Problem Chosen	2020 MCM/ICM Summary Sheet	Team Control Number
A		2019470

First we note that the most suitable depth and temperature of habitat of the herring and mackerel. And we choose three area in Scotland and we investigate that each area is suitable for the habitat of adult herring and mackerel. Also we make a function which is relation between depth and temperature and apply for three area.

Table of Contents

1. Introduction

Hi, we are members of KW Consultants Company. We want your company to find the best place where you move. Then first of all we have to know where is the best place to grow Scottish herring and mackerel. So we find the life cycle of herring and mackerel. Let's see the life cycle of herring and mackerel. First of all, we want to show the depth of their habitats.

2. The depth of habitat for herring and mackerel

[i]Table 1.Habitat depth for herring

Life Stage	Preferred depth
Eggs	**20 - 50 m, averaging 45 m**
Larvae	**10 - 250 m, averaging 50 - 90 m**
Juveniles	**30-90 m in spring, 15-135 m in summer, 30-60 m in fall and winter**
Adults	**30-50 m in spring, 20-130 m in summer, 60-170 m in fall, and 70-100 m in winter.**
Spawning Adult	

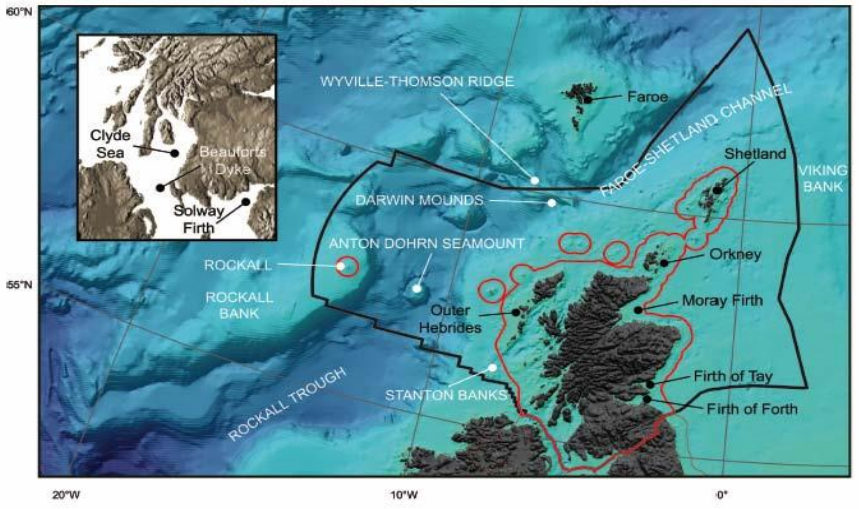
[ii]First, herring eggs were usually spawned on relatively shallow area(averagely depths of 20~50m). And the eggs were laid on gravel, sand, rocks, shell fragments and so on. Second, the larvae most were collected at stations with depths of 50-90m. Finally, catches of adult herring were greatest at 30-50m in spring and 20-130m in summer, and 60-170m in fall, and 70-100m in winter. Then How about mackerel case? We have a table about habitat depth for mackerel.

[iii]Table 2. Habitat depth for mackerel

Life Stage	Preferred depth
Eggs	**10 - 325 m, averaging 30 -70 m**
Larvae	**10-130 m averaging 50 m**
pelagic Juveniles	**30-90 m in spring. 20-50 m in summer. 20-40 m in fall. 50-70 m in winter.**
Adults	**60-170 m in spring. 50-70 m in summer.60-80 m in fall. 20-30 m in winter.**

[iv]First, mackerel eggs were usually spawned on 30-70m. And the larvae were distributed at depths usually at <50m. pelagic juvenile were most abundant at 30-90m in spring and 20-50m in summer, and 20-40 in fall, 50-70m in winter. When they grew up, (i.e., when we can start fishing), they were ~25% at 60-170m in spring, >60% at 50-70m in summer, >50% at 60-80m in fall, ~50% at 20-30m in winter.

Thus we have to note the depth of the herring and mackerel's habitats. It is about 20~200m in a relatively shallow area. And the depths of habitat of adult herring and mackerel which is the most important thing are 50-150m. So we propose three regions in Scottish North Atlantic. Let's see the picture.



- [v]**Figure 1 Scotland's Seas**

The offshore environment in Scottish waters ranges from shelf sea areas which are generally shallower than 250 m (average ~100 m) and deep ocean regions with depths greater than 2,000 m. What do you see in this picture? What do you think is an appropriate three area in this picture? We think they are Shetland, Orkney and Outer Hebrides. They have appropriately shallow area and also deep area. So they are we think the best places to locate the fishing company.

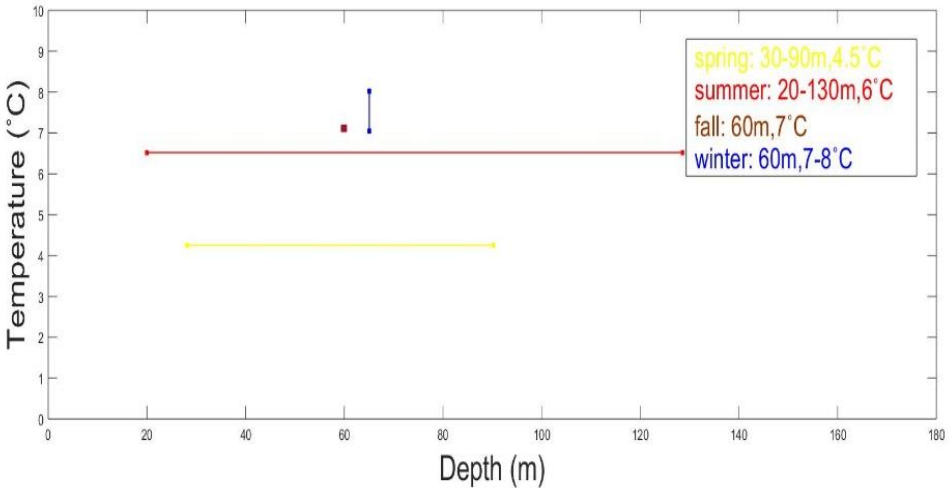
But is it enough to satisfy the depth condition to grow herring and mackerel? No. We have to consider the ocean temperature condition. Then, what is the best temperature which is to grow herring and mackerel?

3. The temperature of habitat for herring and mackerel

[vi]**Table 3. Habitat temperature for herring**

Life Stage	Preferred temperature
Eggs	**10°C - 15°C**
Larvae	**9-12°C from September to November, 8-9°C in December**
Juveniles	**3-4°C in spring, 6-9°C in summer, 8°C in fall, and 2-4°C in winter**
Adults	**5°C in spring, 6°C in summer, 5-6°C in fall, and 7-8°C in winter**
Spawning Adult	

[vii]First, the spawning of herring eggs occurred at temperatures of about 8-12 ˚C. And Larvae occurred at temperatures of about 9-16 ˚C. In the NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) survey, most larvae were collected at 8-14 ˚C from September to November; maximum abundance was at 9-12 ˚C. In December, larvae occurred at 6-11 ˚C with the majority collected at 8-9 ˚C. And when they became juveniles, they were most abundant at temperature of 3-4 ˚C in spring, 6-9°C in summer, 8°C in fall, and 2-4°C in winter. When they became adults, they usually liked 5°C in spring, 6°C in summer, 5-6°C in fall, and 7-8°C in winter. Therefore we should note that each temperature associate with season(of course we should note the depth too). And so we arrange the most suitable temperatures and depth for juvenile and adult herring by the graph (figure 2).(Since the simultaneous range between juvenile and adult has been prioritized, the area of±1 ˚C is also included as the optimal habitat range.)

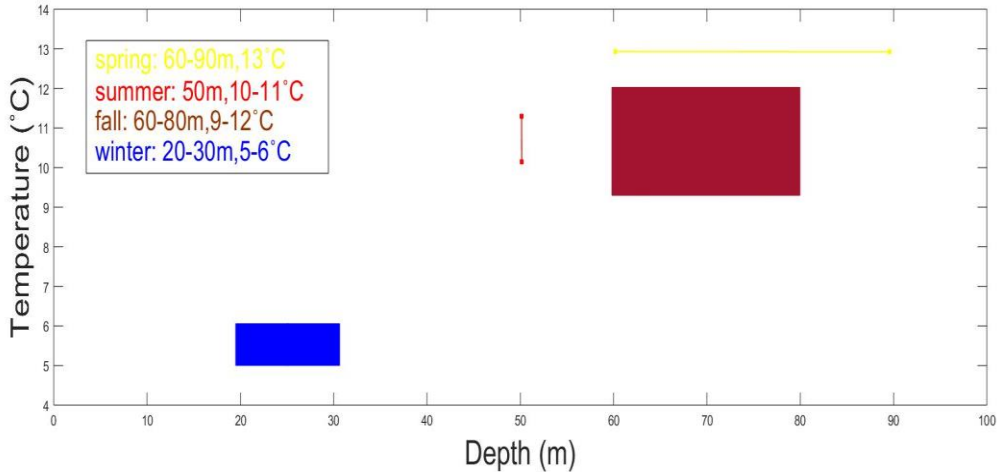


- **Figure 2. The most suitable temperature and depth for juvenile and adult herring**

[viii]**Table 4. Habitat temperature for mackerel**

Life Stage	Preferred temperature
Eggs	**7-16°C**
Larvae	**8-13°C**
Juveniles	**5-6°C in spring, 8-13°C in summer, 9-13°C in fall, and 5-6°C in winter**
Adults	**13°C in spring, 10-11°C in summer, 9-12°C in fall, and 5-6°C in winter**
Spawning Adult	

[ix]First, the mackerel eggs were highest abundance from 7-16℃. And larvae usually collected at 8-13℃. When they became juveniles, they most found 5-6℃ in spring, 8-13℃ in summer, 9-13℃ in fall, and 5-6℃ in winter. And also when they became adults, they are found >25% at 13℃ in spring, >30% at 10-11℃ in summer, >80% 9-12℃ in fall, and ~70% at 5-6℃ in winter. And we also arrange the most suitable temperatures and depth for juvenile and adult mackerel by the graph(figure 3).



- **Figure 3. The most suitable temperature and depth for juvenile and adult mackerel**

4. The depth and temperature condition of Orkney, Shetland, and Outer Hebrides

So we note that these temperature and the probability of occurrence. The very things are the most important things in locating the company. Hence consider the three place which is the most suitable place. And also because plan of your company is about after 50 years, we predicted the ocean temperature anomalies of these three places after 50 years. First of all, watch the graph of the average temperature of three area for 5 years.

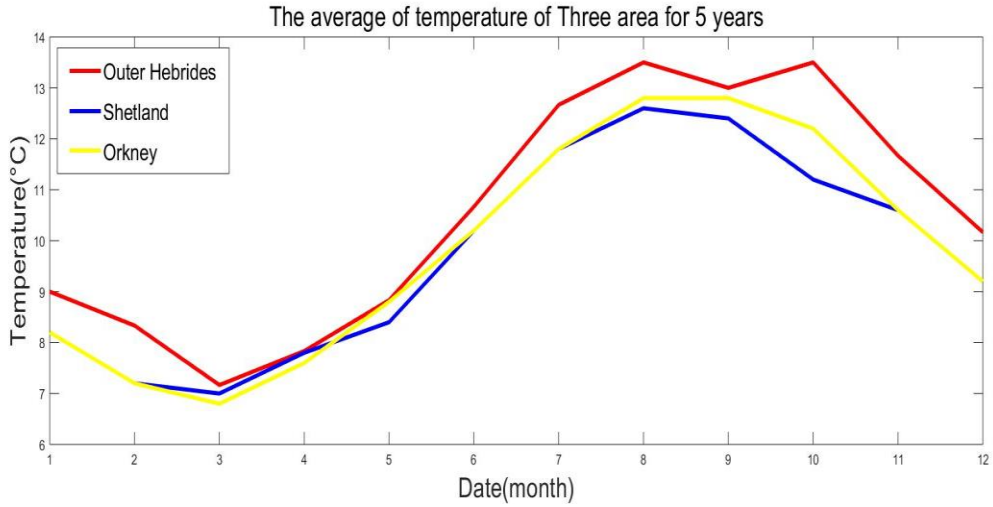


Figure 4 The average of temperature of three area for 5 years

If you look at the graph, Outer Hebrides, which is located in the south has relatively higher temperature and Shetland, which is located in the north has relatively lower temperature. And then we compare that where is the best place to live herring and mackerel.

First, we draw simple table and contour about depth and surface temperature distribution around each area. The criteria of the temperature is in February. And we will expand the February temperature information to other month temperature information through the fact that we looked before. Here, since we investigated the best place to live herring and mackerel about the season, we consider approximately temperature which is the average of three month such that the average of the temperature of February, March and April is the temperature of the winter, the average of the temperature of May, June and July is the temperature of the spring and so on. (This information is roughly presented in a picture of Scottish ocean in February.)

Table 5 The approximate depth and surface temperature distribution around Orkney(table)

140 (8.6°C)	160 (8.4°C)		120 (8.2°C)	70 (8°C)	50 (7.8°C)
100 (8.4°C)	120(1,3) (8.2°C)		80 (8°C)	40 (7.8°C)	100 (7.6°C)
80 (8.4°C)	100 (8.2°C)		**Orkney**	70 (7.8°C)	120 (7.4°C)
60 (8°C)	60 (8°C)		50 (8°C)	70 (7.8°C)	120 (7.6°C)
Land	50 (8°C)	80 (7.8°C)	120 (7.6°C)		

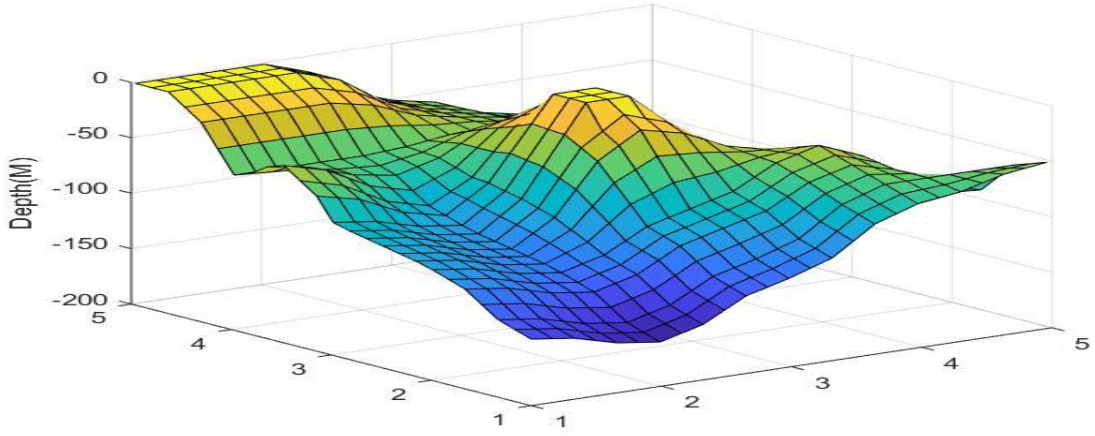


Figure 5 The approximate depth of Orkney(contour)

Table 6 The approximate depth and surface temperature distribution around Outer Hebrides(table)

1000 (9°**C**)	900 (8.8°**C**)	160 (8.6°**C**)	100 (8.4°**C**)	80 (8.2°**C**)
500 (8.8°**C**)	150 (8.6°**C**)	100 (8.4°**C**)	80 (8.2°**C**)	60 (8°**C**)
200 (8.8°**C**)	100 (8.6°**C**)	**Outer Hebrides**	90 (8°**C**)	
200 (9.0°**C**)	100 (8.8°**C**)	90 (8.8°**C**)	land	
150 (9°**C**)	100 (9°**C**)	90 (8.8°**C**)		

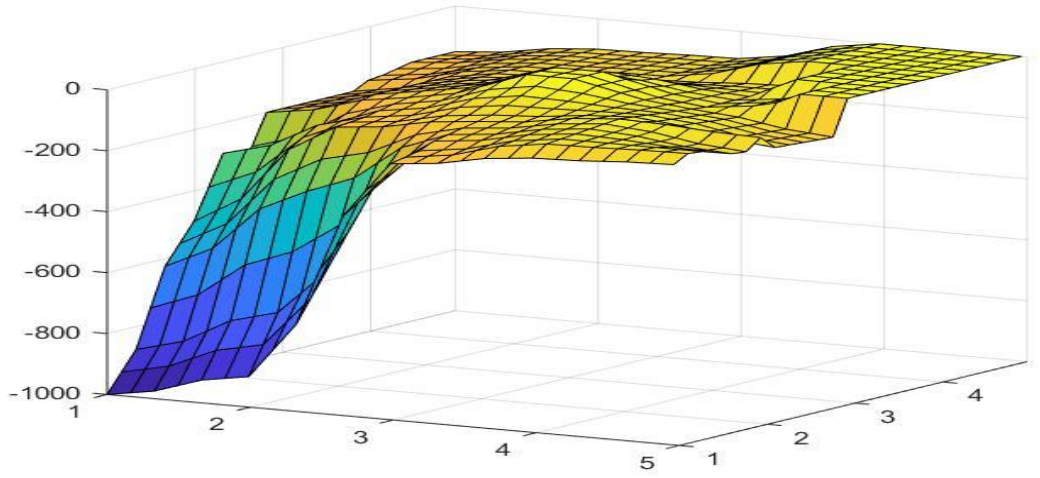
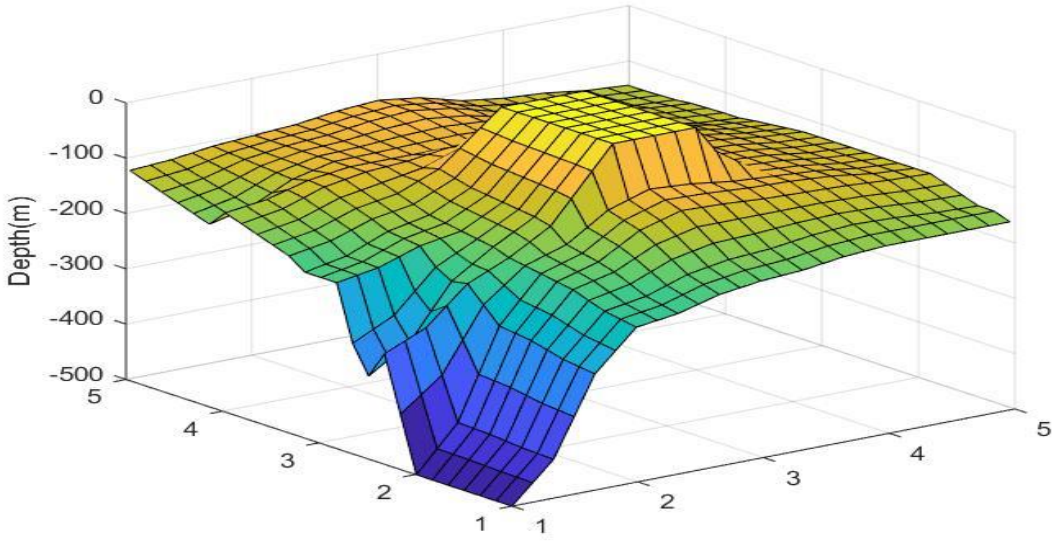


Figure 6 The approximate depth of Outer Hebrides(contour)

Table 7 The approximate depth and surface temperature distribution around Shetland(table)

500 (8°**C**)	220 (8.2°**C**)	180 (8.2°**C**)	160 (8.2°**C**)	160 (8°**C**)
500 (8.2°**C**)	180 (8.2°**C**)	100 (8.2°**C**)	100 (8.2°**C**)	120 (8°**C**)
200 (8.4°**C**)	150 (8.2°**C**)	**Shetland**	100 (8°**C**)	120 (7.8°**C**)
140 (8.4°**C**)	100 (8.2°**C**)	100 (8°**C**)	120 (7.6°**C**)	140 (7.2°**C**)
120 (8.4°**C**)	100 (8°**C**)	80 (7.6°**C**)	120 (7.2°**C**)	140 (7°**C**)

Figure 7 The approximate depth of Shetland(contour)



Now, we need to know about the vertical and seasonal distribution of water temperature. Look at the figure 8.

5. The relation between depth and temperature

[x]Figure 8 Vertical and seasonal distribution of water temperature.

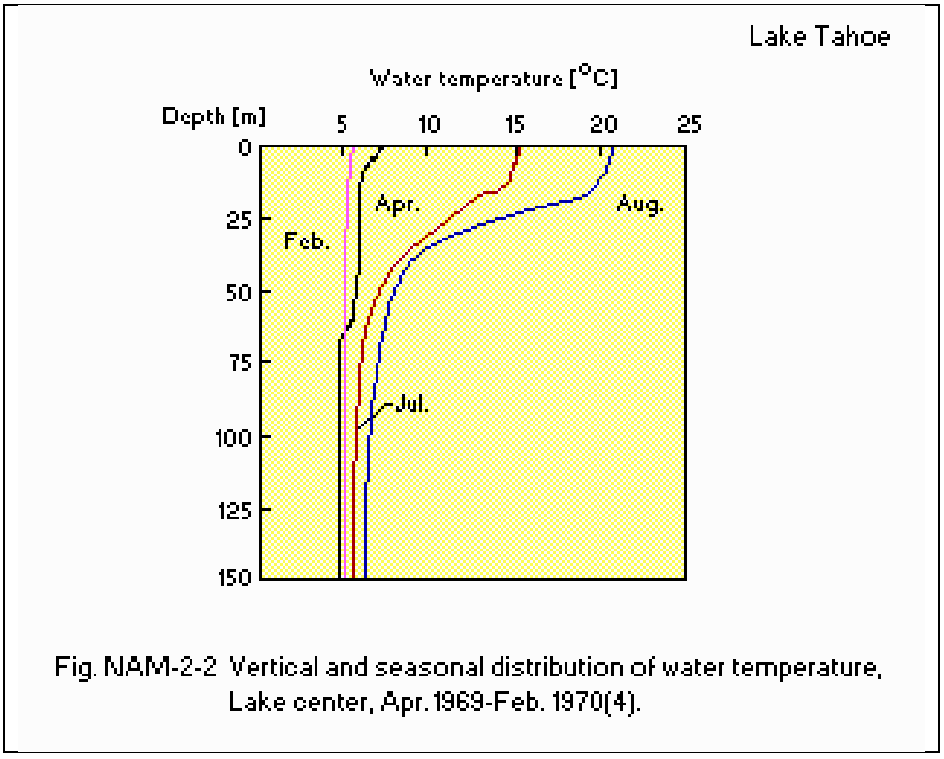
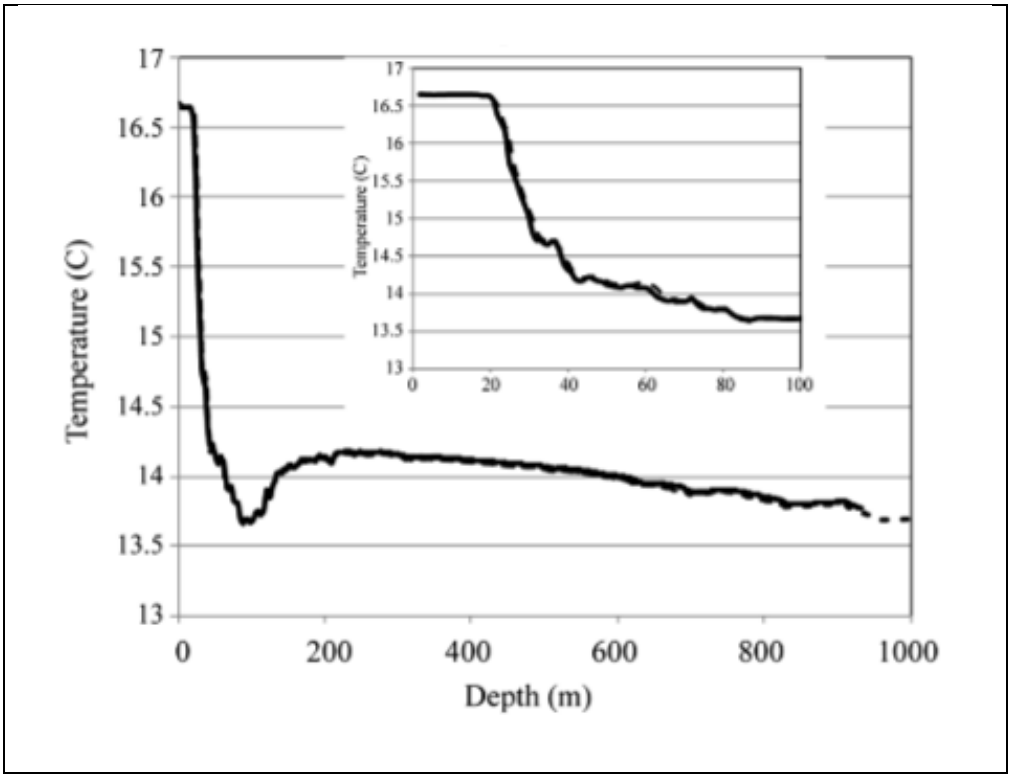


Fig. NAM-2-2 Vertical and seasonal distribution of water temperature, Lake center, Apr. 1969-Feb. 1970(4).

The figure 8 is about vertical and seasonal distribution of water temperature. Although the information is about lake, We could know interesting fact about the temperature of water. First, the depth does not significantly affect temperature changes after about 40 meters. Second, We can get the information that temperatures begin to decrease monotonically beyond **a certain depth**, regardless of surface water temperature. And so look at the figure 9 about the interesting result.

- [xi]Figure 9 The graph of the relationship between ocean depth and temperature



The figure 9 is a graph of the relationship between ocean depth and temperature. We can get the information that the specific depth at which the temperature begins to decrease monotonically after about **200 m.** Also, the water temperature within 20m is similar to the surface temperature and between 20m and 200m, a temperature drop of about 3.5 degrees occurs, taking the form of a quadratic curve. Based on the above information, modeling the function of the relationship between depth and water temperature is as follows. So we make function based on the above information.

6. The most suitable area to fish

Table 8 The function of the relationship between depth and water temperature

$$
\begin{aligned}
T_z(a) &= a && (where\ \ 0 \le z \le 20)\\
T_z(a) &= -0.125z + a + 2.5 && (where\ \ 20 < z \le 40)\\
T_z(a) &= -0.003z + a - 2.375 && (where\ \ 40 < z \le 200)
\end{aligned}
$$

(**a: surface temperature of seawater ,z: depth of water**)

To simplify the function, we represent one quadratic curve with two linear curves. This has the advantage of being easier to calculate the vertical water temperature of seawater. So let's take an example from (1,1)th-entry of Table 7. The season is winter, and the surface temperature is 8°**C**. And the deepest depth is 500m. So consider the most suitable temperature and depth for juvenile and adult herrings. They are greatest at 60m in winter. So let a=8, z=60. Then the temperature is 5.607°C. But since the most suitable temperature is 7-8°C, it is not suitable area for catching herrings. Then how about the case of mackerel? In winter, mackerels are most abundant at 20-30m. So let a=8, z=20-30. Then the temperature is 8-6.75°C. Since the suitable temperature to live mackerel in winter is 5-6 ˚C, some mackerel may be caught. Hence we did the calculations all the information of area and so got the following results.

At winter, Scottish herring : 65 m, 7 - 8 ± 1 ℃ is the best condition

mackerel : 20 - 30 m , 5 - 6 ± 1 ℃ is the best condition

6.03	5.83	5.63	5.43	5.23
7.35-8.6	7.15-8.4	6.95-8.2	6.75-8	6.55-7.8
5.83	5.63	5.43	5.23	5.03
7.15-8.4	6.95-8.2	6.75-8	6.55-7.8	6.35-7.6
5.83	5.63	**Orkney**	5.23	4.83
7.15-8.4	6.95-8.2		6.55-7.8	6.15-7.4
5.43	5.43	5.43	5.23	5.03
6.75-8	6.75-8	6.75-8	6.55-7.8	6.35-7.6
Land		5.43	5.23	5.03
		6.75-8	6.55-7.8	6.35-7.6

6.43	6.23	6.03	5.83	5.63
7.75-9	7.55-8.8	7.35-8.6	7.15-8.4	6.95-8.2
6.23	6.03	5.83	5.63	5.43
7.55-8.8	7.35-8.6	7.15-8.4	6.95-8.2	6.75-8
6.23	6.03	**Outer**	5.43	
7.55-8.8	7.35-8.6	**Hebrides**	6.75-8	
6.43	6.23	6.23	Land	
7.75-9	7.55-8.8	7.55-8.8		
6.43	6.43	6.23		
7.75-9	7.75-9	7.55-8.8		

5.43	5.63	5.63	5.63	5.43
6.75-8	6.95-8.2	6.95-8.2	6.95-8.2	6.75-8
5.63	5.63	5.63	5.63	5.43
6.95-8.2	6.95-8.2	6.95-8.2	6.95-8.2	6.75-8
5.83	5.63	**Shetland**	5.43	5.23
7.15-8.4	6.95-8.2		6.75-8	6.55-7.8
5.83	5.63	5.43	5.03	4.63
7.15-8.4	6.95-8.2	6.75-8	6.35-7.6	5.95-7.2
5.83	5.43	5.03	4.63	4.43
7.15-8.4	6.75-8	6.35-7.6	5.95-7.2	5.75-7

Thus we can get the information that Outer Hebrides has the good condition to catch the Scottish herring and mackerel, but Orkney and Shetland have a good condition for catching mackerel but not for catching Scottish herring during the winter.

At spring, Scottish herring : 30 - 90 m, 4.5 ± 1 ℃ is the best condition

mackerel : 60 - 90 m , 13 ± 1 ℃ is the best condition

9.5-10.35	9.3-10.15	9.1-9.95	8.9-9.75	8.7-9.55
8.955-9.055	8.755-8.855	8.555-8.655	8.355-8.455	8.155-8.255
9.3-10.15	9.1-9.95	8.9-9.75	8.7-9.55	8.5-9.35
8.755-8.855	8.555-8.655	8.355-8.455	8.155-8.255	7.955-8.055
9.3-10.15	9.1-9.95	**Orkney**	8.7-9.55	8.3-9.15
8.755-8.855	8.555-8.655		8.155-8.255	7.755-7.855
8.9-9.75	8.9-9.75	8.9-9.75	8.7-9.55	8.5-9.35
8.355-8.455	8.355-8.455	8.355-8.455	8.155-8.255	7.955-8.055
Land		8.9-9.75	8.7-9.55	8.5-9.35
		8.355-8.455	8.155-8.255	7.955-8.055

9.9-10.75	9.7-10.55	9.5-10.35	9.3-10.15	9.1-9.95
9.355-9.455	9.155-9.255	8.955-9.055	8.755-8.855	8.555-8.655
9.7-10.55	9.5-10.35	9.3-10.15	9.1-9.95	8.9-9.75
9.155-9.255	8.955-9.055	8.755-8.855	8.555-8.655	8.355-8.455
9.7-10.55	9.5-10.35	**Outer Hebrides**	8.9-9.75	
9.155-9.255	8.955-9.055		8.355-8.455	
9.9-10.75	9.7-10.55	9.7-10.55	land	
9.355-9.455	9.155-9.255	9.155-9.255		
9.9-10.75	9.9-10.75	9.7-10.55		
9.355-9.455	9.355-9.455	9.155-9.255		

8.9-9.75	9.1-9.95	9.1-9.95	9.1-9.95	8.9-9.75
8.355-8.455	8.555-8.655	8.555-8.655	8.555-8.655	8.355-8.455
9.1-9.95	9.1-9.95	9.1-9.95	9.1-9.95	8.9-9.75
8.555-8.655	8.555-8.655	8.555-8.655	8.555-8.655	8.355-8.455
9.3-10.15	9.1-9.95	**Shetland**	8.9-9.75	8.7-9.55
8.755-8.855	8.555-8.655		8.355-8.455	8.155-8.255
9.3-10.15	9.1-9.95	8.9-9.75	8.5-9.35	8.1-8.95
8.755-8.855	8.555-8.655	8.355-8.455	7.955-8.055	7.555-7.655
9.3-10.15	8.9-9.75	8.5-9.35	8.1-8.95	7.9-8.75
8.755-8.855	8.355-8.455	7.955-8.055	7.555-7.655	7.355-7.455

During spring, it is difficult to identify the most suitable locations for herring and mackerel. If global warming is getting worse, all three regions could be in locations where mackerel is more likely to exist. (If the worst case occurs, the spring will be the time to fish) But if not we can't fish. However don't worried about it. We use spring to earn much money to use salted method. According to our resort, in spring the fish amount falls rapidly. And then if we salt fish which caught in winter, many people will visit our company in spring. So spring will become the season of opportunity.

At summer, Scottish herring : 20 - 130 m, 6 ± 1 ℃ is the best condition

mackerel : 50 m , 9 - 12 ± 1 ℃ is the best condition

11.335-14.1	11.135-13.9	10.935-13.7	10.735-13.5	10.535-13.3
11.575	11.375	11.175	10.975	10.775
11.135-13.9	10.935-13.7	10.735-13.5	10.535-13.3	10.335-13.1
11.375	11.175	10.975	10.775	10.575
11.135-13.9	10.935-13.7	**Orkney**	10.535-13.3	10.135-12.9
11.375	11.175		10.775	10.375
10.735-13.5	10.735-13.5	10.735-13.5	10.535-13.3	10.335-13.1
10.975	10.975	10.975	10.775	10.575
Land		10.735-13.5	10.535-13.3	10.335-13.1
		10.975	10.775	10.575

10.735-13.5	10.535-13.3	10.335-13.1	10.135-12.9	9.935-12.7
10.975	10.775	10.575	10.375	10.175
10.535-13.3	10.335-13.1	10.135-12.9	9.935-12.7	9.735-12.5
10.775	10.575	10.375	10.175	9.975
10.535-13.3	10.335-13.1	**Outer Hebrides**	9.735-12.5	
10.775	10.575		9.975	
10.735-13.5	10.535-13.3	10.535-13.3	land	
10.975	10.775	10.775		
10.735-13.5	10.735-13.5	10.535-13.3		
10.975	10.975	10.775		

10.235-13.0	10.435-13.2	10.435-13.2	10.435-13.2	10.235-13.0
10.475	10.675	10.675	10.675	10.475
10.435-13.2	10.435-13.2	10.435-13.2	10.435-13.2	10.235-13.0
10.675	10.675	10.675	10.675	10.475
10.635-13.4	10.435-13.2	**Shetland**	10.235-13.0	10.035-12.8
10.875	10.675		10.475	10.275
10.635-13.4	10.435-13.2	10.235-13.0	9.835-12.6	9.435-12.2
10.875	10.675	10.475	10.075	9.675
10.635-13.4	10.235-13.0	9.835-12.6	9.435-12.2	9.235-12.0
10.875	10.475	10.075	9.675	9.475

During summer, all areas have the best conditions for mackerel, but finding the optimal habitat for herring is not easy. So in summer, plan the business about mackerel rather than herring.

At fall, Scottish herring : 60 m, 7 ± 1 ℃ is the best condition

mackerel : 60-80 m , 9 ~ 12 ± 1 ℃ is the best condition

8.045	7.845	7.645	7.445	7.245
7.985-8.045	7.785-7.845	7.585-7.645	7.385-7.445	7.185-7.245
7.845	7.645	7.445	7.245	7.045
7.785-7.845	7.585-7.645	7.385-7.445	7.185-7.245	6.985-7.045
7.845	7.645	**Orkney**	7.245	6.845
7.785-7.845	7.585-7.645		7.185-7.245	6.785-6.845
7.445	7.445	7.445	7.245	7.045
7.385-7.445	7.385-7.445	7.385-7.445	7.185-7.245	6.985-7.045
Land		7.445	7.245	7.045
		7.385-7.445	7.185-7.245	6.985-7.045

8.445	8.245	8.045	7.845	7.645
8.385-8.445	8.185-8.245	7.985-8.045	7.785-7.845	7.585-7.645
8.245	8.045	7.845	7.645	7.445
8.185-8.245	7.985-8.045	7.785-7.845	7.585-7.645	7.385-7.445
8.245	8.045	**Outer**	7.445	
8.185-8.245	7.985-8.045	**Hebrides**	7.385-7.445	
8.445	8.245	8.245	land	
8.385-8.445	8.185-8.245	8.185-8.245		
8.445	8.445	8.245		
8.385-8.445	8.385-8.445	8.185-8.245		

7.445	7.645	7.645	7.645	7.445
7.385-7.445	7.585-7.645	7.585-7.645	7.585-7.645	7.385-7.445
7.645	7.645	7.645	7.645	7.445
7.585-7.645	7.585-7.645	7.585-7.645	7.585-7.645	7.385-7.445
7.845	7.645	**Shetland**	7.445	7.245
7.785-7.845	7.585-7.645		7.385-7.445	7.185-7.245
7.845	7.645	7.445	7.045	6.645
7.785-7.845	7.585-7.645	7.385-7.445	6.985-7.045	6.585-6.645
7.845	7.445	7.045	6.645	6.445
7.785-7.845	7.385-7.445	6.985-7.045	6.585-6.645	6.385-6.445

Outer Hebrides has the good condition for catching the Scottish herring and mackerel, Orkney and Shetland are good location to catch herring but they are not the best places for mackerel. But it doesn't matter because we can stock a lot of mackerel up in summer. And so we enough to catch the herring in fall.

7. The temperature difference after 50 years.

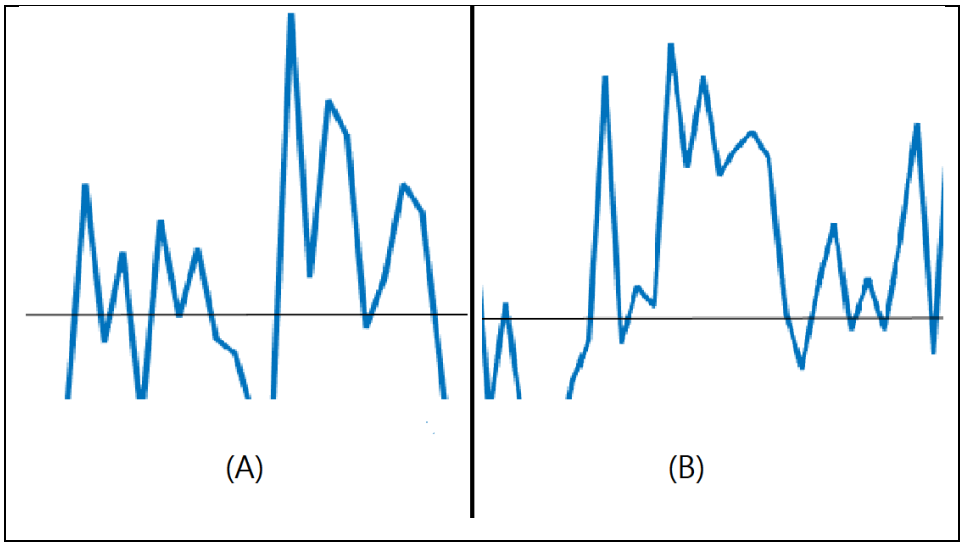


Figure 10 Two picture about the temperature

How do you think about two pictures? Could you find the differences between two picture? The two picture are from following figure.

xii

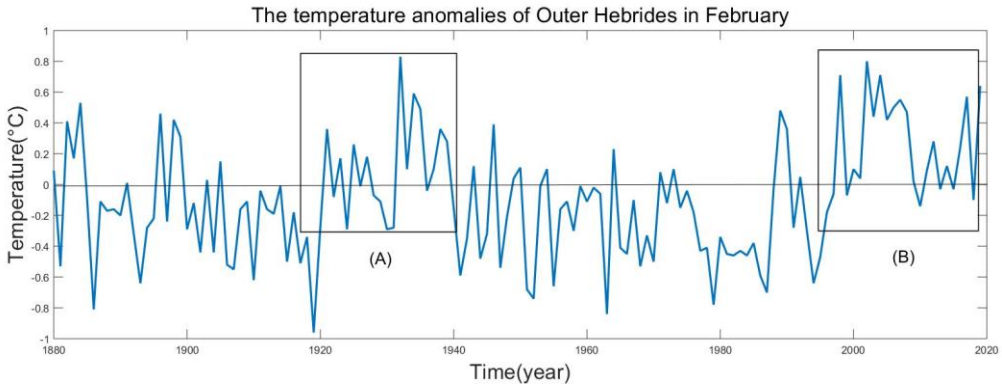


Figure 11 The temperature anomalies of Outer Hebrides in February.

Yes, they are the temperature of 1920-1940 and 2000-2020. But did you think there was a big difference between the two pictures? The pictures are as different as 80 years! So we expect that there is not a big temperature difference for 50 years. Therefore you just fish for 50 years at the place we've designated. Of course, you only keep what we've told you. So the best case which we predict will be the above case.

But if and when there is a big temperature, namely there will become the worst case, we predict

there will be a temperature difference of up to 1°C. Although it did happen, you don't need to worry about that. Because it will rise very slowly(roughly 0.1°C in five years at the earliest).And it too low to affect fishing very much.

Hence go to the three island and make your company right now!

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[i]Characteristics Robert N. Reid, Luca M. Cargnelli, Sara J. Griesbach, David B. Packer, Donna L. Johnson, Christine A. Zetlin, Wallace W. Morse, and Peter L. Berrien National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Herring, Clupea harengus, Life History and Habitat Characteristics; 15p

[ii]Characteristics Robert N. Reid, Luca M. Cargnelli, Sara J. Griesbach, David B. Packer, Donna L. Johnson, Christine A. Zetlin, Wallace W. Morse, and Peter L. Berrien National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Herring, Clupea harengus, Life History and Habitat Characteristics; 4-6

[iii]Anne L. Studholme, David B. Packer, Peter L. Berrien, Donna L. Johnson, Christine A. Zetlin, and Wallace W. Morse National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Mackerel, Scomber scombrus, Life History and Habitat Characteristics; 16p

[iv] Anne L. Studholme, David B. Packer, Peter L. Berrien, Donna L. Johnson, Christine A. Zetlin, and Wallace W. Morse National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Mackerel, Scomber scombrus, Life History and Habitat Characteristics; 4-6

[v] Reprinted from "Scotland's Seas: Towards Understanding their State"

[vi]Characteristics Robert N. Reid, Luca M. Cargnelli, Sara J. Griesbach, David B. Packer, Donna L. Johnson, Christine A. Zetlin, Wallace W. Morse, and Peter L. Berrien National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Herring, Clupea harengus, Life History and Habitat Characteristics; 15p

[vii]Characteristics Robert N. Reid, Luca M. Cargnelli, Sara J. Griesbach, David B. Packer, Donna L. Johnson, Christine A. Zetlin, Wallace W. Morse, and Peter L. Berrien National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Herring,

Clupea harengus Characteristics, Life History and Habitat; 4-6

[viii] Anne L. Studholme, David B. Packer, Peter L. Berrien, Donna L. Johnson, Christine A. Zetlin, and Wallace W. Morse National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Mackerel, Scomber scombrus, Life History and Habitat Characteristics; 16p

[ix] Anne L. Studholme, David B. Packer, Peter L. Berrien, Donna L. Johnson, Christine A. Zetlin, and Wallace W. Morse National Marine Fisheries Serv., James J. Howard Marine Sciences Lab., 1999. Essential Fish Habitat Source Document: Atlantic Mackerel, Scomber scombrus, Life History and Habitat Characteristics; 16p

[x] Lake center. 1969. Vertical and seasonal distribution of water temperature.

[xi] J. P. Abraham, M. Baringer, N. L. Bindoff, T. Boyer, L. J. Cheng, J. A. Church, J. L. Conroy, C. M. Domingues, J. T. Fasullo, J. Gilson, G. Goni, S. A. Good, J. M. Gorman, V. Gouretski, M. Ishii, G. C. Johnson, S. Kizu, J. M. Lyman, A. M. Macdonald, W. J. Minkowycz, S. E. Moffitt, M. D. Palmer, A. R. Piola, F. Reseghetti, K. Schuckmann, K. E. Trenberth, I. Velicogna, and J. K. Willis. 2013. A REVIEW OF GLOBAL OCEAN TEMPERATUREOBSERVATIONS: IMPLICATIONS FOR OCEANHEAT CONTENT ESTIMATES ANDCLIMATE CHANGE. 462p

[xii] NOAA National Centers for Environmental information, Climate at a Glance

The global warming? It can't stop us from fishing!

Recently, many people worried about the news such that the migration of Scottish herring and mackerel occurs because of global warming. So many people in the fishing industry were worried about losing their jobs.

But according to a recent KW Consultants Company's survey, the company said that there is no need to worry about problems caused by temperature changes caused by global warming over the next 50 years. They said the temperature change of global warming will be too small to affect the migration of these fish, and although the change will be enough to affect the migration of these fish, the change will be too slow to affect fish industry.

First, they mentioned about the most suitable depth and temperature of habitats of herring and mackerel. And they said Outer Hebrides, Orkney and Shetland are the best place to fish in Scotland. Also the interesting thing they said is that spring will become the season of opportunity. They stated the reason that the fish amount falls rapidly in spring. So they suggested that salted method in winter as a solution. And they said that if the worst case occurs, rather, the fish amount will increase.

So Scottish North Atlantic fishing company already construct their company building in Shetland. In addition many experts said that Shetland will become one of the biggest fishing village in the Scotland and so many fisher head toward Shetland. Also fishery stock prices of the Shetland's fishery industry rose suddenly.

However, there were some people who worried about this happening. Some scientist said that people in Shetland become insensitive to safety, and the global warming will be worse than we think. They mentioned the recent temperature change as the reason. According to them, the latest temperature changes are unpredictable and we must always be prepared for global warming. Furthermore if the temperature changes take a recent tendency, the temperature of Scottish North Atlantic will increase about 5℃ above the present. So they suggested to prepare for migration of the herring and mackerel to many fisher.

But despite suggestions from some scientists, Shetland was crowded with people who came fishing. Because KW Consultants Company's survey's grounds were valid, many people believed the survey. Our reporter met an old man today. The old man told to us.

"Go out to sea and fish!"