Case study

Proximity diagnostics

Objectives

The main objective of this case was to develop a method in PatternFinder to evaluate the proximity of two cods. If the proximity is within a certain limit the assumption can be made that the fish were shoaling.

The research is based on data from two DST-centi recorders manufactured by Star-Oddi.
The cods, that were a part of a tagging experiment carried out by Vilhjálmur Thorsteinsson at MRI in Iceland, were tagged in 2003 and caught in 2006. Both tags recorded about 3 years of data.

Definition of terms:

- Proximity: The closeness of fish.
- Shoaling: Fish swimming in a group.
- Proximity limits:

Temperature proximity limit	Tl:	2°C
Depth proximity limit	Dl:	20m
Ocean depth proximity limit	Ol:	20m

The goal is to determine a statistical value for proximity.

Method

The method used to find the proximity is based on the comparison of three parameters.

- Temperature:
  Temperature proximity Tp= |T1-T2|
- Depth:
  Depth proximity Dp= |D1-D2|
- Ocean depth:
  The assumption that the cod will, at least once a day, dive to the bottom of the sea helps us determine the Ocean depth.
  Ocean depth proximity Op= |O1-O2|

If proximity values for all parameters are within the defined limits at the same time, Tp<= Tl, Dp<=Dl and Op<=Ol, it can be assumed that the fish are close to each other and, as a result, shoaling.

Creating a multiple file project (MFP)

A multiple file project, called P.MFP, was created. The project contains two SFPs, one for each cod, called P1 and P2,
P1 contains the DAT file 1C0307.DAT and P2 1C0407.DAT

SFP data:

SFP	Tag	Deployed	Retrieved	Data (Year:Month)
P1	1C0397	15-04-2003	25-02-2006	2:10
P2	1C0407	15-04-2003	02-05-2006	3:01

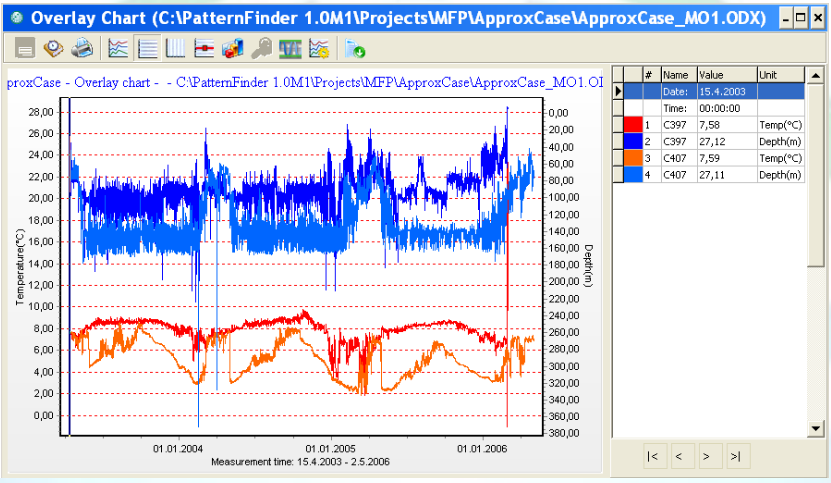


Figure M1. Temperature and Depth overlay

The overlay of both DAT files shows that they begin recording at midnight on April 15th 2003. The memory in 1C0407 fills up and it stops recording on May 2nd 2006.
1C0397 is caught earlier on February 25th 2006.

Data which was recorded after 1C0397 was caught will be cut out as it is irrelevant to the study.

The data which was recorded until February 26th 2006 (measurement number 121572) will be cut from 1C0407 to match the data from 1C0397.

Steps for each SFP

Before we can compare the two cod signals we must first prepare the individual parameters for evaluation. This can be done in 3 steps for each SFP as described below. We will use P1 as an example.

Step 1: Extracting signals from the DAT file

1.1: Extracting the Temperature signal

Select the DAT file in P1 and extract temperature measurements 1-121572.

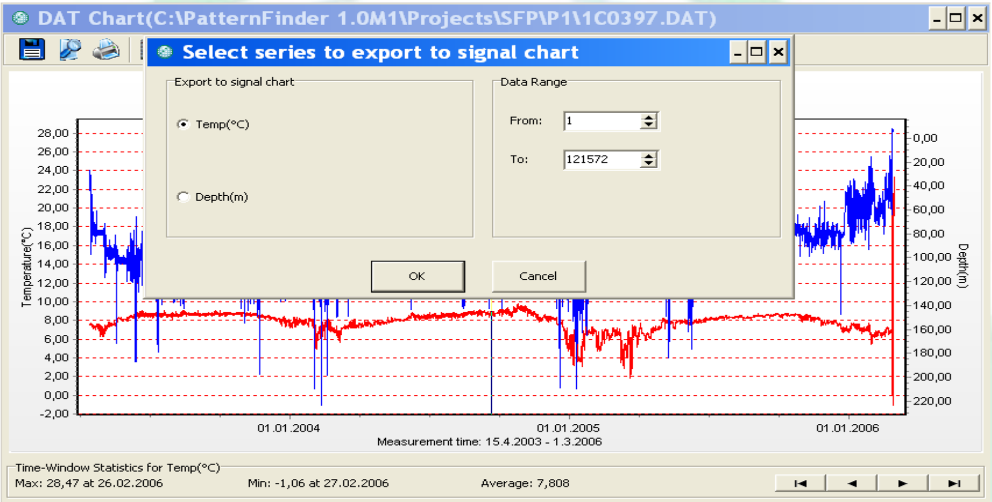


Figure 1.1 Extracting the temperature signal from the DAT file.

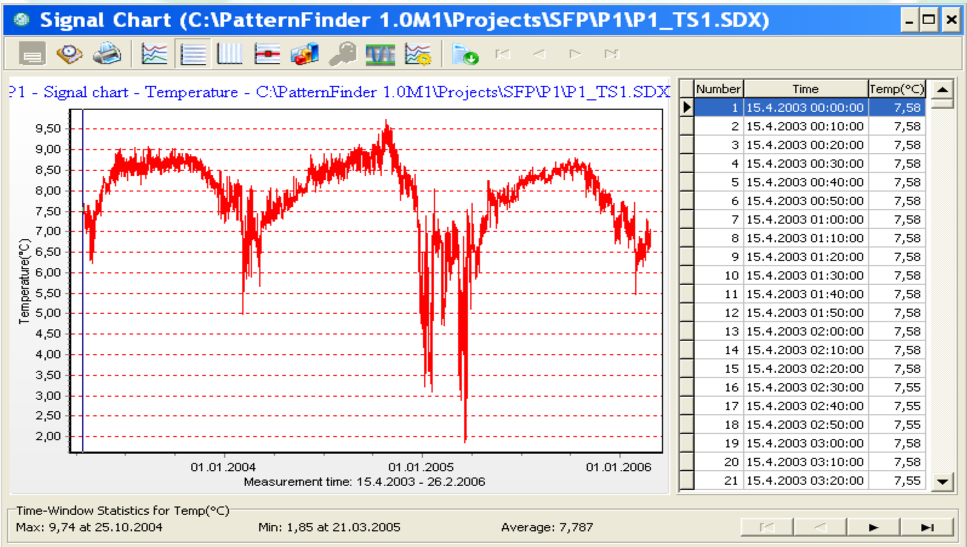


Figure 1.2 Temperature signal from P1

The signal chart in figure 1.2 is saved as P1_T.

Note that it is important to use descriptive alias names to avoid confusion.

1.2: Extracting the Depth signal

Select the DAT file and extract depth measurements 1-121572.

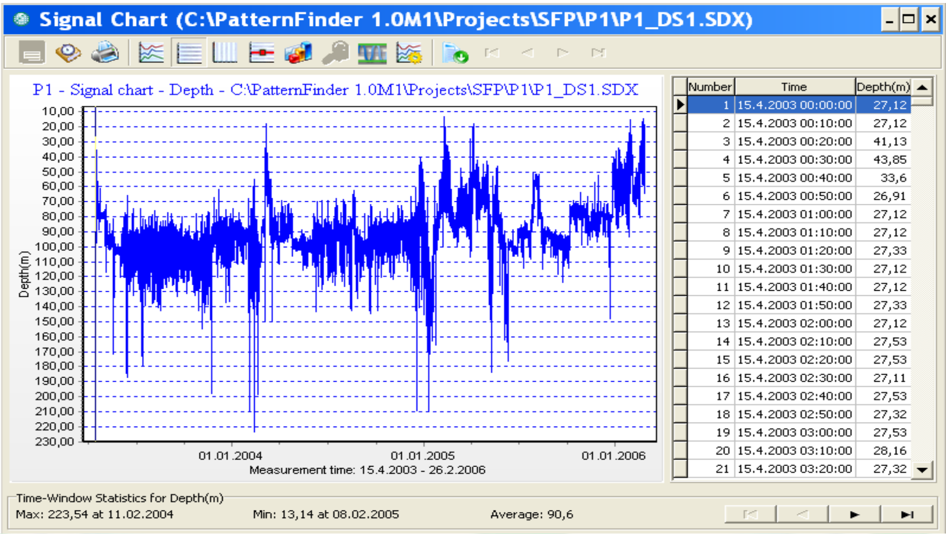


Figure 1.3 Depth signal from P1

The signal chart in figure 1.3 is saved as P1_D.

Step 2: Signal Periodic Statistics

2.1: Temperature Periodic Statistics

Open the P1_T chart and perform a statistical analysis. Select 1 day as the time-averaging period. Because we are going to use the mean value select “Interpolate period” and “Time weighted statistics”.

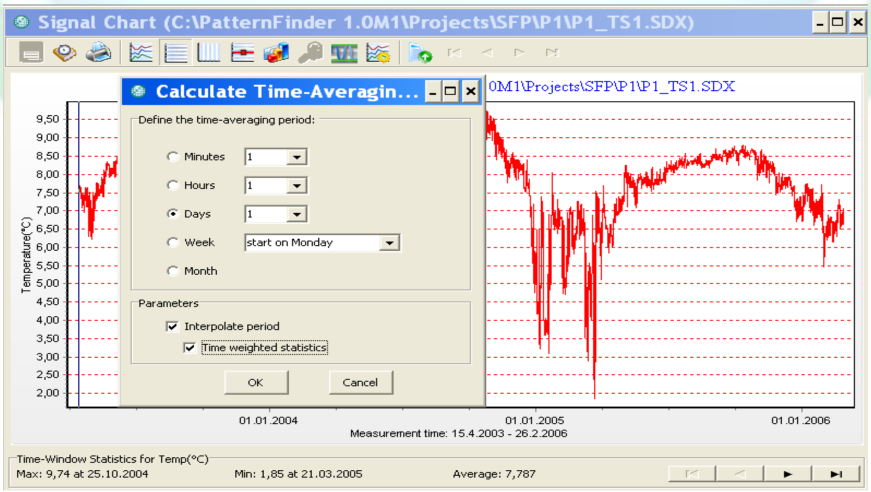


Figure 2.1 Defining a Signal Period Statistics operation as 1 Day

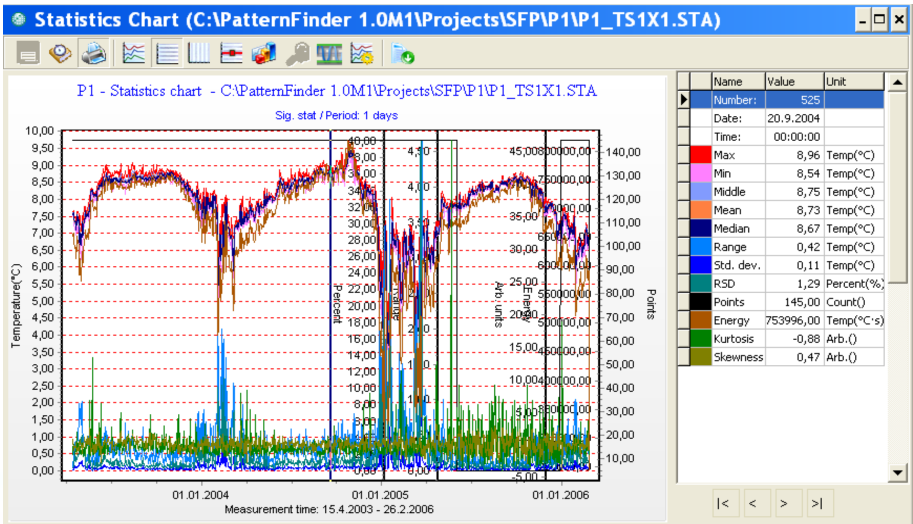


Figure 2.2 Signal period statistics chart

The statistics chart in figure 2.2 is saved as P1_T_XD.

As can be seen from the points parameter in figure 2.2 the sampling period was not consistent throughout the measurement period. One of the benefits of using periodically averaged values is that the sampling period is not an issue when comparing signals.

We now extract the mean value from the statistics chart.

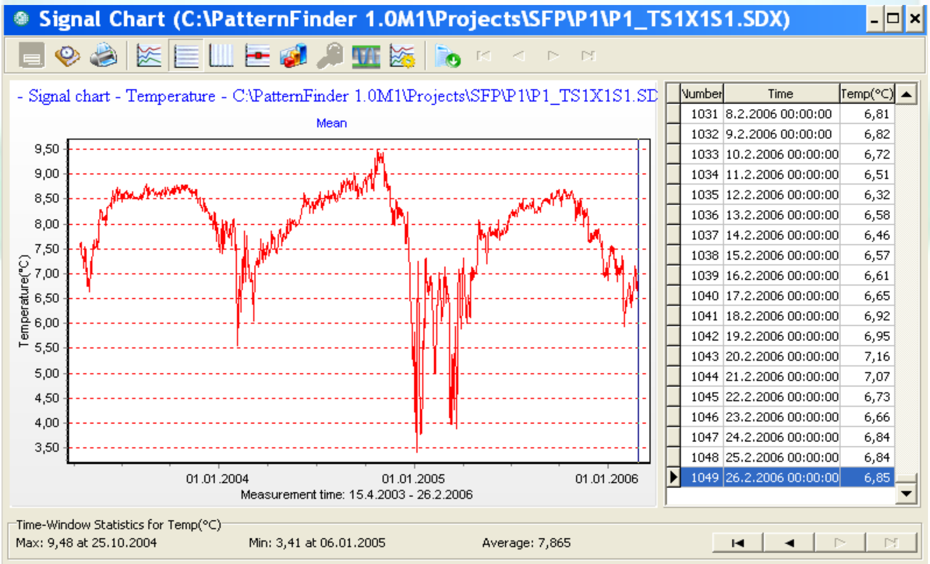


Figure 2.3 Extracted temperature mean.

The signal chart in figure 2.3 is saved as P1_TM.

2.2: Depth Periodic Statistics

Open the P1_D chart and perform a Signal Period Statistics operation. Select 1 Day as the time-averaging period. Because we are going to use the mean value select “Interpolate period” and “Time weighted statistics”.

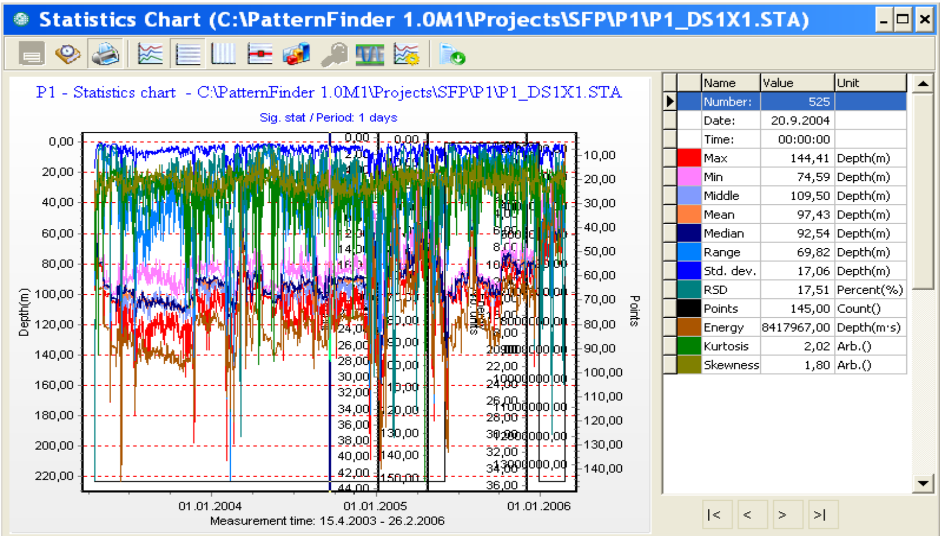


Figure 2.4 Signal period statistics chart

The statistics chart in figure 2.4 is saved as P1_D_XD.

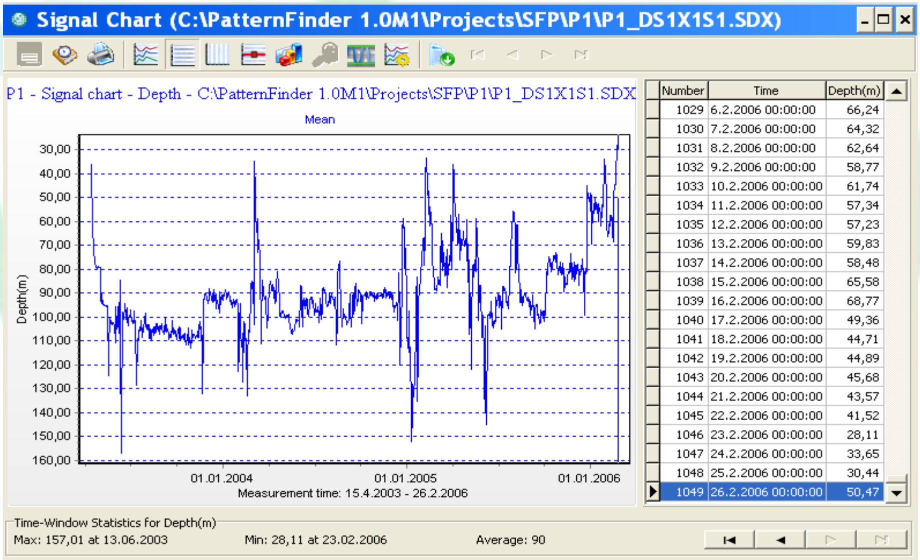


Figure 2.5 Depth mean extracted.

The signal chart in figure 2.5 is saved as P1_DM.

Step 3: Finding the Ocean depth

The fact that the cod will, at least once a day, dive to the bottom of the sea helps us determine the Ocean depth.

Open the P1_D chart and perform a Period Statistics analysis. Select 1 day as the time-averaging period. Because we are going to use the max value and want a real measurement value the “Interpolate period” and “Time weighted statistics” options are not checked.

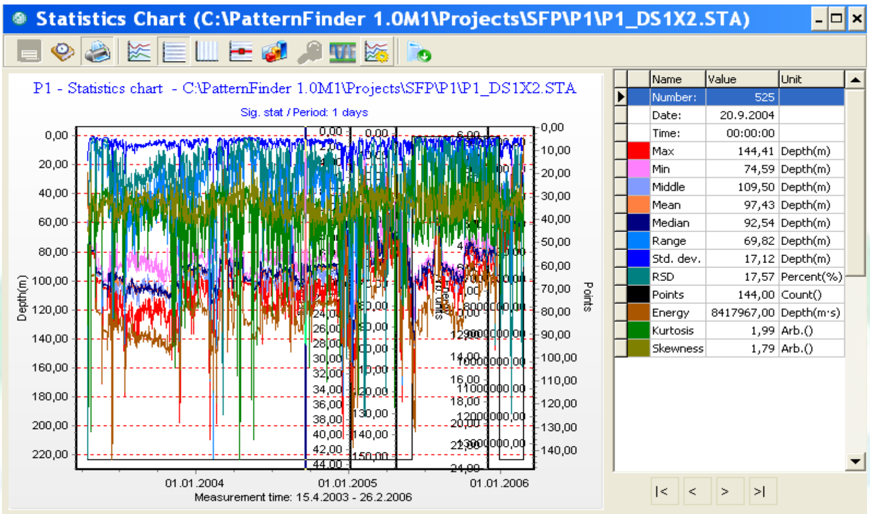


Figure 3.1 Signal period statistics chart

The statistics chart in figure 3.1 is saved as P1_D_XDNI.

To see the ocean depth we extract the Maximum signal from the statistical chart. Because we defined the time-averaging period as 1 day the ocean depth is represented as a singular point per day (see figure 3.2).

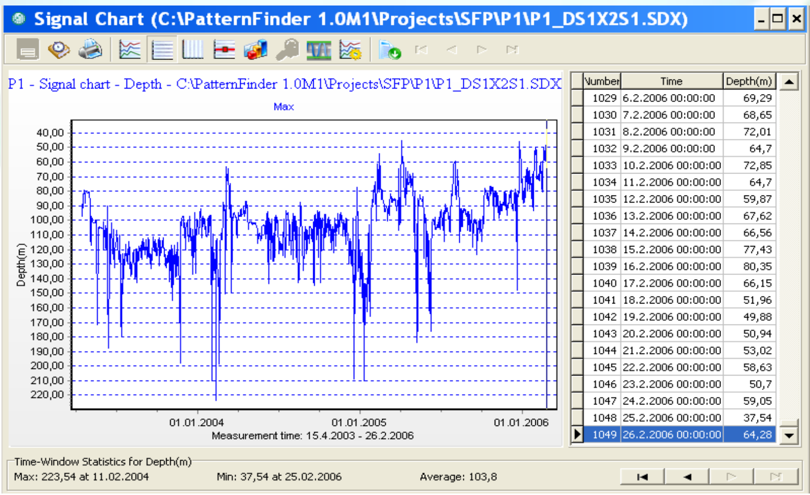


Figure 3.2 Ocean depth

The signal chart in figure 3.2 is saved as P1_OD.

Proximity analysis

Temperature proximity

Subtract P2 Temperature from P1 Temperature

Open the P1_TM chart and select “Subtract” under “Signal operation”.

For subtraction select the P2_TM chart and check the “Absolute difference” box.

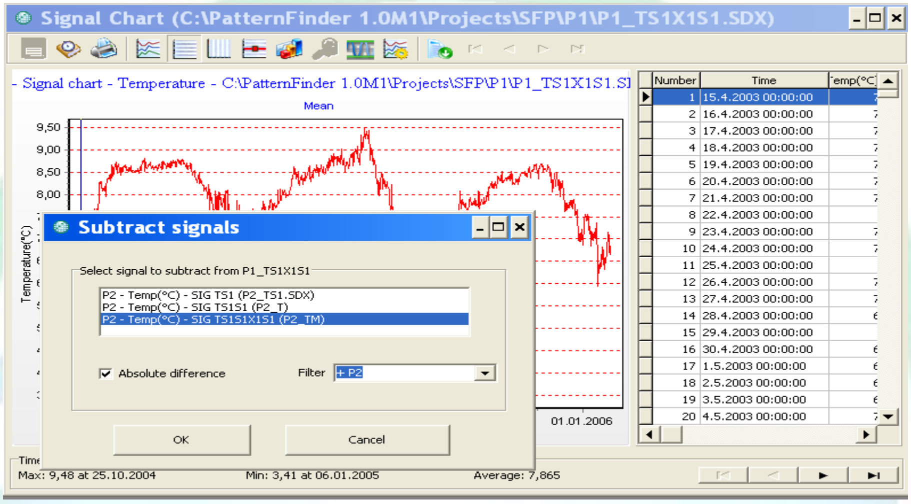


Figure TP.1 Subtraction operation

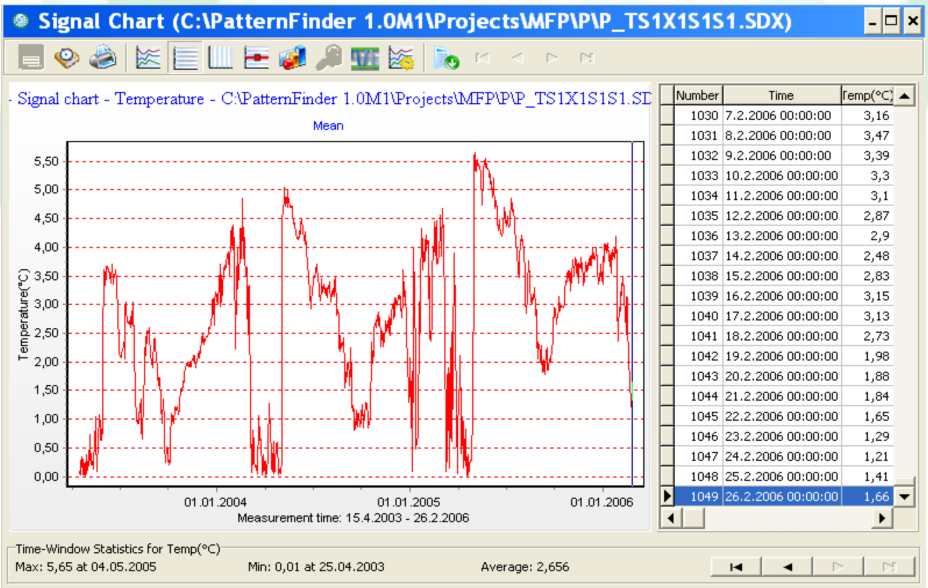


Figure TP.2

The signal chart in figure TP.2 is saved as P1_TP.

Temperature proximity event analysis

Open the P1_TP chart, click the **Create event chart** button and select **Ambient** Analysis.

As can be seen in figure TP.3 we created an Ambient level template called **Prox-T** with 2 levels, TL1: 0-2°C and TL2: 2-100°C. The template was used for both SFPs.

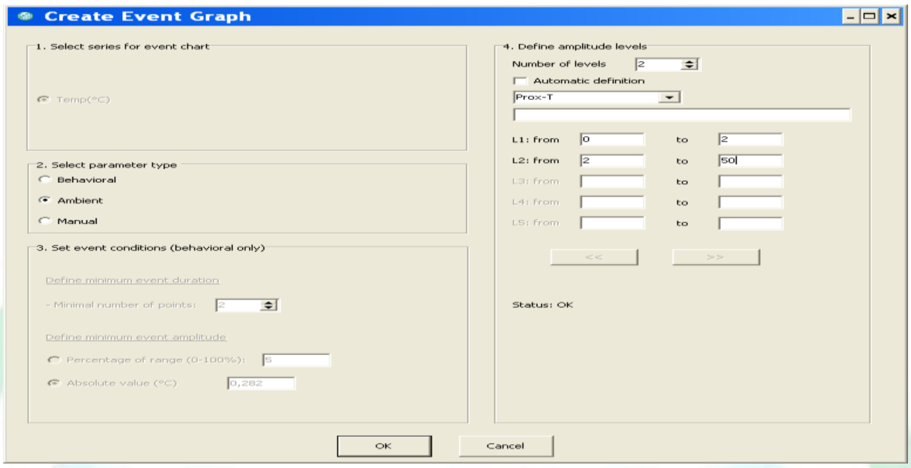


Figure TP.3 Temperature Event anlysis definition

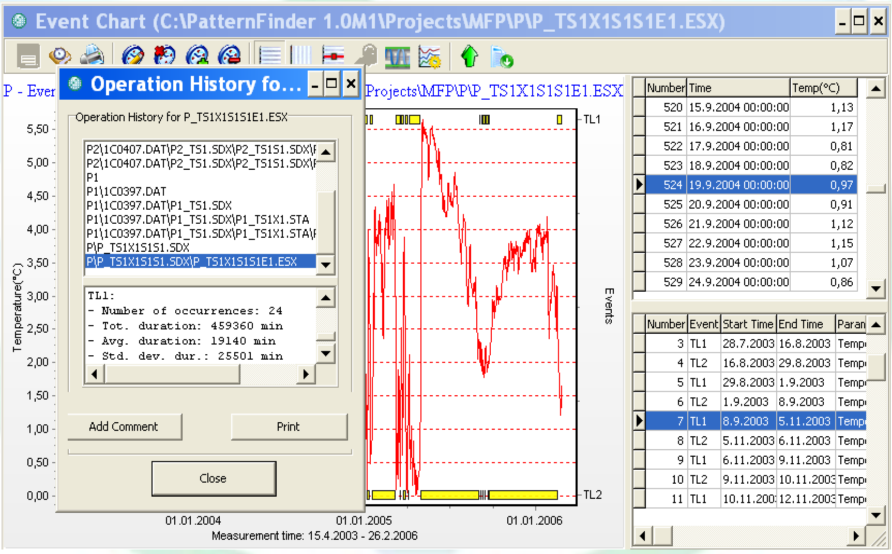


Figure TP.4. Temperature proximity event results, TL1

Click the **History** button to see the results of the operation.

The event chart in figure TP.4 is saved as P_TPE.

Depth proximity

Subtract P2 Depth from P1 Depth

Open the P1_DM chart and select “Subtract” under “Signal operation”.

For subtraction select the P2_DM chart and check the **Absolute difference** box.

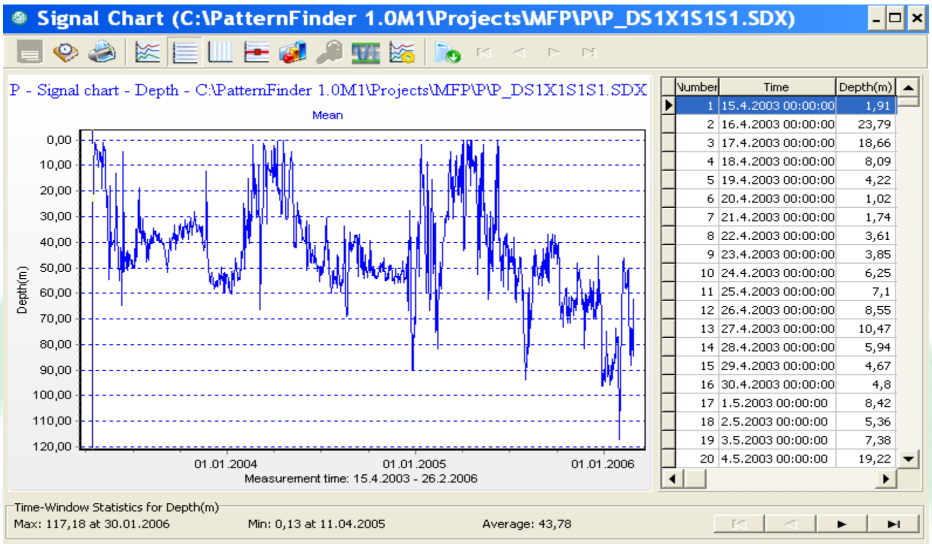


Figure DP.1 Absolute depth difference between P2 and P1

The signal chart is saved as P_DP.

Depth proximity event analysis

Open the P_DP chart, click the **Create event chart** button and select **Ambient** Analysis.

We created an Ambient level template **Prox-D** with 2 levels, DL1: 0-20m and DL2: 20-1000m. The template was used for both SFPs.

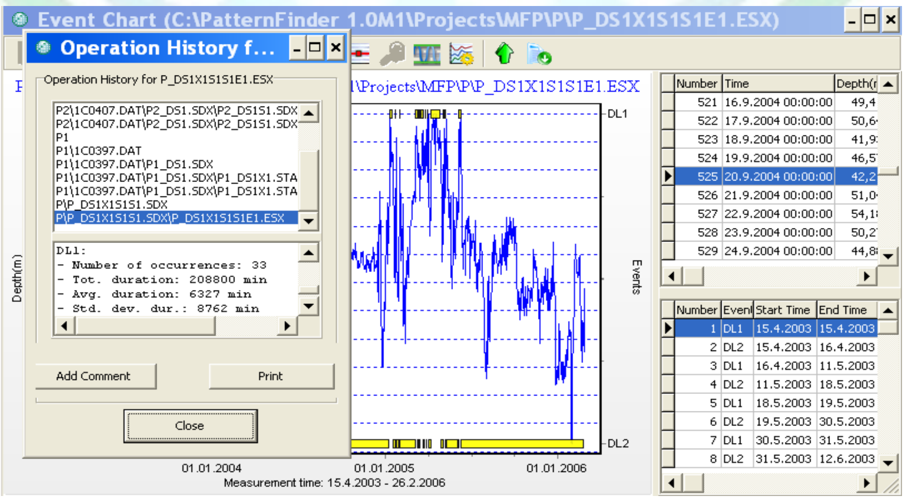


Figure DP.2. Depth proximity event results, DL1

Click the **History** button to see the results of the operation.

The event chart in figure DP.2 is saved as P_DE.

Ocean Depth proximity

Apply the same procedure as in the depth proximity analysis, i.e., subtract P2_OD from P1_OD. Save the resulting chart as P_ODiff.

Perform an Ambient event analysis on P_ODiff. You can use the Prox-D template as it has the same levels.

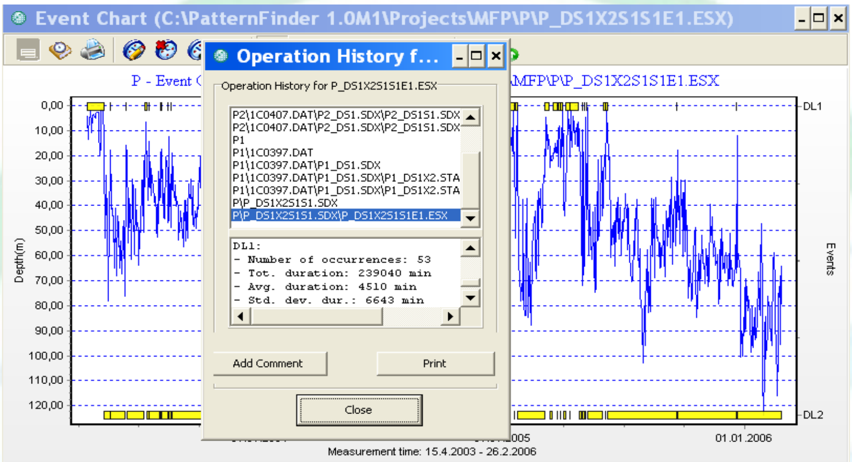


Figure OP.1. Ocean Depth proximity event results, DL1

Click the **History** button to see the results of the operation.

The event chart in figure OP.1 is saved as P_OE.

Combining proximity results:

To determine the total proximity we need to overlay the temperature, depth and ocean depth proximity results.

Overlay proximity events

Click the **Create multi event chart** button and select all the proximity event files (see figure EO.1).

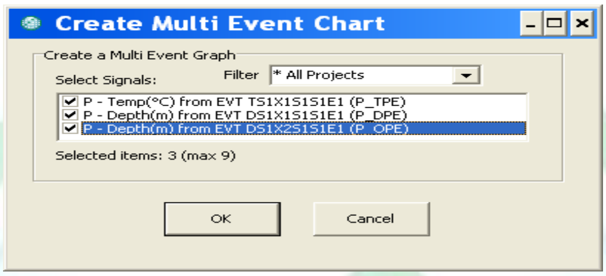


Figure EO.1 Event overlay files selection

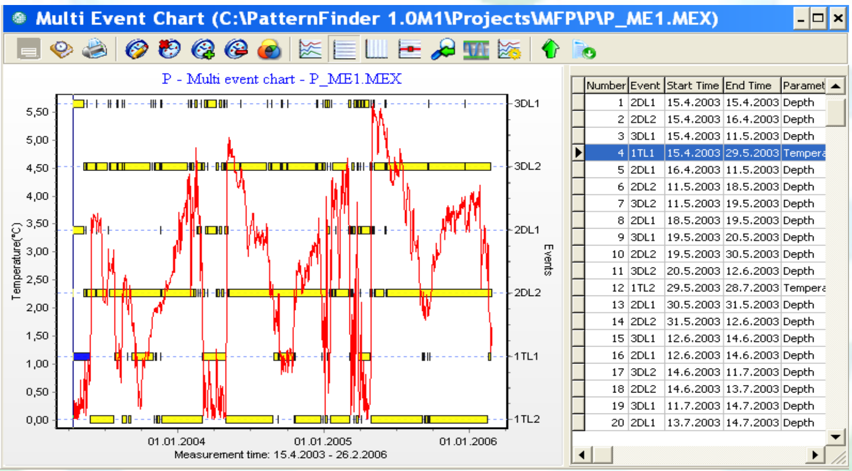
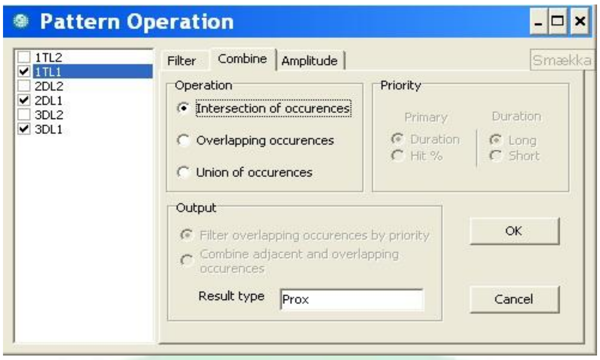


Figure OE.2 Multiple Proximity Event chart

The multi event chart in figure OE.2 is saved as P_MPE.

Find Intersecting Event

To determine the total proximity select the **events operations** button on the multi event chart. The total proximation is defined by the three events: 1TL1, 2DL1 and 3DL1. The name of intersecting event is Prox.



I.1 Intersection events selection

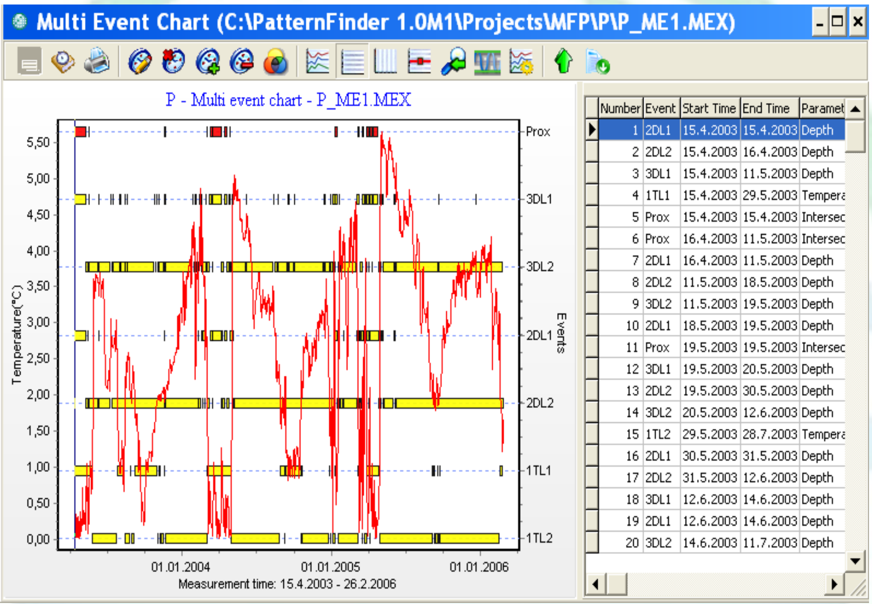


Figure I.2 Prox is the Total Proximity event

As can be seen in figure I.2 the intersecting event, Prox, is placed on the multi event chart. The Prox event is the intersection of Temperature proximity events, Depth proximity events and ocean depth proximity events. When all three intersect, proximity is assumed.

Periodic Event analysis

Perform an event statistical analysis to get a statistical value of the proximity. Select **Month** as the time-averaging period.

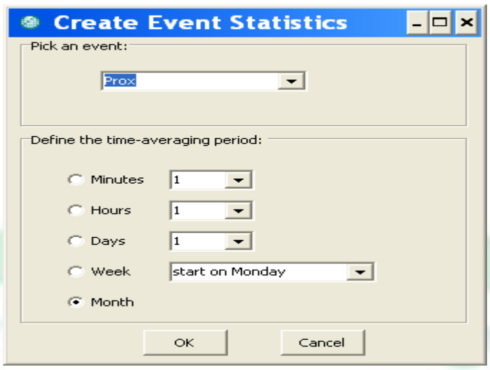
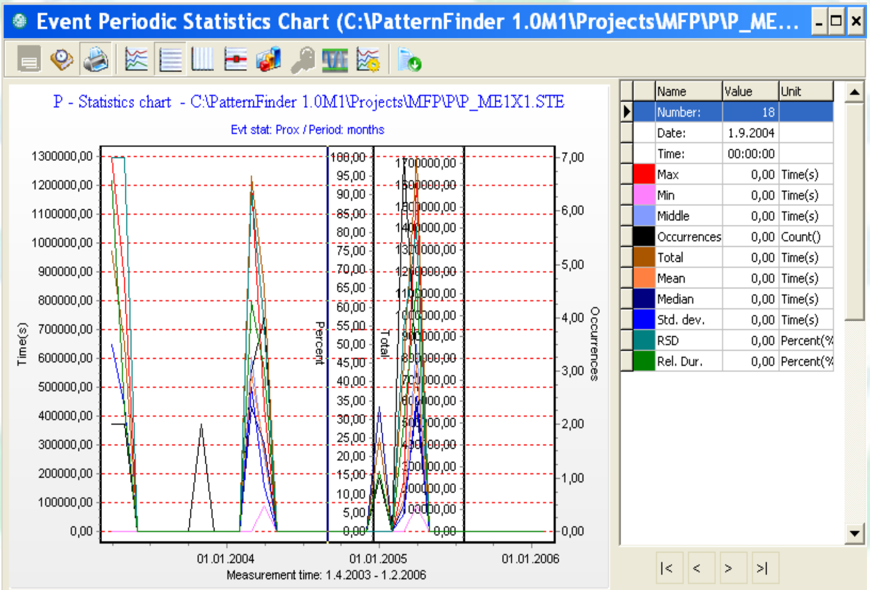


Figure P.1 Periodic Event Analysis



P.2 Periodic events analysis on the Prox event

The event periodic statistics chart in figure P.2 is saved as P_Prox_XM.

Results:

Extract the Rel. Dur. Parameter from P_Prox_XM. The Relative Duration will give us the proximity approximation represented as a monthly percentage.

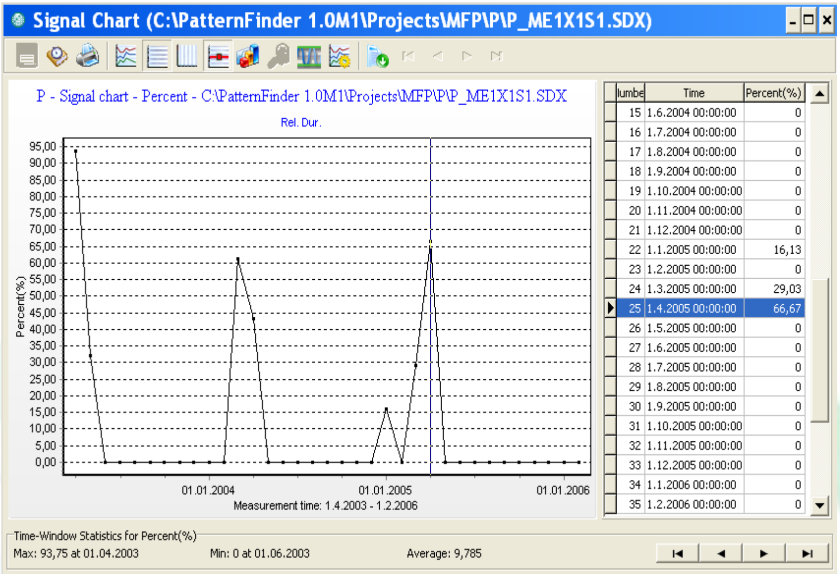


Figure R.1Proximity approximation as a monthly percentage

The signal chart in figure R.1 is saved as P_Prox_%M.

Obviously the first month has a very high value, over 90%. This is understandable as both fish were released simultaneously. This first month will however skew the results statistically and will therefore be removed. The easiest way to do that is to extract the signal from P_Prox_%M, starting at point 2. The resulting file is saved as P_Prox_%M-1.

As the signal covers almost three years it is interesting to look at it on an annual basis. We click the overlay button, select P_Prox_%M-1 and apply annual comparison.

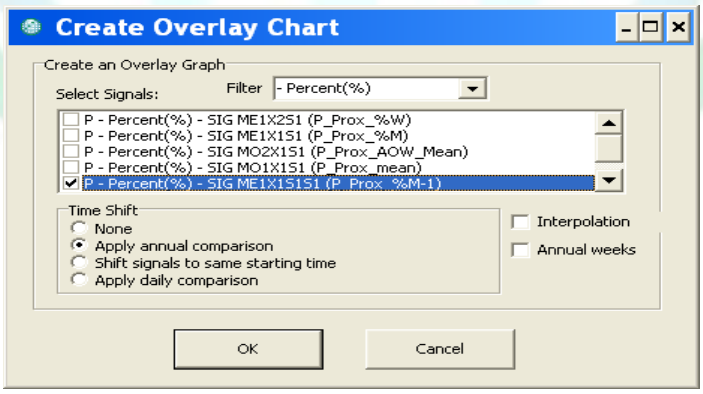


Figure R.2 Annual overlay definition

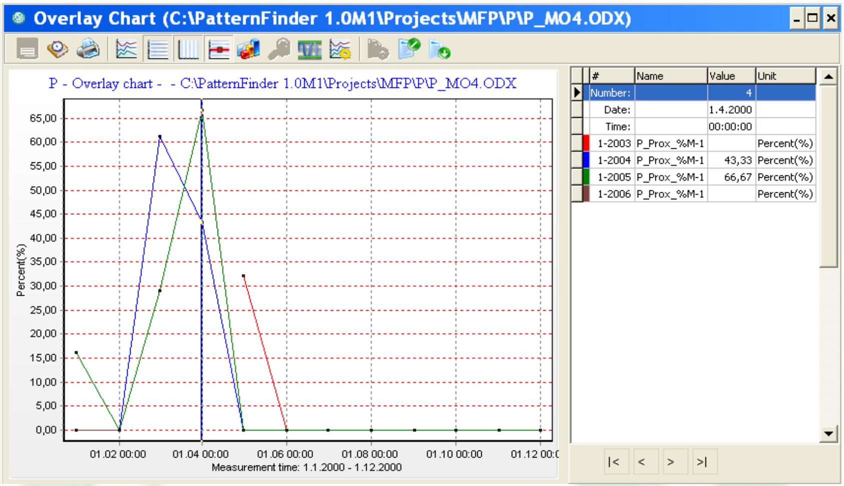


Figure R.3 Annual comparison of proximity as percentage per month

The annual overlay chart in figure R.3 is saved as P_Prox_AOM-1.

The Red curve represents 2003. It starts in May (April was removed).
The blue curve represents 2004 and the green 2005. Both cover a whole year.
The brown curve represents 2006, January and February.
The red curve (2003) seems to be a bit shifted compared to 2004 and 2005.

To view the average value we perform an overlay statistical operation.

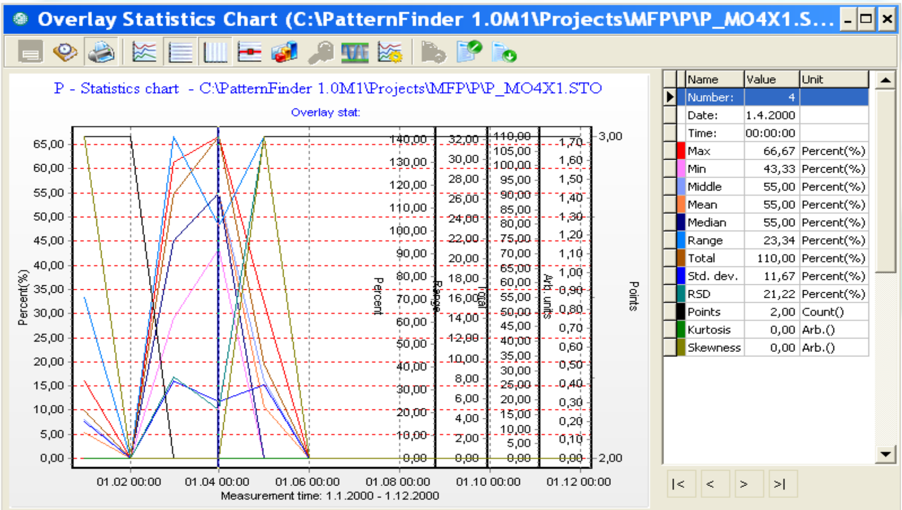


Figure R.4 Statistics result of annual proximity

The overlay statistics chart in figure R.4 is saved as P_Prox_AOM-1_X.

By extracting the **Mean** parameter from P_Prox_AOM-1_X we get the annual proximity as a monthly percentage.

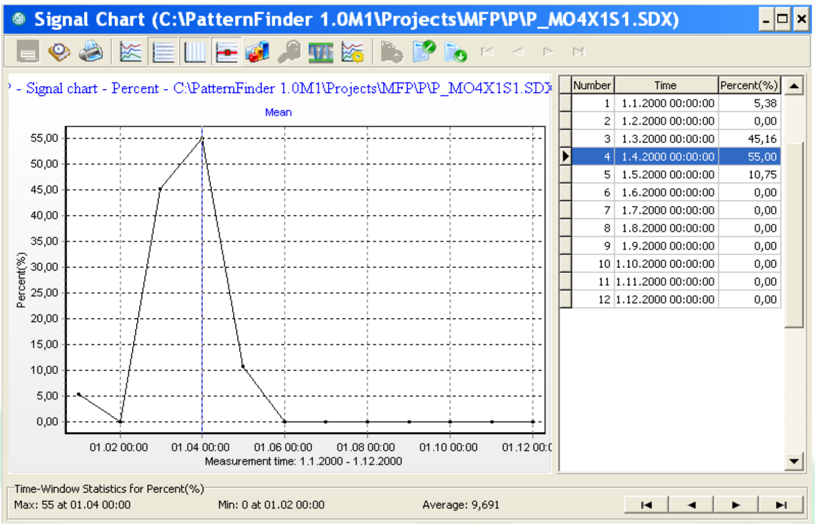


Figure R.5 Average proximity per month

The signal chart in figure R.5 is saved as P_Prox_AOM-1_Mean.

From figure R.5 it can be seen that there is no proximity for most of the year. But in Mars and April proximity ranges from 45% to 55%.

References:

This case study is based on data from two DST-centi recorders manufactured by Star-Oddi.

The tagged cod were a part of a multinational tagging project, CODISSEY, which was supported by the EU. In Iceland the project was managed by Vilhjamur Thorsteinsson at MRI (Iceland).

A paper that uses data from the tagging project has been written:

Grabowski TB, V Thorsteinsson, BJ McAdam, G Marteindottir. “Evidence of Segregated Spawning in a Single Marine Fish Stock: Sympatric Divergence of Ecotypes in Icelandic Cod?”.