cats. In addition, a lot of climate change was still to be experienced. Fishing techniques were very simple to begin with, hand gathering, spearing, possibly angling, and netting and trapping came later<sup>1</sup>.



Fishing then developed steadily through the ages and became basically an important part of most ancient societies and is accredited in China to folklore hero Fu Xi<sup>2</sup>, Europe has its own champion in the Greco-Roman God Neptune with his fishing trident and, as everybody knows, fish and fishermen have their important place in the Bible.

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<sup>1</sup> Pitcher, T.J. & Lam, M.E. 2015. Fish commoditization and the historical origins of catching fish for profit. *Maritime Studies*, 14(2): doi:10.1186/s40152-014-0014-5 [online]: [Cited 14 January 2016]. [www.maritimestudiesjournal.com/content/14/1/2](http://www.maritimestudiesjournal.com/content/14/1/2)

<sup>2</sup> Wikipedia, the Free Encyclopedia



It is also clear that trade in general developed early and to a large extent around fishing and the trade in fish was also often linked to and related to the trade in salt<sup>3</sup>. This is not surprising since when permanent settlements started to appear fishing communities were perhaps less self-sufficient than others for many items and therefore needed to trade more than others. This is not at all at odds with their still hunter-gatherer nature since they are known to trade extensively with outside communities<sup>4</sup>.

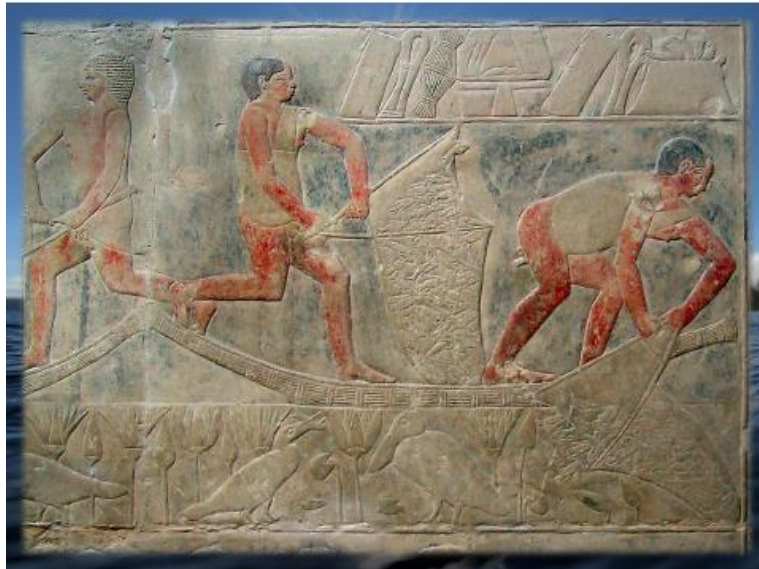


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<sup>3</sup> heritageofjapan.wordpress.com, Amazing Jomon Japan

<sup>4</sup> Encyclopedia.com, SALanoue, 2002

One can say that fishing was an integral part of all the Mediterranean societies and their culture and trade in the period 1 000-500 BC, and later extending further north. Such was the extent of the activities that changes in stock productivity were seen as early as the first century AD and at the beginning of the second millennium AD local sources could not supply growing cities of Europe like London for example<sup>5</sup>. In fact trade in certain products and trade-links in these products that still exist today can be over a thousand years old as is the case in the trade between the Nordic Countries and Italy in dried cod, the stock-fish<sup>6</sup>.



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<sup>5</sup> Pitcher, T.J. & Lam, M.E. 2015. Fish commoditization and the historical origins of catching fish for profit. *Maritime Studies*, 14(2): doi:10.1186/s40152-014-0014-5 [online]: [Cited 14 January 2016]. [www.maritimestudiesjournal.com/content/14/1/2](http://www.maritimestudiesjournal.com/content/14/1/2)

<sup>6</sup> Wikipedia, the Free Encyclopedia

Aquaculture is much younger than capture fisheries and much younger than agriculture. The cradle is undoubtedly in China and in the second millennium BCE even though eels may have been raised as early as 6 000 BCE in Australia. Farming is thought to have started when fish, probably the common carp ended up accidentally in flooded rice paddies after bad weather. A fortunate genetic mutation later during the Tang dynasty led to the emergence of gold fish. However, aquaculture was known in various areas of the world such as Japan and Hawaii, and the Romans also bred fish in ponds. This tradition migrated to monasteries in central Europe which in that way kept themselves stocked with fish, kept alive in ponds, in spite of the long distance from the ocean. Aquaculture as we know it today has however evolved from the late 19<sup>th</sup> century, but the production levels we know today only started appearing after 1950. In spite of great production strides in salmonids in western countries China is the by far the greatest aquaculture producer in a global aquaculture production which now totals half the fish supplied for human consumption.<sup>789</sup>



## A way of life or a science?

There are interesting questions that arise when considering the history and development of fisheries and aquaculture through the ages. When did this activity change from a way of life to the science based industry we know today or indeed has that change happened or to what extent has that change taken place today?

<sup>7</sup> FAO. 2015. *Food Outlook: biannual report on global food markets, October 2015*. Rome. 131 pp. (also available at [www.fao.org/fileadmin/user\\_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf)).

<sup>8</sup> Rabanal, H.R. 1988. *History of aquaculture*. Manila, FAO. (also available at [www.fao.org/3/contents/0edbf87f-b553-5e23-9645-9913009b964c/ag158e00.htm](http://www.fao.org/3/contents/0edbf87f-b553-5e23-9645-9913009b964c/ag158e00.htm)).

<sup>9</sup> Wikipedia, the Free Encyclopedia

What do I mean by a way of life and what do I mean by science? I must admit that I don't use these terms in a very precise way but I ask for your indulgence.

A way of life is the manner in which a person lives<sup>10</sup>. In my considerations of fisheries and aquaculture it is a life which is forced upon one due to circumstances largely beyond ones control, in fact a life without choices or careers at such. The surroundings dictate more or less, what you have to do, possibly generation after generation. There may be some variety or choice but the main path and purpose is clear and simple. In our case, fisheries and later aquaculture. This is not at all the same situation as many modern people find themselves in when they have a choice of careers and lifestyles that has in it, in many cases a life stance<sup>11</sup> position based on ideological or religious positions.

What do I mean by science? Here again I am a little confused since I am talking both in the older sense about the body of knowledge and about the more recent sense of the scientific process or scientific method<sup>12</sup>. I believe that it is necessary to think about it in this way since we span quite a long period in my discussion. It is also interesting, perhaps inevitable, when pondering the question "Fisheries and Aquaculture: A Way of Life or a Science?", to pay particular attention to mathematics and how they have influenced and shaped the developments of fisheries and aquaculture over time and their present situation.

A great respect for mathematics and its importance was instilled in me from a very early age. This respect was so strong that I studied as much mathematics at school as possible without eventually studying at university anything that required a strong mathematical background and opted instead for veterinary medicine. The story goes that my great-great-great-great grandmother who was widowed in the late eighteenth century, taught her second and much younger husband to read, write and calculate. Together they subsequently became successful entrepreneurs in fishing and all things linked to fishing and trade in fish. This included re-establishing shipbuilding in Iceland, including the use of decked vessels and operating a trading fleet of their own. In general they transformed the industry in the country at the time. He, a sign of that era, was eventually knighted for various services to his king and country especially during the Napoleonic wars and is considered the Father of my home town of Hafnarfjörður in Iceland<sup>13</sup>. Such is the power of education and arithmetic.

## Observations and Using Numbers

In the beginning, all fishermen were in my belief fishermen as a way of life. It probably doesn't take fantastic deduction skills to come to that conclusion. Utilizing nature however is not an easy thing; it is in fact a very tricky thing. This, the first settler in Iceland a Norwegian called Hrafna-Flóki, found out when during his first winter in Iceland all his stock starved since he had not taken care to harvest during the summer to have fodder to last through the winter and maintain his stock on. He thus found himself early in the spring devoid of food, perched high on a mountain watching and waiting for the ice-floats to move out of the firths so he could sail straight back to Norway. However, whilst waiting for the ice to clear he gave the country its name, Iceland, which stuck. At least that is what our history tradition tells us<sup>14</sup>.

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<sup>10</sup> Cambridge Dictionaries Online, Cambridge University Press 2016

<sup>11</sup> Wikipedia, the Free Encyclopedia

<sup>12</sup> Wikipedia, the Free Encyclopedia

<sup>13</sup> Saga verslunar og kaupmennsku í Hafnarfirð by Lúðvík Geirsson

<sup>14</sup> Landnámabók manuscript

Utilizing nature takes a lot of deduction power. Repeated observations, trial and error, getting results, repeating your actions, refining your actions. Accumulating and recording knowledge to use it again and survive. Rudimentary numeracy must have been involved. Particularly when trading started, approximates will not have been enough. I feel sure that precision must have been demanded quite early in trade between communities, which was in fact an interaction between strangers.

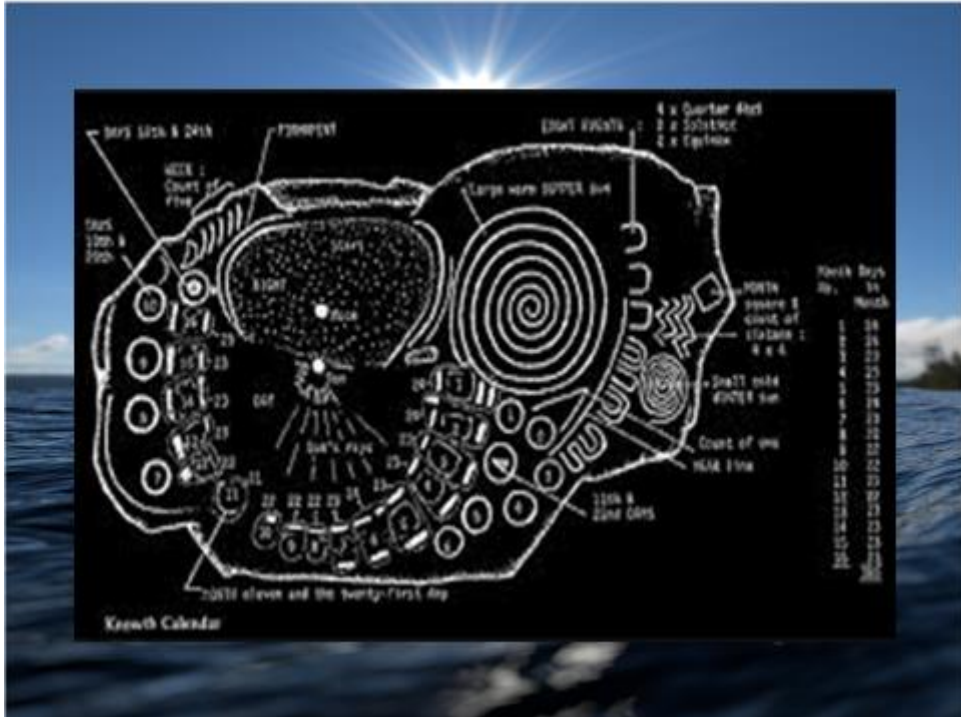


For the information observed and collected to be used appropriately, events needed to be recorded against time in one way or another. How to create a calendar and use it to register an early type of an almanac with experienced and expected events must have been something that was developed early on. The very word al-manakh is even hypothesized as being Arabic and meaning climate<sup>15</sup>. To read the calendar and the almanac therefore required the understanding of figures and mathematics. The oldest calendar is in fact thought to be an 8000 years old lunar calendar in Aberdeen shire in Scotland<sup>16</sup>. Modular arithmetic, right?

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<sup>15</sup> Wikipedia, the Free Encyclppedia

<sup>16</sup> Gaffney, V. *et al.* 2013. Time and a place: a luni-solar 'time-reckoner' from 8th millennium BC Scotland. *Internet Archaeology*, 34 [online]. [Cited 14 January 2016]. <http://dx.doi.org/10.11141/ia.34.1>



Knowing how many fish constituted a good fishing and where and when it was to be had was the insurance for continued existence for fishermen more so than for others. In addition, how much it was worth in bartering, was very important information.



## Going Beyond the Shore-Line

I do not know much about boat building but I am sure that however simple the craft is you want to build you will need to do some measurements. Simple arithmetic will help you along. However, by the time you reach the size of a modern trawler you will need the help of a few centuries of thinkers and engineers.



I don't know much about navigation either but when the vessels were big enough to take you across to the Grand Banks, and I am certain that happened long before Columbus ventured across the pond further south, you needed a compass and a sextant. In addition you needed charts with longitudes and latitudes not only to sail by but also to find the right spot again where you caught all that big cod last season. That is in fact what made your success, to find the right spot repeatedly or to deduce where the cod would go next if circumstances changed. The Vikings did not have this kind of sailing equipment during their time and they therefore were a bit hit and miss in their voyages.



## Approaching Our Times.

As we approach our times our technologies and our mathematics make us more and more efficient in utilizing the fisheries resources. In addition to collecting information about behavior, patterns, places, connections, we come closer and closer to actually seeing the fish. First through sonar and later underwater cameras. There is no end in sight to the physics and the mathematics involved in this and it involves both capture fisheries and aquaculture.

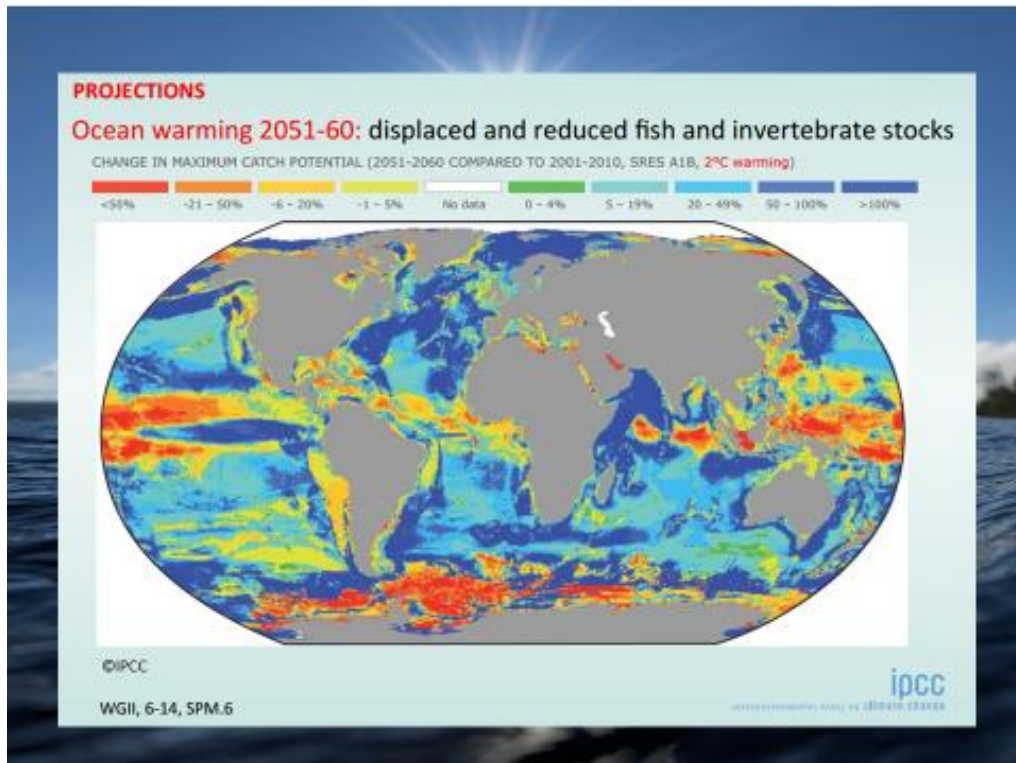
Horsepowers play an enormous role in this since, as we know water is heavy in spite of displacement. We then find ourselves in the situation where our stocks are mostly either fully exploited or overexploited. This calls for very careful management based on the best available science regarding stock size and developments. Fantastic advances have been made in population biology and for a large part of the global fisheries; we now have the biological, mathematical and management tools to handle the situation. Stock assessment involves the use of various biological parameters (growth, maturity, fecundity etc.), fishery data (catch, fishing effort, gear selectivity etc.) and mathematical calculations. To make quantitative assessments about the past and current status of a fish stock, answer questions about the size and productivity of the stock, and make predictions about how a fishery will respond to current and future management measures<sup>17</sup>. A wide range of models can be used for the mathematical calculations and the selection of a specific model depends on the data available, the characteristics of the fishery and the questions to be answered<sup>18</sup>. Modern stock assessment has evolved greatly to multispecies assessments, which consider interactions between targeted and associated species and between different gears and fisheries, and to including social and economic aspects because fishery management decisions are often made on social and economic grounds.

However, these fantastic advances have not reached all and we need to improve particularly in data poor fisheries in the developing world, the so called small scale fisheries which are not so small scale since the bulk of those involved in fisheries in the world are involved in this type of fisheries. In this, we will need some pretty good mathematics.

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<sup>17</sup> Hilborn, R. & Walters, C. 1992. *Quantitative fisheries stock assessment: choice, dynamics & uncertainty*. New York, USA, Chapman & Hall.

<sup>18</sup> Quinn II, T.J. & Deriso, R.B. 1999. *Quantitative fish dynamics*. New York, USA, Oxford University Press.



However, where are the highest-level mathematics being used in regards to fisheries today? The figure above shows a prediction of how the distribution of fish stocks will change with increased ocean temperature (IPCC). I am not a very well qualified person to explain how they were mathematically derived at but I am trying to help people prepare and to respond to these predictions and therefore appreciate very much being able to have this information even though I know they are predictions and can be inaccurate.

## The Present Situation of Fisheries and Aquaculture.

Fish has, as we have seen above, since time immemorial been an important local source of food and nutrition. New technologies and increased affluence have over time made fishing and trading in fish more attractive in terms of employment and investment. Additionally, the positive health effects recognized from consuming fish<sup>19</sup> have led to a demand that makes fish today the world's most traded international food commodity. The developing world counts for more than half of the trade, with the net trading value now higher than that of all other food commodities combined<sup>20</sup>. Almost one billion people or 12% of the global population depend on fish for their livelihoods and the world population depends on fish for 15-25% of its animal protein intake<sup>21</sup>. As mentioned before, half coming now from aquaculture. However, the

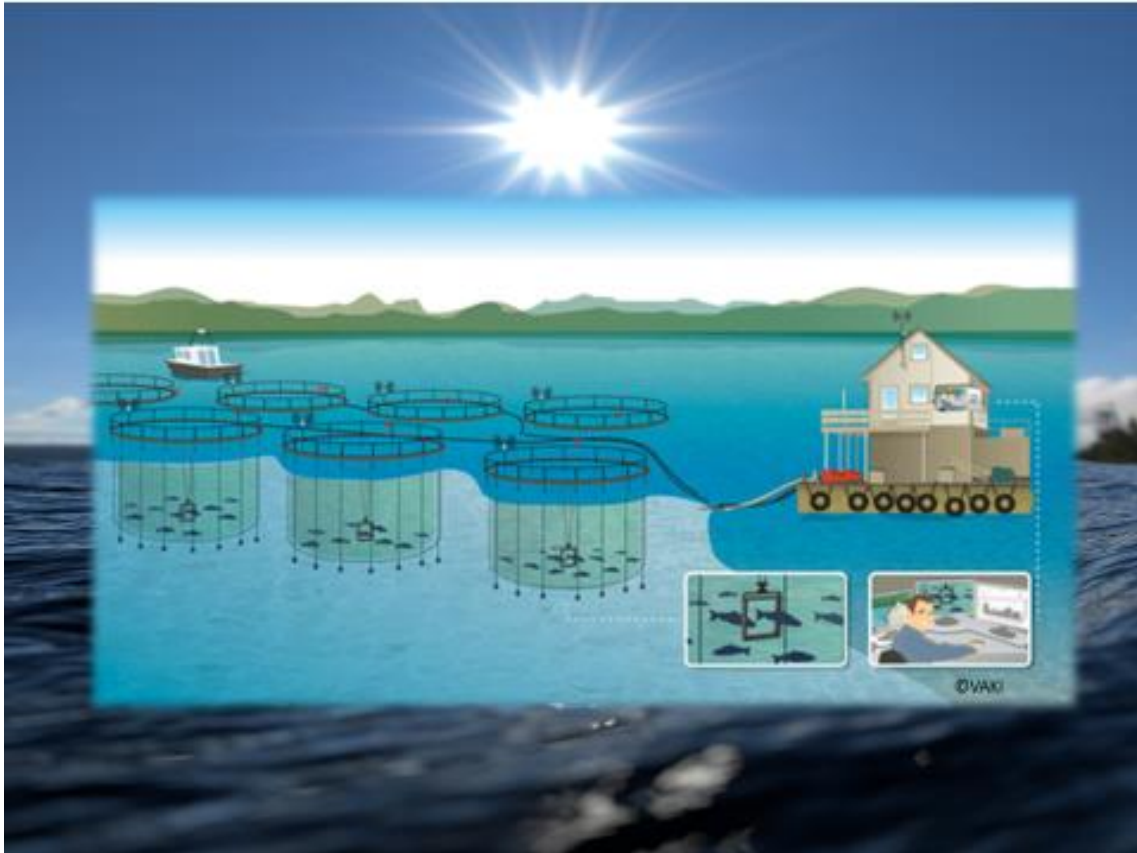
<sup>19</sup> FAO/WHO. 2011. *Report of the Joint FAO/WHO Expert Consultation on the Risks and Benefits of Fish Consumption*. FAO Fisheries and Aquaculture Report No. 978. Rome, FAO. 50 pp. (also available at [www.fao.org/docrep/014/ba0136e/ba0136e00.pdf](http://www.fao.org/docrep/014/ba0136e/ba0136e00.pdf)).

<sup>20</sup> FAO. 2015. FAOSTAT, Trade domain. In: *FAO Statistics Division* [online]. Rome. [Cited 14 January 2016]. <http://faostat3.fao.org/download/T/TP/E>

FAO. 2015. *Food Outlook: biannual report on global food markets, October 2015*. Rome. 131 pp. (also available at [www.fao.org/fileadmin/user\\_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf](http://www.fao.org/fileadmin/user_upload/newsroom/docs/Food%20Outlook%20October%202015.pdf)).

<sup>21</sup> FAO. 2014. *The State of World Fisheries and Aquaculture 2014*. Rome. 223 pp. (also available at: [www.fao.org/3/a-i3720e/index.html](http://www.fao.org/3/a-i3720e/index.html)).

resulting competition has led to over-capacity to fish and to over-fished stocks. Presently 61% of the world stocks are fully fished and about 10% under-fished.



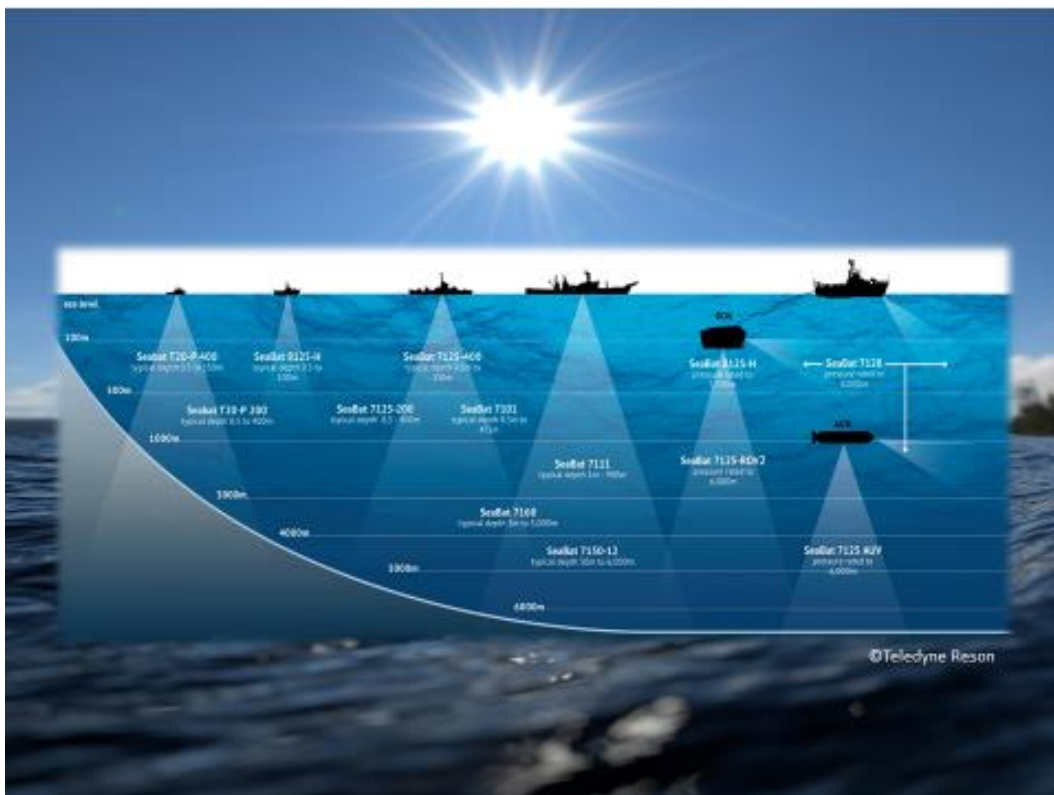
Unfortunately, about 29% are overfished<sup>22</sup> in spite of the international commitment from Johannesburg in 2002 to restore them to sustainable levels by 2015. In fact, the proportion of overfished stocks has increased since then. This is the crux of the problem and we need to do something about it.

Traditionally, fisheries were open to all. However, increased capacity and catches required a new type of governance, fisheries governance calling for restrictions on catches and fishing activities. Typically, decisions like this are controversial, unpopular and difficult to make and therefore, often neither easy to enforce nor successful since they affect people's livelihoods as well as the wellbeing of the communities concerned. Hence, we find ourselves in the present situation regardless of commitments. Fortunately, all is not lost and we can do much to improve the stocks. Some governance and management structures have nevertheless been successful. These systems are characterized by two main elements: reliance on sound information and science as well as an understanding by businesses and communities that their future prosperity depends on the sustainability of the fish stocks. In the developed world this has often happened through rights-based systems of various kinds. Some, but not all, have even been characterized by tradable rights, and as controversial as they may be for their effects on communities, have probably been the most economically successful.

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<sup>22</sup> FAO. 2014. *The State of World Fisheries and Aquaculture 2014*. Rome. 223 pp. (also available at: [www.fao.org/3/a-i3720e/index.html](http://www.fao.org/3/a-i3720e/index.html)).

In the developing world the challenges can be quite different, especially where fishing communities are amongst the poorest. In these cases fishing rights, including community rights, can also be useful and even required from another point of view, namely to secure traditional livelihoods and incomes under perilous conditions of population migration to the coast from inland, drawn by the open-access fishery. Long-distance fleets encroaching on the fishery from the ocean side, often illegally, can also be a threat. With over two-thirds of the global catch and over 95% of the global fisheries workforce coming from the developing world and over 90% of that workforce working in small-scale fisheries. How to develop fair, tenure-secure, sustainable and economic fisheries management systems in this part of the sector becomes the greatest challenge the industry faces.



These challenges are not easily met. However, we have already taken many important steps in that direction. The FAO Code of Conduct for Responsible Fisheries, the Ecosystem Approach to Fisheries and most recently, the CFS Voluntary Guidelines for Tenure in Land, Fisheries and Forests, as well as the FAO Blue Growth Initiative, all laid a very important foundation for the Small-Scale Fisheries Guidelines. Now all this and more needs to be put into practice, employing the practical experience we have gained on how to improve science and link decision-making to the sustainable interests of industry and communities. This we all need to do together: fishermen, communities, the industry along the whole value chain, governments, regional and international organizations, as well as civil society. We need to set aside our prejudice, remove our blinkers and avoid fighting yesterday's battles today. We need to examine what we have done well and what mistakes we need to avoid repeating when designing

the future solutions to our challenges. If we are successful, many of the difficulties we now face in by-catch, illegal fishing, certification criteria, etc. will be reduced and even cease to exist. Above all, however, we must let the countries and the communities concerned lead and make the decisions. For it is their future that is at stake.

This is why we are reaching out for increased cooperation and partnerships. The goal is sustainability of all fish stocks through science, (based on mathematics), fair, tenure-secure and economic management systems. At stake are the fish stocks themselves and the livelihoods of communities. The prize, if we succeed, could be a sustainable increase in global fisheries' net income of USD 50 billion annually as suggested in *The Sunken Billions*, the FAO/world Bank study<sup>23</sup>. That would be the single largest contribution to poverty alleviation we have seen in a long time.

### **A Way of Life or a Science?**

The original question was: Is fisheries and aquaculture a way of life or a science? Before we answer that question let's examine the information I mentioned above that over two thirds of the world catch is caught by the developing countries and almost a third is caught by the developed countries<sup>24</sup>. The third caught by the developed countries is caught by 5% of those involved in fisheries in the world. They use the highest technology available, are highly trained, highly skilled and highly professional in a western scientific sense. They are sought after and therefore have career choices. The developing countries two-thirds are caught by the other 95% of fishermen. The bulk of these 95% are small scale fishermen which are often the poorest of the poor in their own countries<sup>25</sup>. They in general don't have a choice. Being a fisherman is their way of life, the only one they have, the only one they know, the only one they are likely to get and they in fact need support to protect it. This is why working directly with these communities is so important.

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<sup>23</sup> World Bank & FAO. 2009. *The sunken billions: the economic justification for fisheries reform*. Washington, DC, The World Bank, and Rome, FAO. 100 pp.

<sup>24</sup> World Bank. 2012. *Hidden harvest: the global contribution of capture fisheries*. Washington, DC. 69 pp. (also available at <https://openknowledge.worldbank.org/handle/10986/11873>)

<sup>25</sup> World Bank. 2012. *Hidden harvest: the global contribution of capture fisheries*. Washington, DC. 69 pp. (also available at <https://openknowledge.worldbank.org/handle/10986/11873>)



## Conclusion

I come from Iceland where fisheries through the ages were so dominant that they say “lífið er saltfiskur” (Icelandic) or “la vita è baccalà” (Italian) or in English “life is salted cod”<sup>26</sup>. My own background is very much in that direction. One of my ancestors was a Governor of Iceland during the reign of the Kalmar Union. When he sailed from my home town Hafnarfjörður, in the early 15<sup>th</sup> century into a self-imposed exile in England, after having probably been involved in fisheries disputes between the English and the Hanseatic League, he had a King’s ransom worth of stock-fish on aboard his ship<sup>27</sup>. Another ancestor, mentioned earlier, owned, built and operated the first decked schooners in Iceland virtually starting the Industrial revolution in the country during the Napoleonic era.<sup>28</sup> Later my great grand- father bought and operated the first Icelandic trawler 111 years ago<sup>29</sup>. In spite of this background, it did not occur to me at all when I was deciding what to study at university to study anything remotely related to fisheries. It was my love of horses that drew me to veterinary medicine. However, during the time of my studies I acquired an interest in aquaculture and the last thing I did before leaving Scotland after graduation was to apply for a Masters course a year later in fish pathology.

After that I went and worked on fish diseases and aquaculture during a very active aquaculture period in Iceland. That type of industry development work drew me in to politics and I was elected to the Icelandic parliament. However, 8 years later when I joined the Cabinet, I joined as the Minister of Fisheries. Leaving the Cabinet and politics ten years later I went back into

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<sup>26</sup> Salka Valka by Halldór Kiljan Laxnes

<sup>27</sup> Öldin fimmtánda by Óskar Guðmundsson

<sup>28</sup> Saga verslunar og kaupmennsku í Hafnarfirð by Lúðvík Geirsson

<sup>29</sup> Hafnarfjarðarjarlinn: Einars saga Þorgilssonar by Ásgeir Jakobsson, 1987

practicing veterinary medicine. That did not last long since by 2010 I was in Rome and again in charge of both fisheries and aquaculture. Now at FAO.

This tells me that fish, fisheries, aquaculture and the Oceans in general have an enormous draw. A magic draw similar to Schiller's Lorelei but hopefully more constructive. Many of my compatriots feel this as well and I think you can even sense this in the national psyche. If you talk about fisheries everybody is an expert, everybody has an opinion and no wonder half of our external earnings come from fish. In Iceland the technology is all there, the science is all there and the mathematics are all there contrary to how it is in many of the communities that rely on fisheries and aquaculture for their subsistence. However, in spite of the mathematics and the science as well as all the modern career choices the country has to offer, in Iceland fisheries is whether we like it or not the same as in these small communities in the developing countries, still a way of life. Fisheries are in our blood.

