Dr.philos. Thesis

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The Lunar nodal cycle influence on the Barents Sea

Chosen Trial

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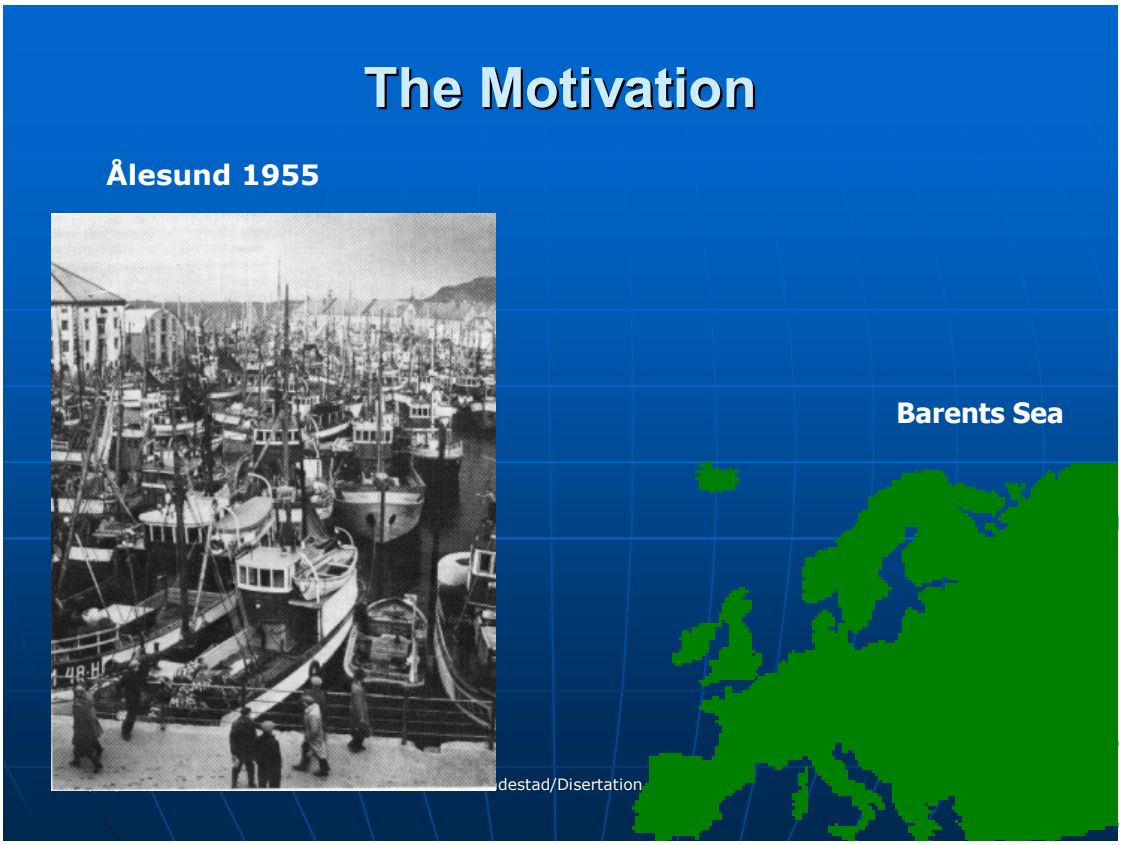
The Motivation



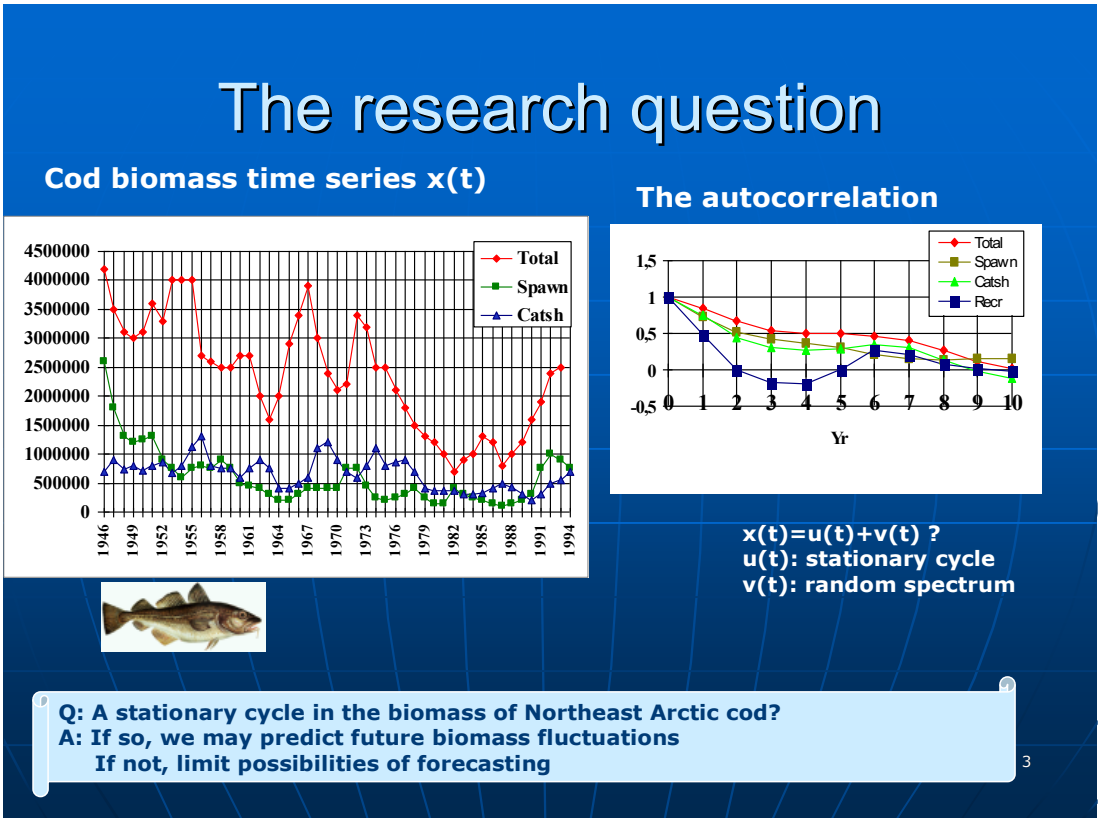
Question: Why this topic?

This is a picture from Aalesund, when I was a young boy in the 1950's.
The harbor was full of fishing boats.
Everybody was involved in the fishing industry, one way or another.
The whole town was a complete marine cluster, to get more fish, selling more fish, and develop better equipment to get the fish faster.

Everybody was happy, till the fish disappeared.

1. Fisheries have represented the foundation for the economy on Norwegian coastline over a period of more than thousand years.
2. At the same time, there has always been large fluctuations in the fisheries
3. People had food, money and wealth in good times.
4. Many were hungry in bad times.
5. 100 years ago, marine science was established to gain better biomass forecasts.
6. Better long-term planning was the motivation for better planning of the economy and settlements on the Norwegian coastline.

The Research Question



This is the time series of Northeast Arctic cod from 1946 to 1995. The biggest stock of cod in the world.

About 10 years ago I was engaged in a project to answer the question

1. Is it possible to forecast the future stock of cod the next 15 years?
2. If it is possible, we may forecast potential income to the fishery. A good question where I live.

The autocorrelation

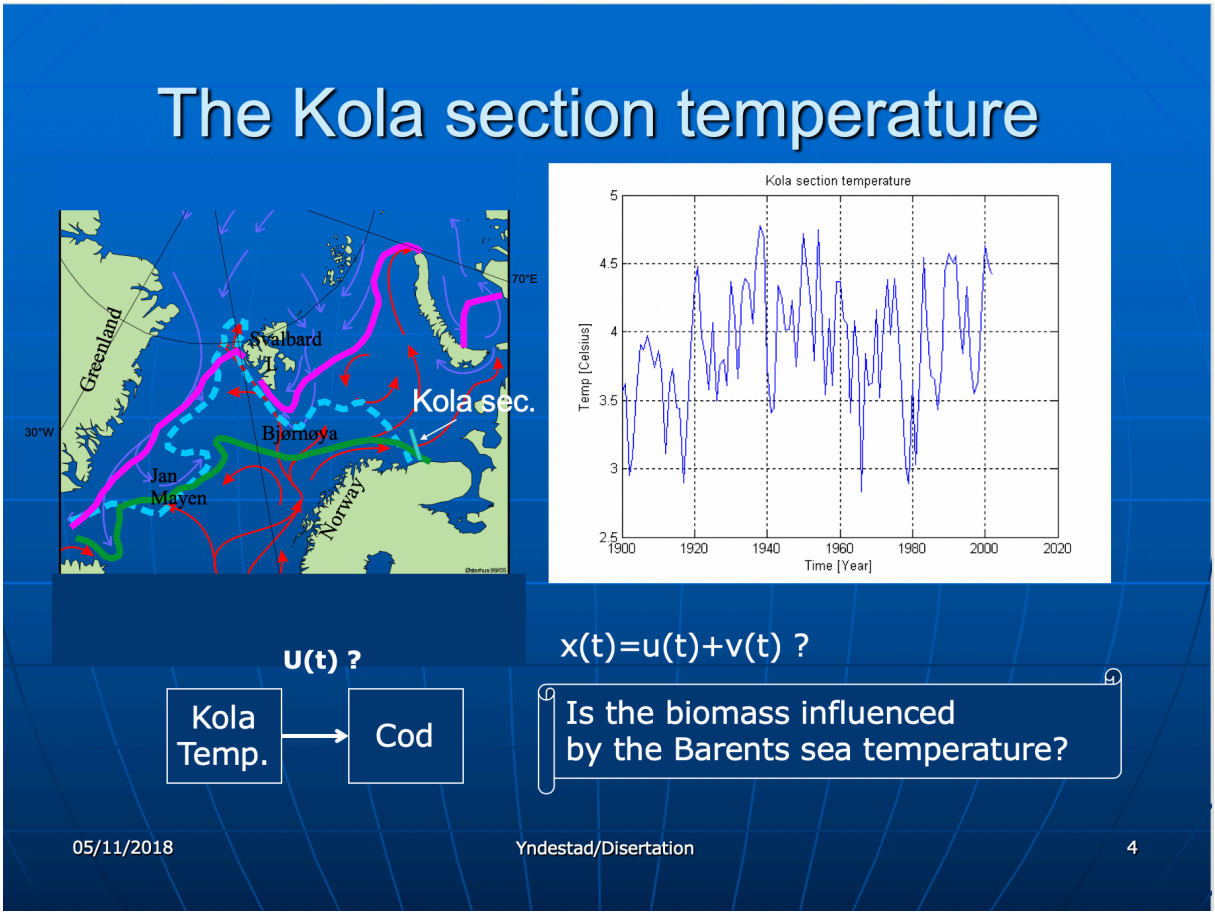
This is the Autocorrelation function of the same time series

1. The rapid falling autocorrelation indicates, a forecast of more than a year, is not realistic.
2. But the autocorrelation indicated a 6-year cycle

So, the next question was.

1. Is there a 6-year stationary cycle in the biomass?
2. If there is a stationary cycle, we may forecast the best time to invest in fishery

The Kola section temperature



If there is a stationary cycle, it must come from something fundamental in nature.
A potential source is the sea temperature.

This slide shows the temperature data series from the Kola section in the Barents Sea. Russian scientists have monitored this time series, each month in a period of 100 years.

A cross correlation analysis identified easily a 6-year cycle in the temperature

1. But, where does this 6-year cycle come from?
2. Is there a random or a stationary 6 years cycle in the sea temperature?

If it is a stationary cycle, it must come from something more fundamental in nature.

1. A possible source is the tide or the earth rotation.
2. More investigations showed the 6 years cycle was a 3. harmonic of the 18.6 years Earth nutation cycle.

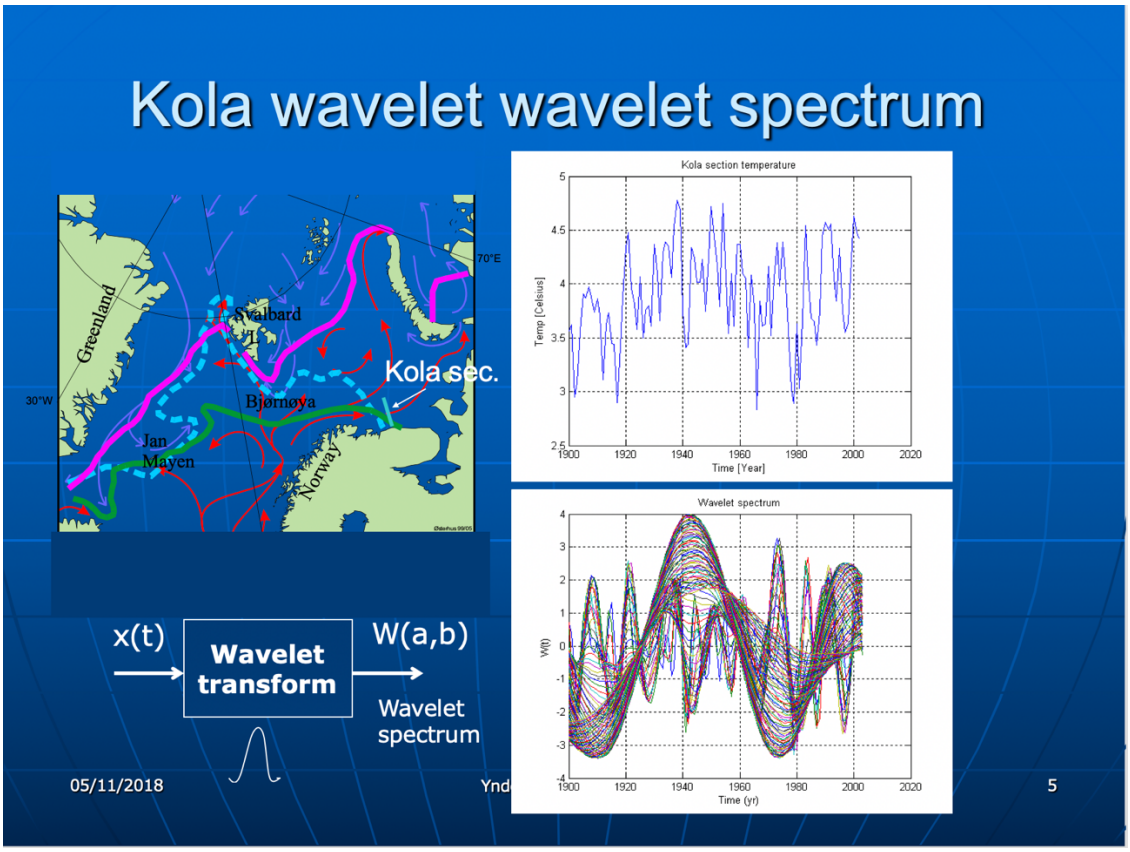
A closer study showed, however, the spectrum was not the same in the first and the second part of the time series. This introduced a new challenge. This is a time variant spectrum that

1. excludes standard spectrum analysis methods
2. excludes standard statistic verification methods

Later I found that this was the normal situation in all-time series from nature.

The next years I analyzed a large number of time series from nature. All was time variant, and I had to develop a different analysis method.

The Kola wavelet spectrum



The wavelet spectrum

The time variant problem was solved by a wavelet transform of the time series.
A wavelet transform is a correlation between the time series and a bell-shaped pulse.
A correlation to a set of pulses, gives us a wavelet spectrum.
The pulse width that has the best correlation, has a maximum wavelet response.
By this method it is possible to identify single dominant cycle periods in time series.

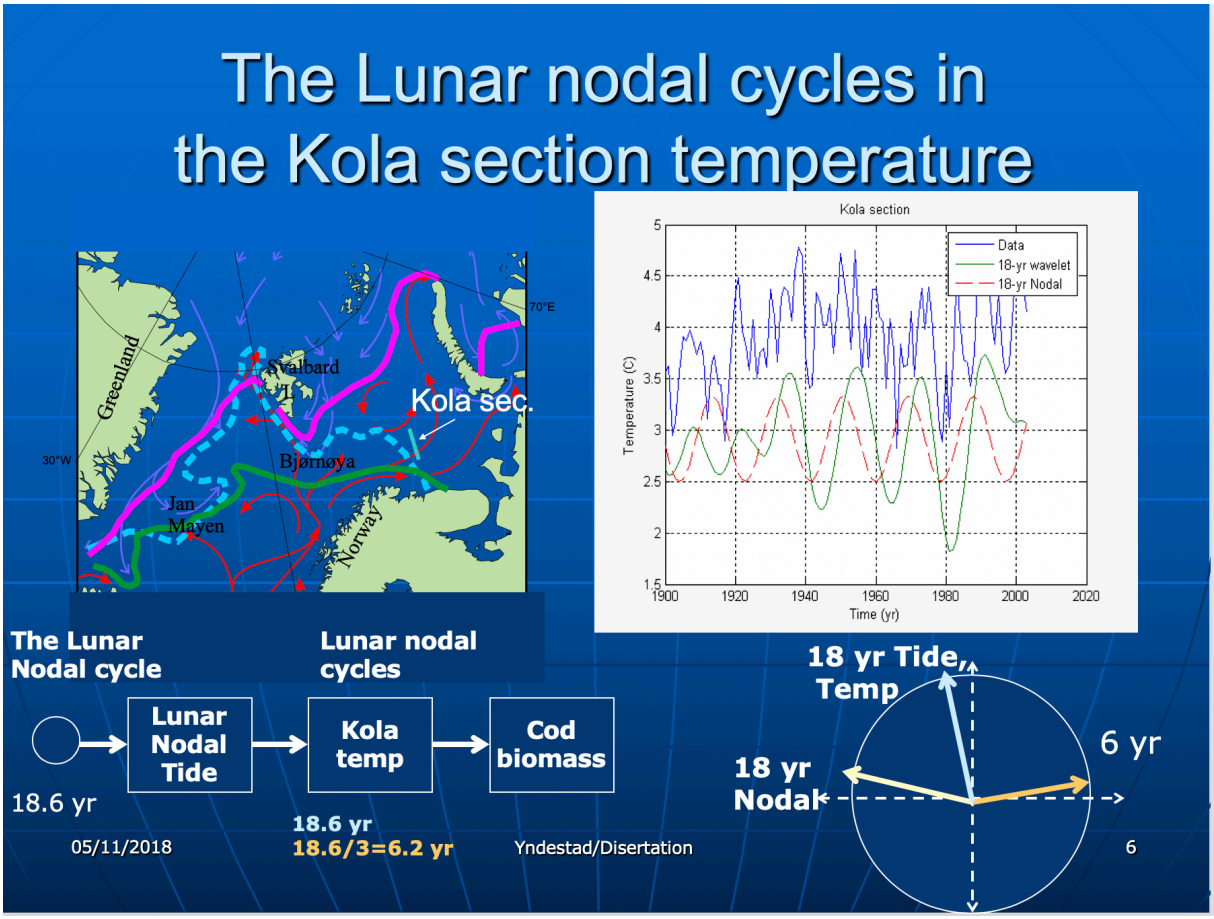
The slide shows the wavelet transform of the Kola section time series.
It shows that come cycles, are more dominant than others.

The cycle phases

And the best thing, we are able to identify the cycle phase. This information is of most importance, because this is information about the timing of events.

1. By this way, we are able to study the timing of events, between a set of time series.
2. Timing of events between a set of time series, say something about a chain of causes.

Lunar nodal cycles in Kola temperature



After a wavelet transform, it is easy to select the most dominant wavelet cycles in the spectrum. These cycles are a reflection of dynamic causes in nature. The next question than is: What may be the cause of the fluctuations?

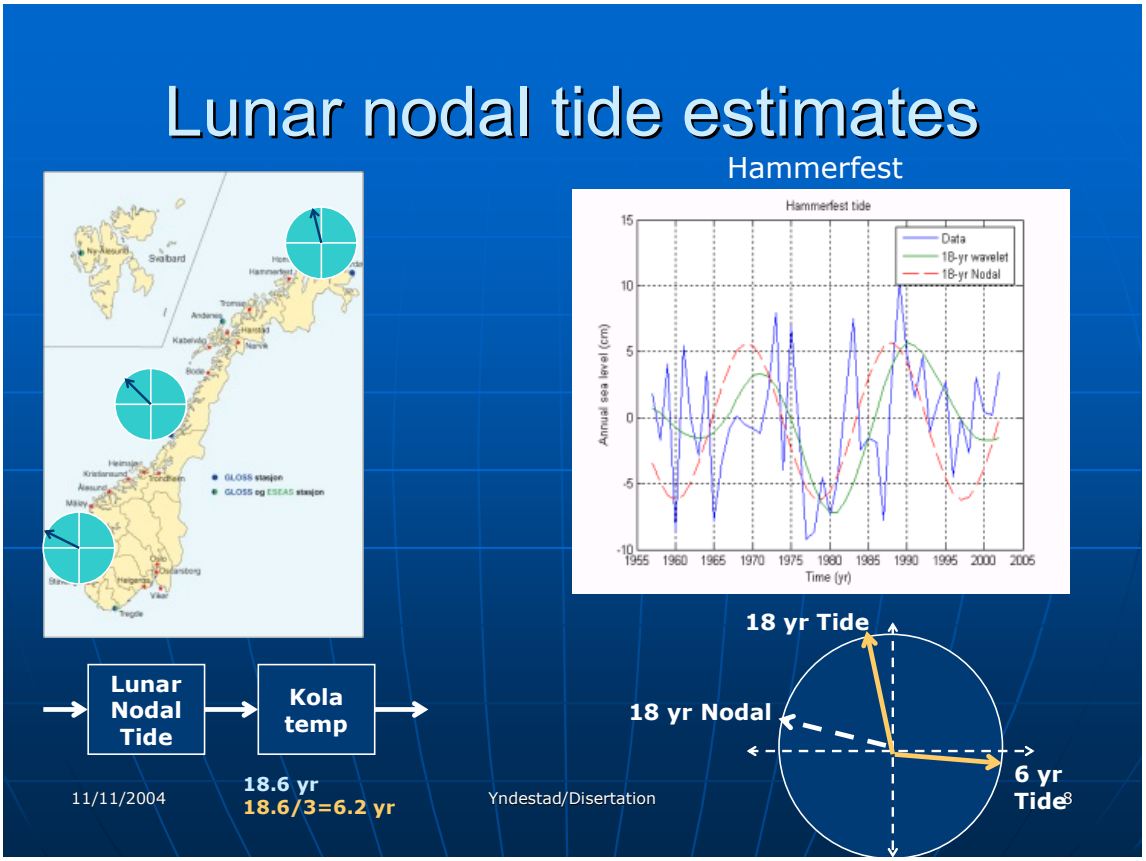
This slide shows the Kola temperature series, the 18 years wavelet cycle and a perfect 18.6 years lunar cycle. It shows that

1. There is an 18 years cycle in the Kola spectrum.
2. This cycle has a phase delay of about 3 years behind the lunar nodal cycle
3. The 18 years cycle has a 180-degree phase-reversal at about 1920 An important discovery.

A closer analysis showed that.

4. There is a 3. harmonic 6 years cycle in the Kola spectrum. This explained a possible relation to the cod biomass fluctuation
5. There is a 3. sub harmonic cycle of about 55 years.

The Hammerfest tides



The Kola section time series is an indicator of warm Atlantic inflow to the Barents Sea.
The close correlation to the 18.6 years cycle, indicates that the 18.6 years lunar nodal tide may be the source of the dominant temperature fluctuations.

This slide shows the time series of

1. the annual mean sea level at Hammerfest.
2. the dominant 18 years cycle
3. the perfect 18.6 years lunar nodal cycle

The results

1. The dominant 18 years Kola cycle is correlated to this dominant Hammerfest 18 years cycle
2. But, delayed about a year

More investigations have

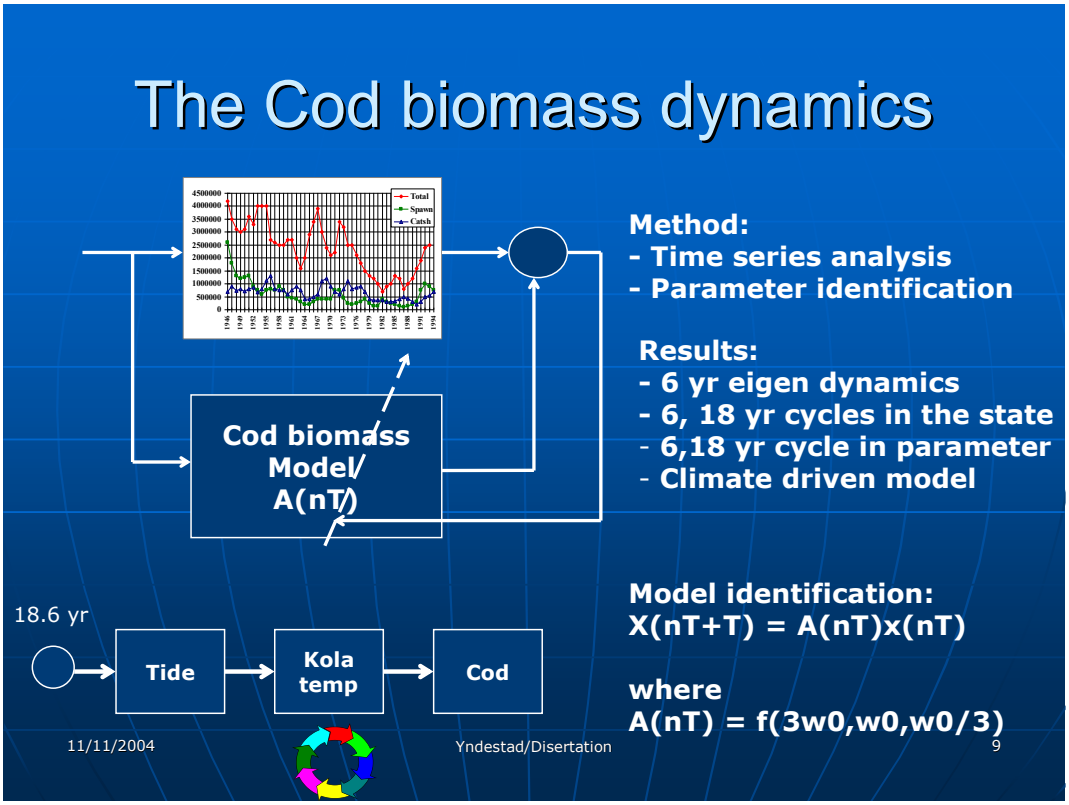
1. Identified the 18.6 years tide in a number sea level time series on the coastline between Oslo and Murmansk.
2. The lunar nodal tide has a phase delay of about 3 years between Møre and Lofoten

The lunar nodal vertical tide is only about 5 cm.
So, why is this tide so important? The answer is:

1. It represents a small stationary force over a long period in one direction.
2. It represents a small stationary force over a large area in the same direction

In other words, it is the sum of the many small events in the same direction.

Cod biomass dynamics



The identification of a lunar nodal spectrum in the Kola temperature indicate
There is a set of temporary stationary cycle in the Barents Sea.
The next question was:

1. What is the influence on biomass of Northeast Arctic cod?
2. It is possible to make a biomass forecast for the next 20 years?

To answer this question, it was identified a cod biomass model.

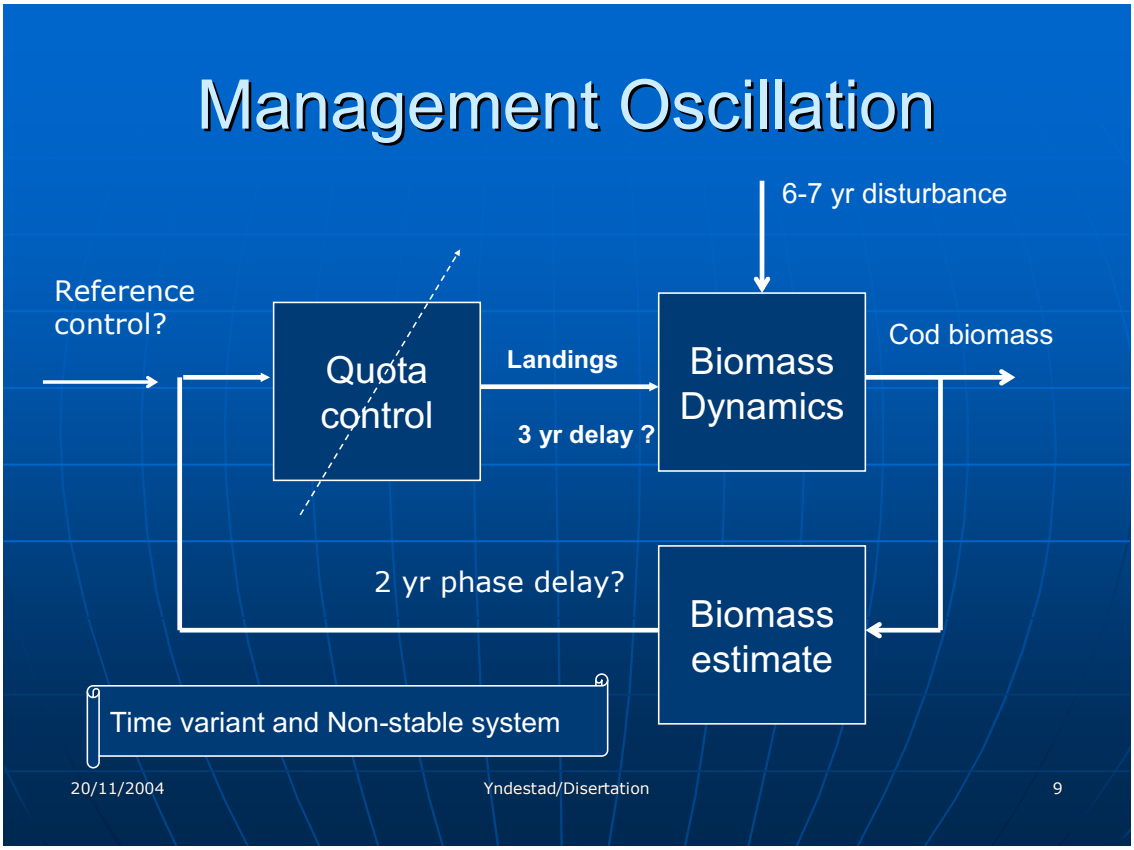
1. The model was based on more than 100 difference equations.
2. The model was adapted to climate change, by an adoption to the lunar tide cycles.
3. The model had 20 years forecast period

The results showed

1. Recruitment is related exponentially to the Kola temperature spectrum
2. The parameters are related to the lunar nodal spectrum
3. The eigen dynamics (resonance) is related to the 6 years cycle

From this analysis I had an answer:
There is a stationary cycle in the cod biomass, but it is a temporary stationary cycle.

Cod biomass management



The model had a good recruitment model. This opened a possibility of estimating a 20-year forecast model. A 20-year forecast model is an interesting exercise. It tells you something about the long-term biomass dynamics.

1. How a large fluctuation one year, will influence the next biomass generations
2. How a different quota control strategy will influence the biomass dynamics

The next question:
How does the management influence the biomass fluctuations?

This slide shows a simple concept model.

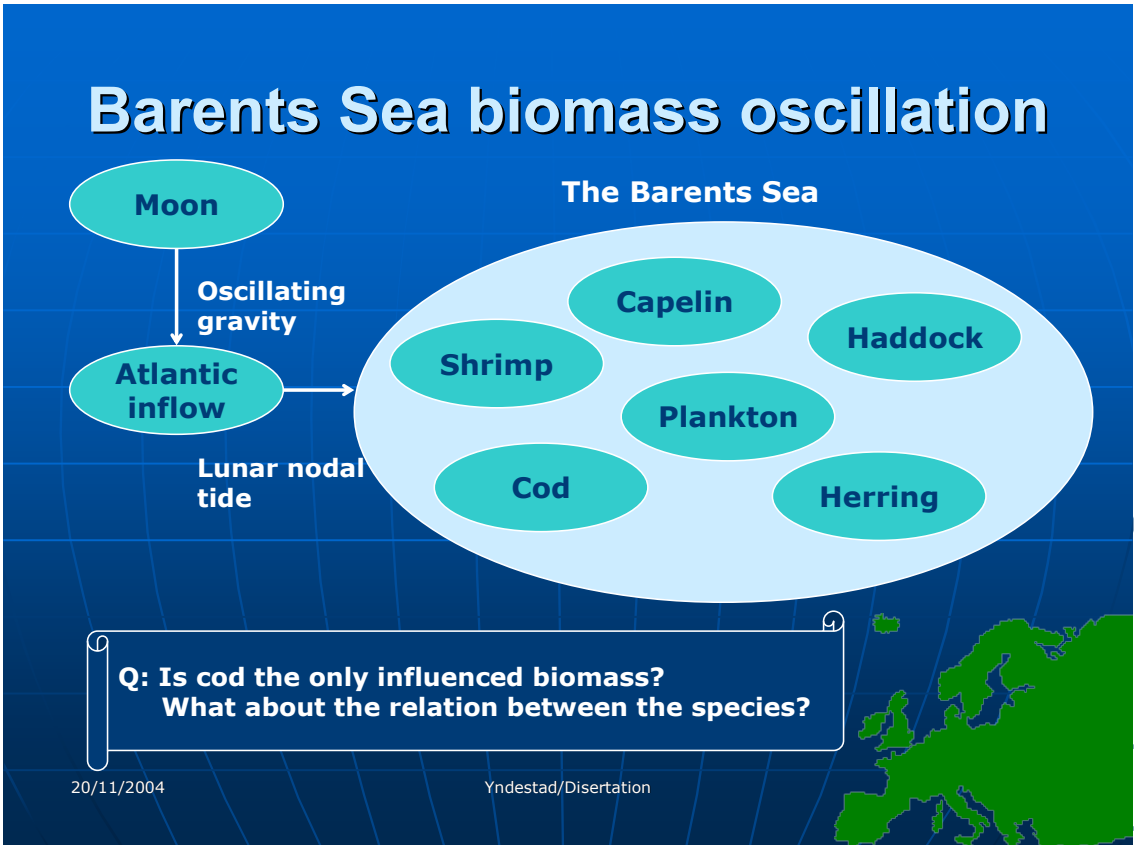
1. The biomass has a growth dynamic, influenced by temperature cycles of about 6 and 18 years.
2. The biomass is estimated by data 10 years back in time and produces a phase delay in the last estimate.
3. The biomass quota is adjusted each year, or every 3. years.
4. Before 20 to 50 percent of the quota is taken each year.

If we look at this system as a control problem.

1. We have a feedback instability of about 6 years
2. There is no long-term control strategy
3. There is no reference to a wanted biomass state

In other words, the management will introduce more unstable biomass fluctuations.

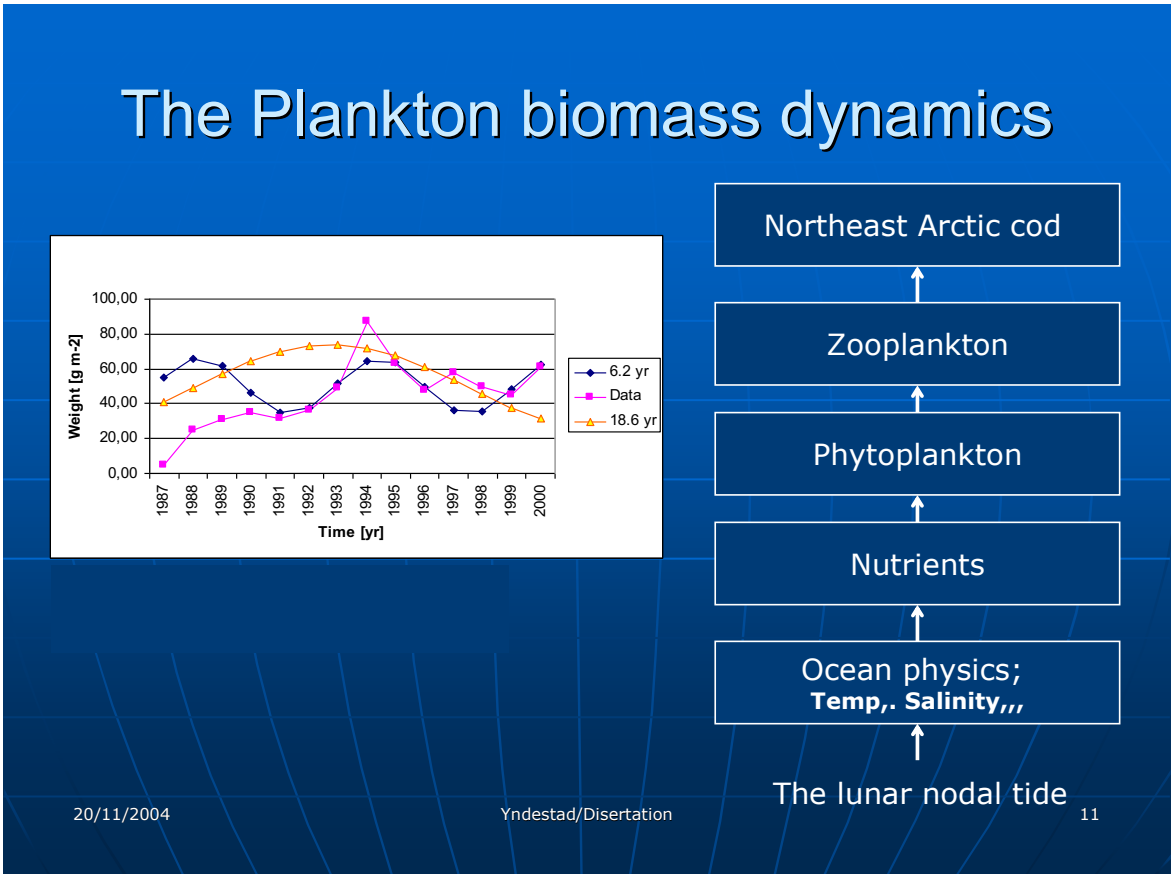
The Barents Sea biomass oscillation



The analysis of the Kola section temperature and the biomass of Northeast Arctic cod indicated a stationary cycle in the biomass. At the same time, it opened a new set of questions.

1. What about the other species? If this is caused by the tide, it may influence all species.
2. How does the relation between the species influence the dynamics?
3. Why are there 50 to 80 years fluctuations of herring?

Plankton dynamics



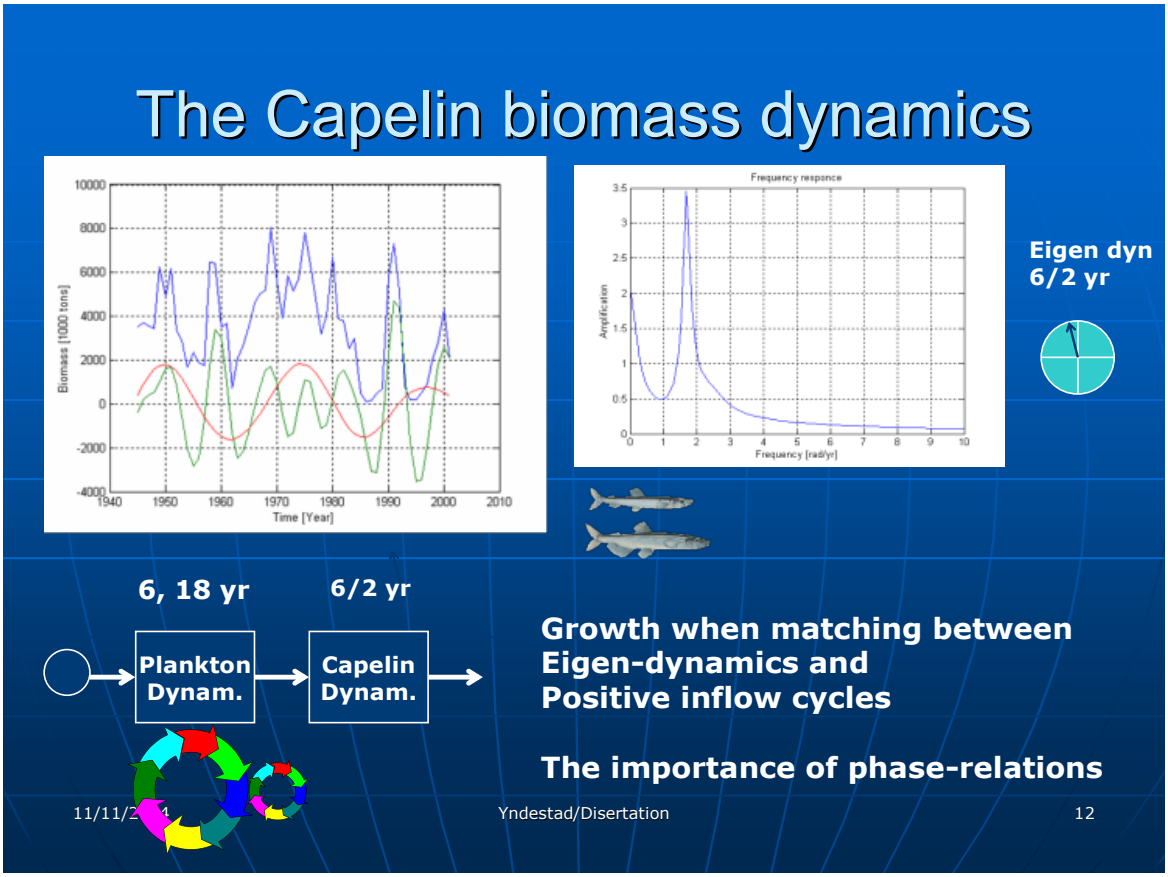
The exponential relation between the Kola temperature cycles and cod recruitment, indicated there must be something between. The temperature is only an indicator of biomass growth.

This slide shows some relations in the food web.

1. The lunar nodal tide influences the ocean physics
2. Ocean physics influences Nutrients
3. Nutrients influences the phytoplankton biomass
4. Phytoplankton influences zooplankton biomass
5. The zooplankton biomass influences how much larvae from cod that will survive

We have no long time series of nutrients and phytoplankton from the Barents Sea. Only a short time series of zooplankton. This short time series indicates a math between zooplankton fluctuations and the identified tide cycles.

Capelin biomass dynamics



The next step was to study more closely the fundamental dynamics of the other species in the Barents Sea. Barents Sea capelin dynamics was studied first, because it is special.

1. Capelin is an important biomass in the food chain to other biomasses
2. The biomass is well known for large fluctuation
3. The fluctuation was not well understood.

The analysis was based on a

1. A biomass growth model
2. Wavelet analysis of time series

The biomass model was converted to a frequency transfer function in a MATLAB computer program. To my surprise there was a sharp resonance at a frequency of about 6.2/2=3.1 years. This showed that:

1. The biomass had a resonance cycle time, which was the half of the 6.2 years Kola temperature cycle.
2. This mean the capelin biomass has a strategy of getting maximum growth every second generation.

This result told me something more.

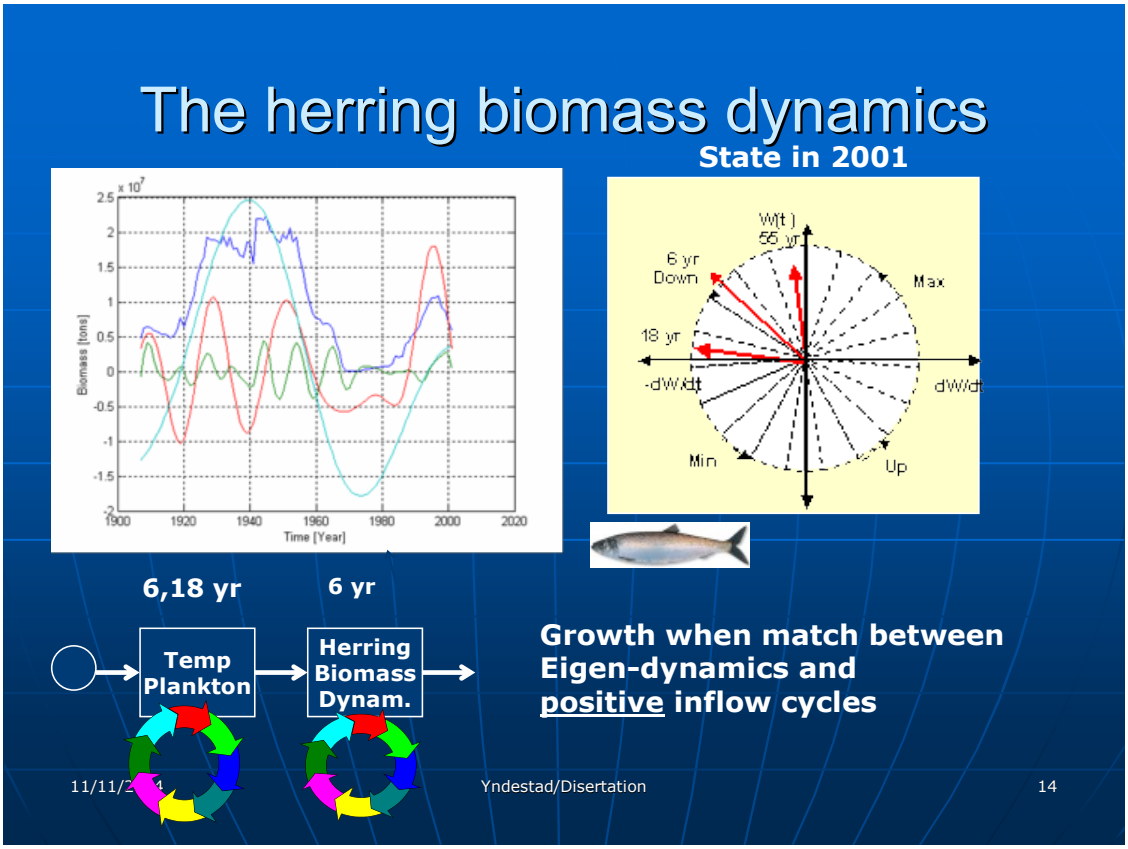
1. The importance of the phase in a biomass fluctuation.
2. It is the phase in biomass fluctuation, that controls the long-term growth.

A closer study of the capelin biomass time series showed that.

1. The biomass has a synchronization to a 6.2 years cycle when the 18.6 years tide is positive
2. The biomass has a synchronization to a 9 years cycle when the 18.6 years tide is negative

At the moment the 18.6 years tide is at a negative state. According to this theory, it explains why the capelin biomass is in a negative state. The next large growth period is expected to be at about 2009.
In other words, it is not the right time to invest in marine fisheries.

Herring biomass dynamics



The analysis of the Barents Sea capelin dynamics put forward another question.
Why are there long-term biomass fluctuations of Norwegian Spring herring? The long-term biomass fluctuation of herring has been discussed over a period of more than 100 years. Landings records from Sweden have showed that the herring fishery in Gulmarfjord had temporary cycles of about 80 years the last 1000 years. Historical records from Norway shows similar long-term fluctuations.

This time the analysis was based on the same method.

1. A Dynamic biomass model based on difference equations
2. Analysis of parameter fluctuations
3. Eigen dynamic analysis of the biomass (resonance).
4. Wavelet analysis of the time series

The results showed that

1. Biomass had an eigen dynamics at about 6 years. The same cycle time as the 6 years cycle tide.
2. The biomass was growing when the 6 and the 18 years cycle were positive at the same time.
3. The biomass was reduced when the 6 and the 18 years cycle were not positive at the same time.
4. The biomass was reduced to a minimum when the 6 and the 18 years cycle were negative the same time.

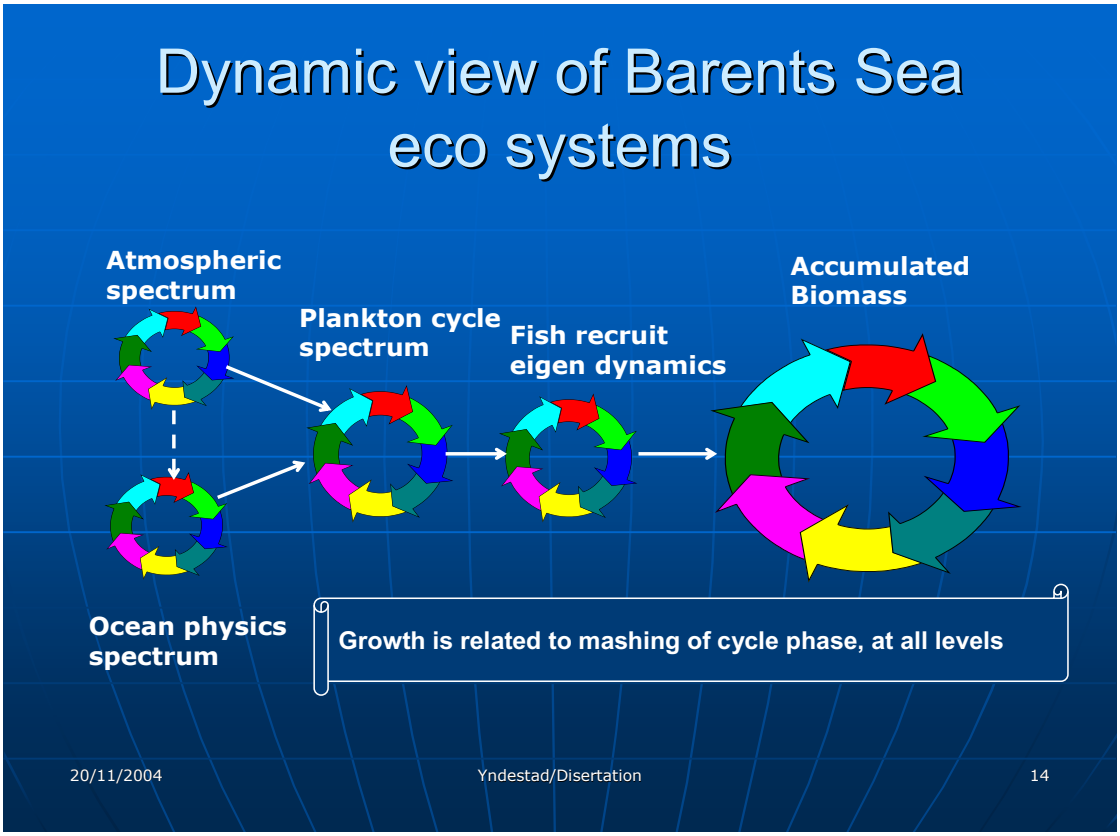
Biomass growth is related to:

1. The tidal cycles of Atlantic inflow to the Barents Sea
2. The phase-relation between the tidal cycles
3. The phase-relation between the tidal cycles and the biomass eigen dynamics.

In other words, a matching theory on all levels.

Later investigations have shoved the 18 years lunar nodal tide influences the fluctuation of temperature and salinity on the coastline where the herring biomass is spawning.

Dynamic view of Barents Sea eco system



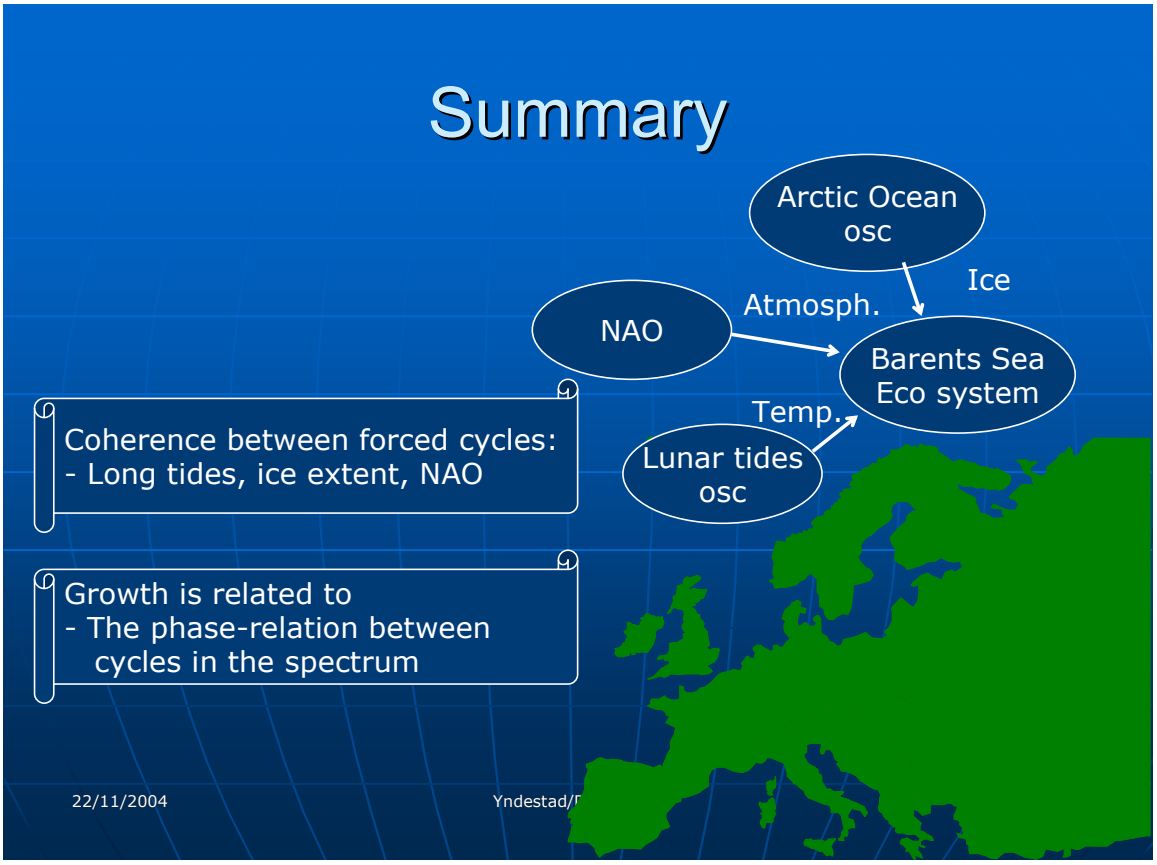
The same type of dynamics was identified in the biomass of Shrimps, cod and Haddock.

This slide shows a simplified model that illustrates the chain of long-term dynamics.

1. The ocean physics state in the sea and the atmospheric state has a spectrum
2. An integration of the many events in the same direction, will influence the Phytoplankton and the zooplankton state dynamics.
3. The matching between plankton dynamics and spawning dynamics, will influence the biomass recruitment.
4. Matching in a set of life cycles leads to a long-term biomass growth.

In other words:
Long-term growth is based on the many small fluctuations in the same direction.

Summary



The Barents Sea eco system has complex dynamics in the food web from the ocean physics to management of the single species.

The time series analysis indicates that the spectrum from the Lunar nodal tide, Barents Sea ice extent and the NAO winter index are influencing the biomasses in the same direction.

1. The biomass growth than is related to the phase-relation between the spectrum from the long-term tides and the biomass eigen dynamics
2. This explain why the Barents Sea eco system has large fluctuations on a few species.

In other words,

1. Growth is not associated with a linear change in the temperature
2. Growth is not associated with fluctuations and mashing
3. If the phase of the stationary cycle changes, it influences biomass growth

In the same way:

1. If the phase between biomass fluctuations and investment changes
2. It influences economic growth

The biomass and investment must follow the same roles to grow.