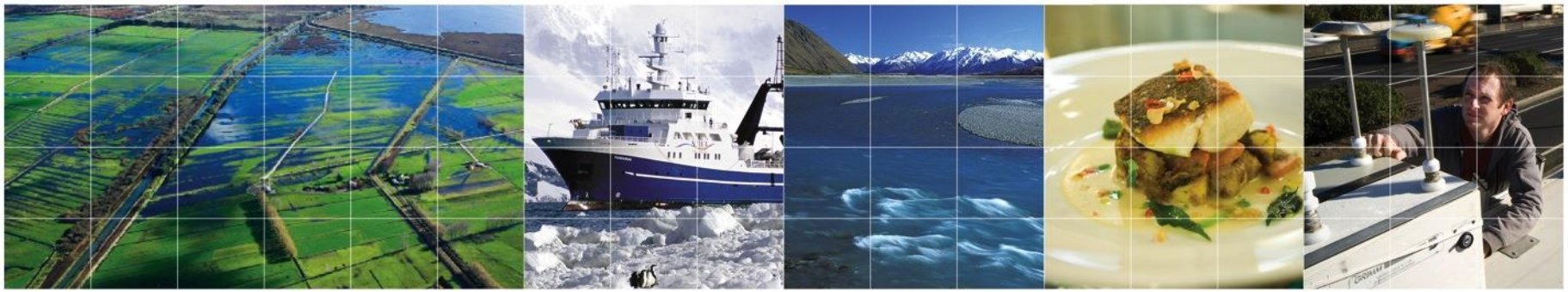
NIWA
Taihoro Nukurangi

Broadening the management perspective for snapper (*Pagrus auratus*) in the Hauraki Gulf, New Zealand, with a Bayesian belief network

Darren Parsons, Bruce Hartill, Jeremy McKenzie, Niall Broekhuizen and Carolyn Lundquist



Broadening the management perspective for snapper (*Pagrus auratus*) in the Hauraki Gulf, New Zealand, with a Bayesian belief network

In this talk I describe a BN model of the snapper fishery in the New Zealand Hauraki Gulf

The core purpose of our BN is to illustrate to stakeholders how non-fishing related factors might influence snapper numbers in the future

Presentation structure

1. Ecosystem Approaches to Fisheries
2. A description of the Hauraki Gulf marine ecosystem
3. An overview of Hauraki Gulf snapper stock status and ecology
4. The BN model structure
5. Some model predictions
6. Conclusions

Ecosystem Approaches to Fisheries (EAF)

”Traditional” fisheries assessment and management largely focused on the productivity dynamics of a single species in a given area termed **stocks**.

A primary objective of “traditional” fisheries management is to optimise yield by setting appropriate limits on exploitation. For the most part the net effect of broader marine ecosystem in “traditional” fisheries assessments is assumed to be constant.

Since the late 1990s there has been an increasing awareness of the importance of the wider marine ecosystem (i.e. trophic processes, habitat quality, fishing impacts) in fisheries management

This shift in thinking has given rise to a new paradigm:

Ecosystem Approaches to Fisheries (EAF)

Ecosystem Approaches to Fisheries

A recognised need under EAF is for greater stakeholder engagement in goal setting, developing management strategies and determining science research needs and directions.

Many of these stakeholders have different expectations and requirements and often contradictory "world views" and levels of understanding.

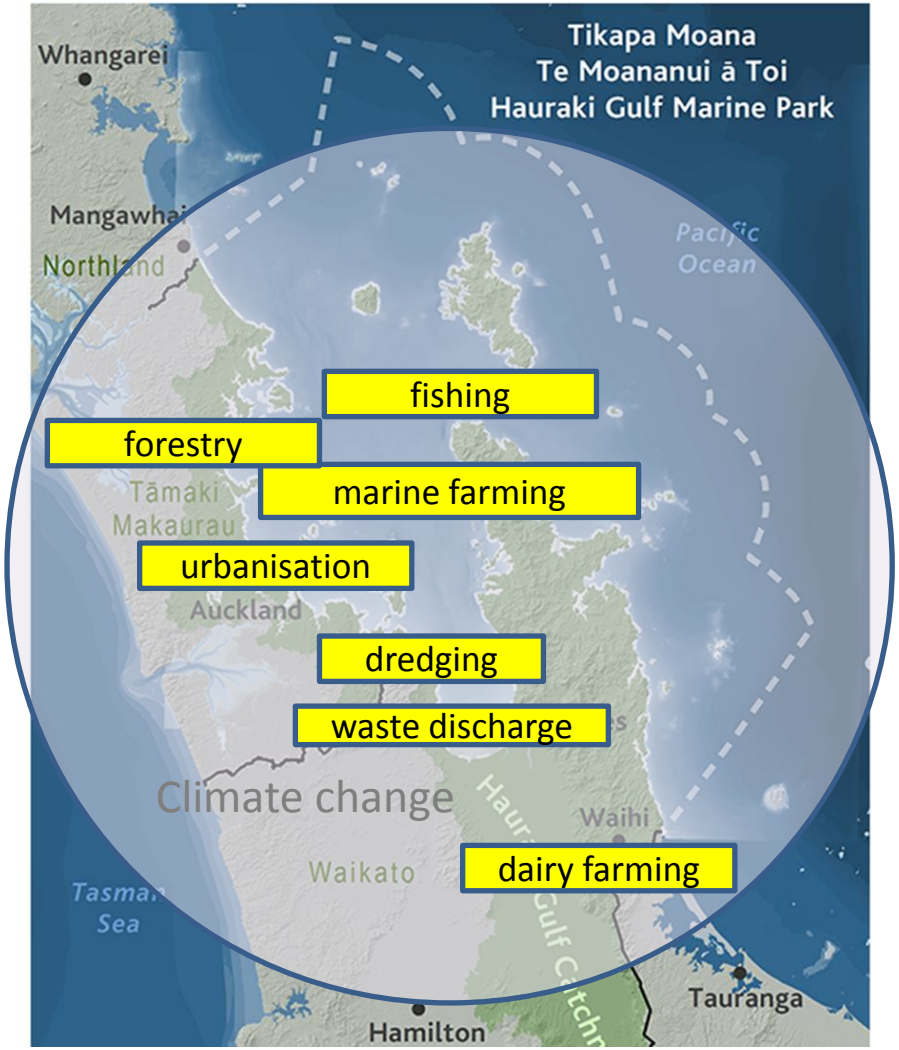
Thus for effective engagement with diverse stakeholders better tools are required to:

- convey complex relationships around ecosystem cause and effect
- compare and contrast different world views
- allow objective consideration of risk and uncertainty
- identify knowledge gaps
- explore trade-offs
- facilitate agreement on environmental outcomes and goals

The probabilistic and states-based nature of BNs make this family of models particularly well suited for demonstrating ecosystem cause and effect and as decision framework tools.

The use of BN modelling in the fisheries management space is relatively new and they are not in common use.

The Hauraki Gulf marine ecosystem



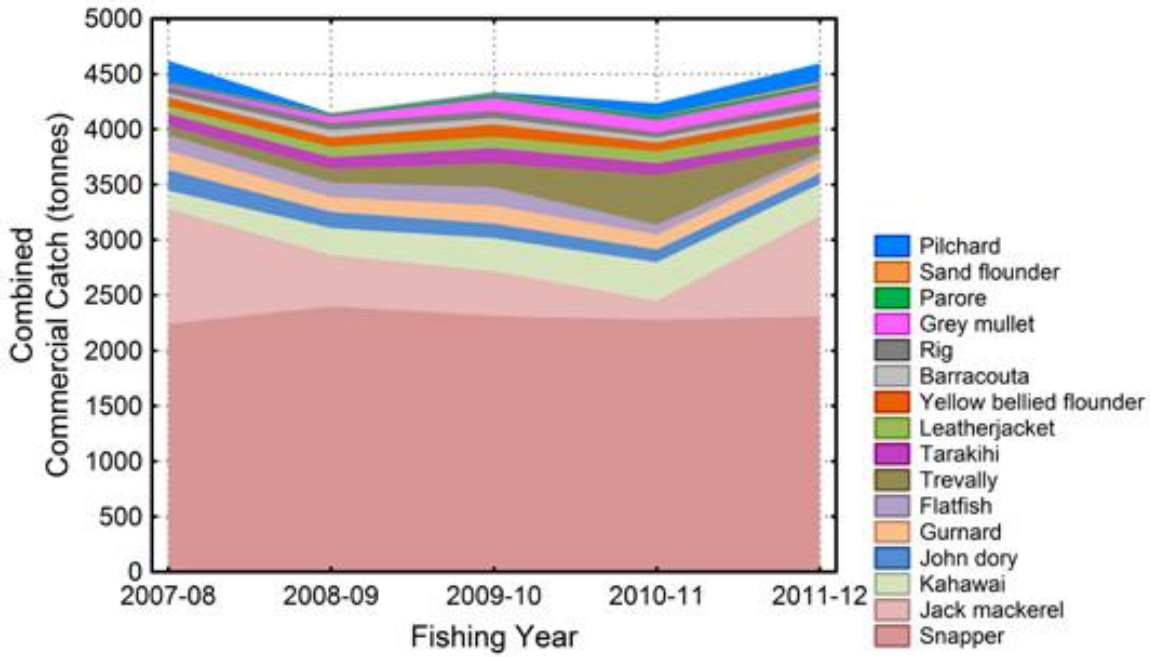
Surrounding New Zealand's largest population centres (pop 1.3 million) from a socio-economic perspective the Hauraki Gulf is one of the country's most important coastal water habitat areas.

Hauraki Gulf marine habitats have been significantly impacted and modified over the past 150 years by human activities in Gulf itself and surrounding catchment. With many of these activities continuing to modify the ecology.

Although external to the Gulf climate change is also likely to be a future driver of ecosystem change.

An overview of Hauraki Gulf snapper stock status and ecology

The Hauraki Gulf supports a large number of commercially and recreationally important fish species the most important being the sea bream or snapper (*Pagrus auratus*)



An overview of Hauraki Gulf snapper stock status and ecology

Stock status

Research suggests Hauraki Gulf snapper comprise one biological stock being the largest of New Zealand's 6 snapper stocks

The annual commercial harvest of approximately 2200 tonnes is exceeded by the recreational catch estimated at 2400 tonnes.

Results from the recent assessment suggest the Hauraki Gulf stock has been rebuilding since 1985 largely in response to above average recruitment but is still below optimum stock levels.

Commercial snapper fishing in the Gulf is constrained by quota such that annual catches have been stable since 1990.

Evidence suggests recreational harvest has been increasing over the last 15 years

Long term modelling projections suggest the Hauraki Gulf snapper stock is likely to decline if recreational catch remains at 2012 levels (this finding in part prompted a reduction in the recreational snapper bag limit in 2013).

An overview of Hauraki Gulf snapper stock status and ecology

Biology

Relatively long lived

Snapper can live up to 60+ years making them relatively long lived compared to other inshore species this implies approximately 7-9% of the adult population dying through natural causes (non-fishing) each year.

Highly fecund

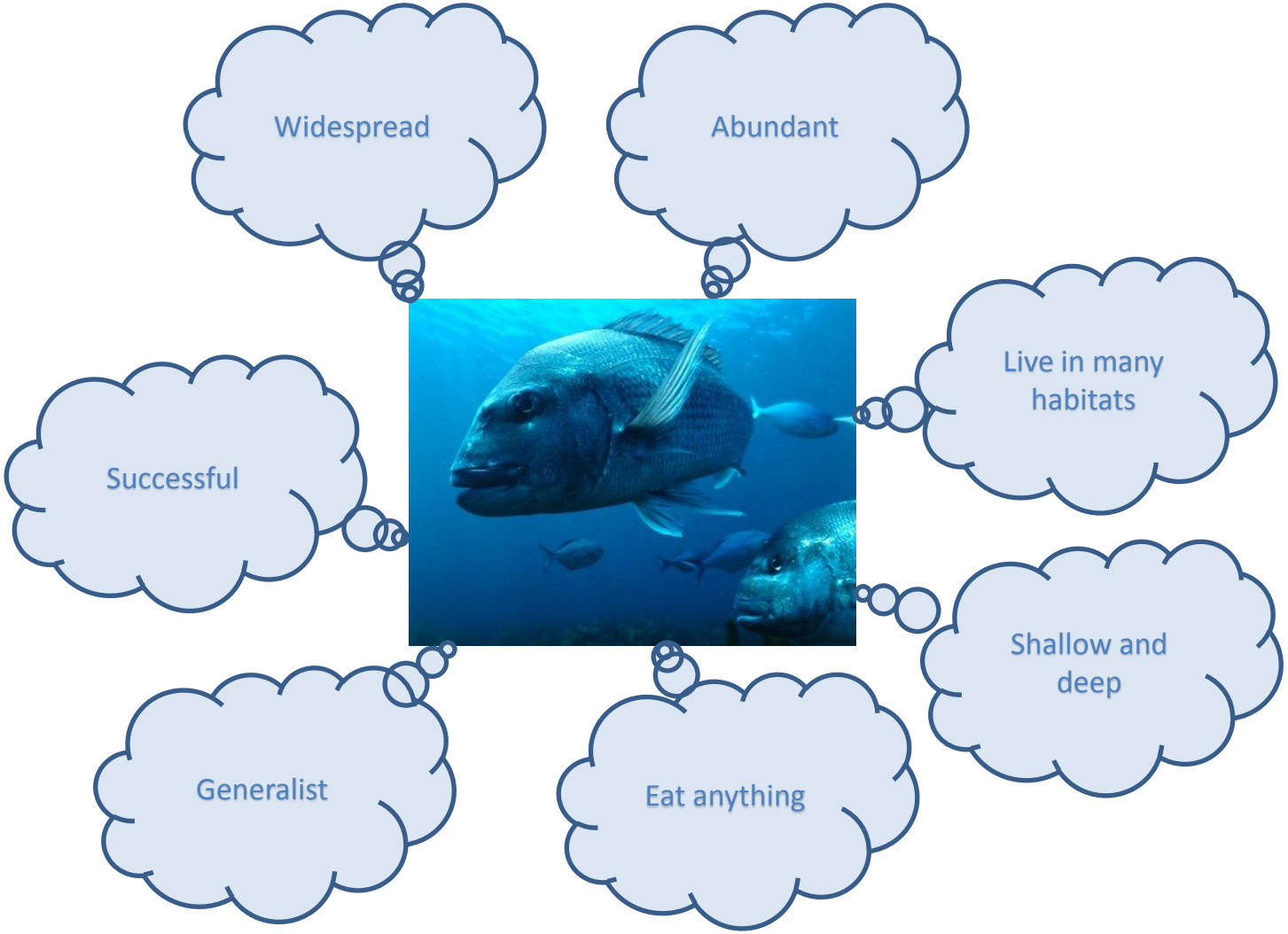
Each mature female snapper releases millions of eggs per year during the spawning season.

The net quantum of eggs released is typically far greater than the environment can support fishing spawning fish therefore is likely to have little or no effect on recruitment success

Annual recruitment success is highly variable and almost certainly environmentally driven

An overview of Hauraki Gulf snapper stock status and ecology

Adult snapper use of the environment



An overview of Hauraki Gulf snapper stock status and ecology

Juvenile snapper use of the environment

Restricted habitat occupation

On the fringe of land and sea

Feed visually – need clear water

Need structure – often living habitat

Specialist

Constrained

Vulnerable

BN model structure

The Hauraki Gulf snapper stock was last assessed in 2013.

In order to investigate the likely effect of other ecosystem drivers on Hauraki Gulf snapper we first had to build a BBN construct of the 2013 assessment model.

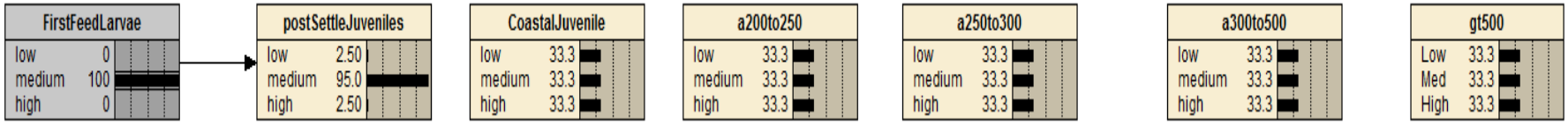
Then “tune” the conditional probability tables so the BN model predictions were consistent with the stock assessment projections.

BN model structure

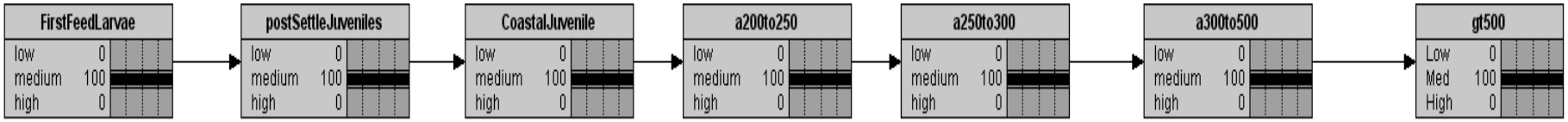
Each node in the core snapper BN model represented a different snapper life history stage in 2050 being in one of three states relative to current (2013):

1. **LOW** (20% or greater below current numbers in 2050)
2. **MEDIUM** (+/- 20% of current numbers in 2050)
3. **HIGH** (20% or greater above current numbers in 2050)

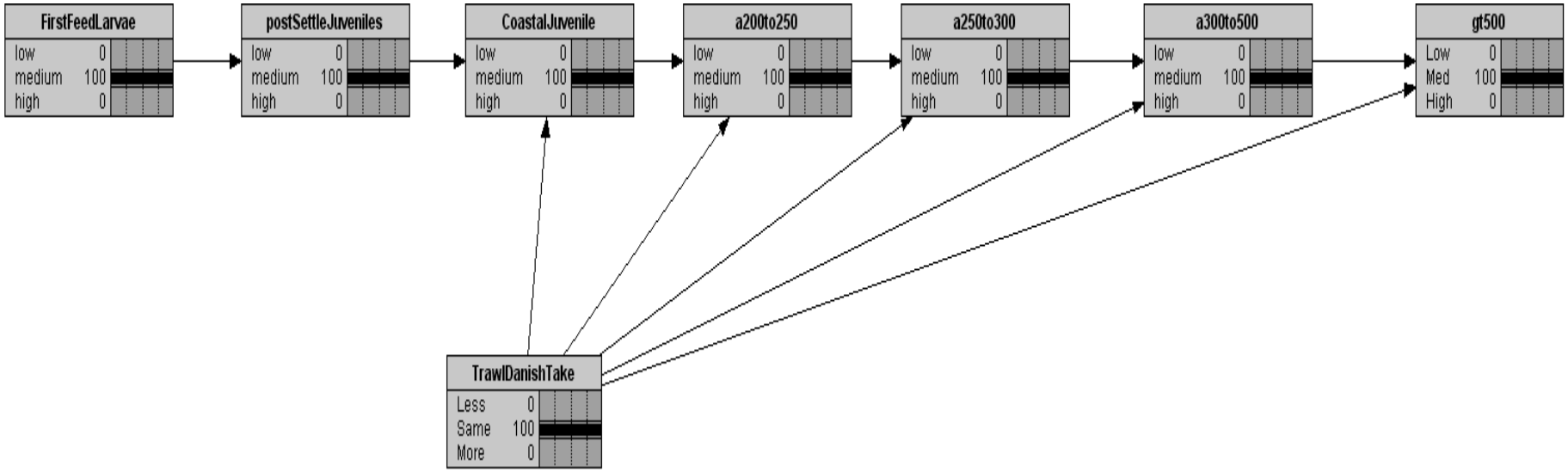
BN model structure



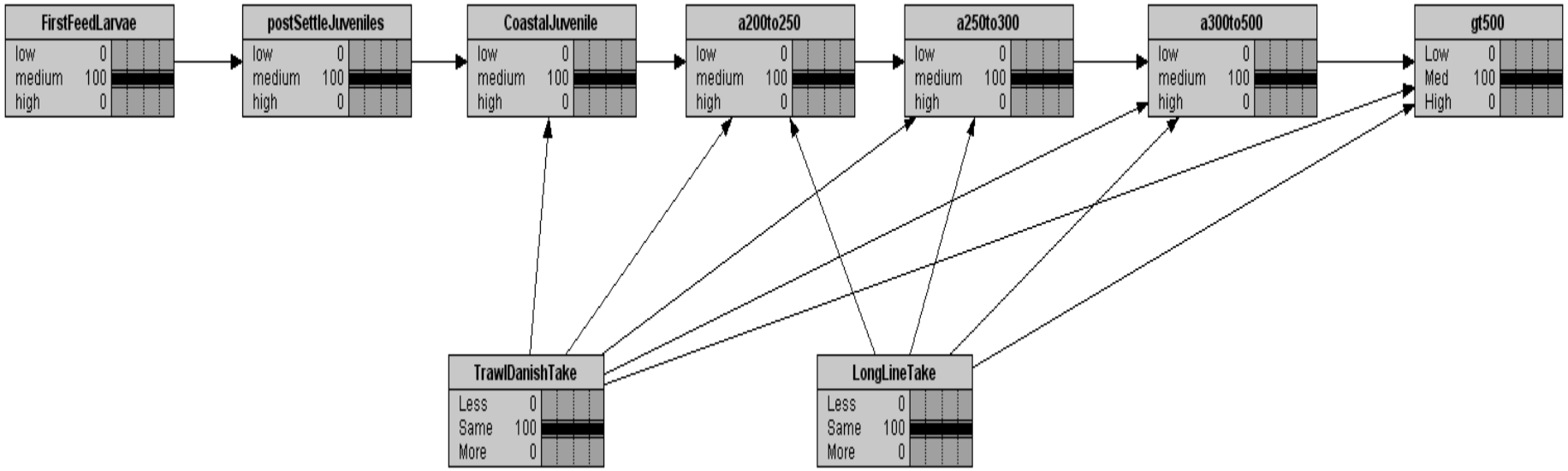
BN model structure



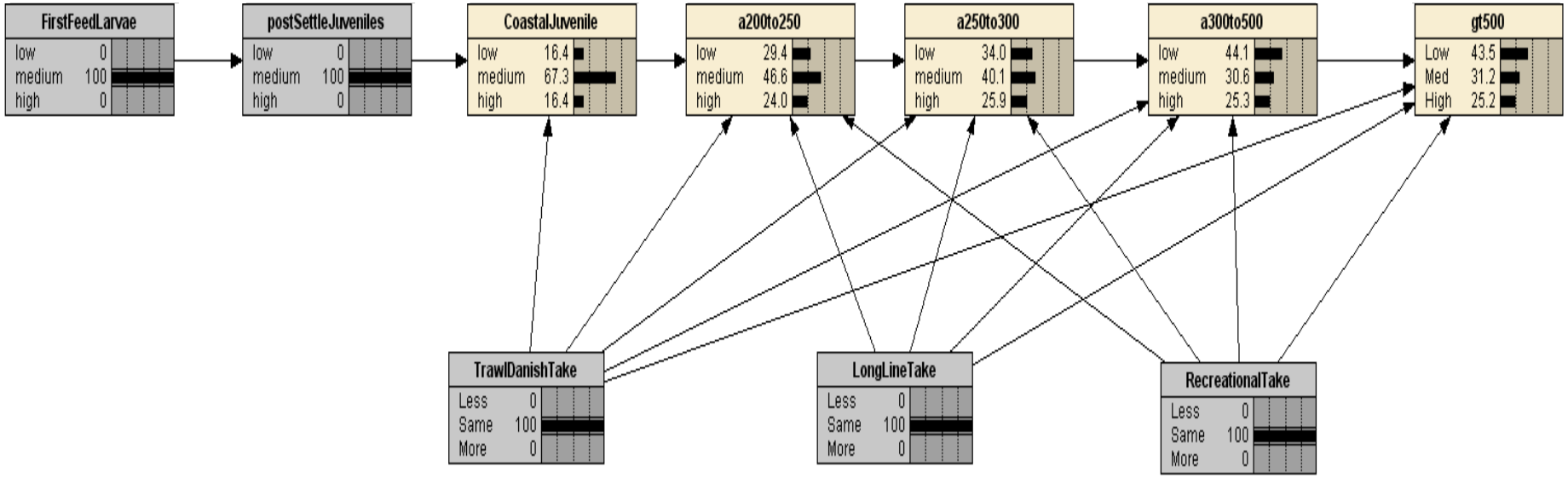
BN model structure



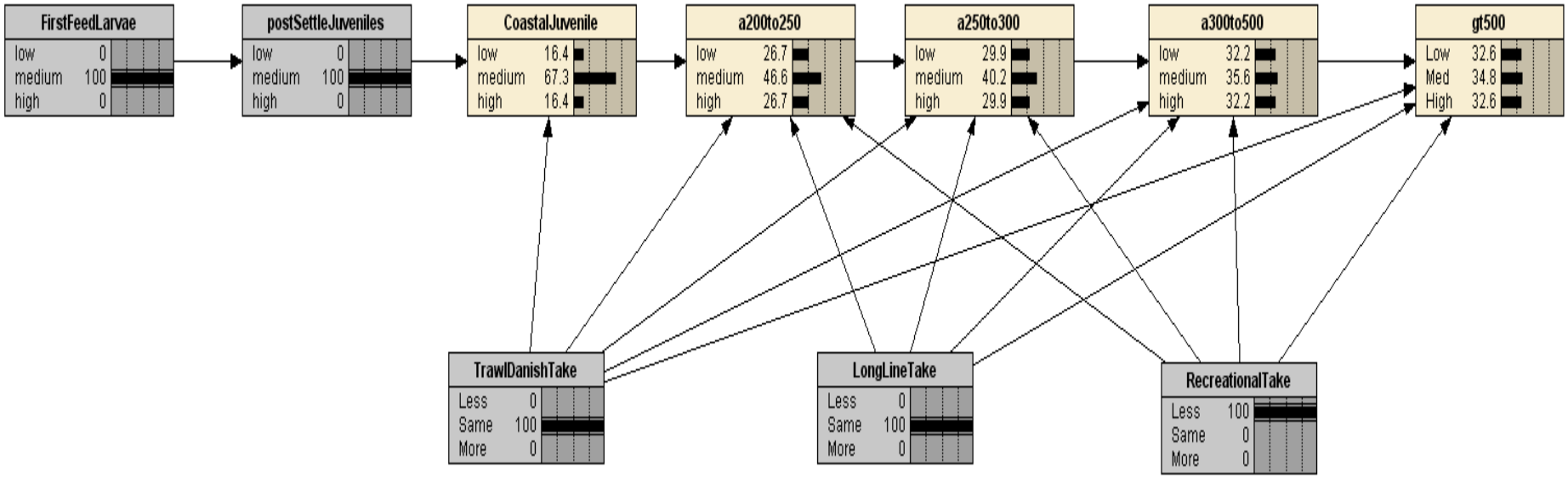
BN model structure



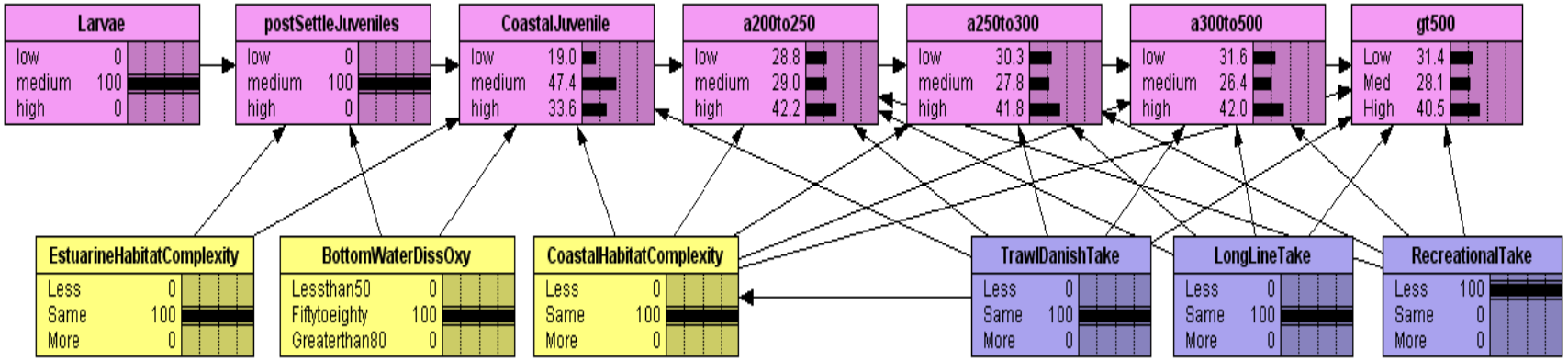
BN model structure



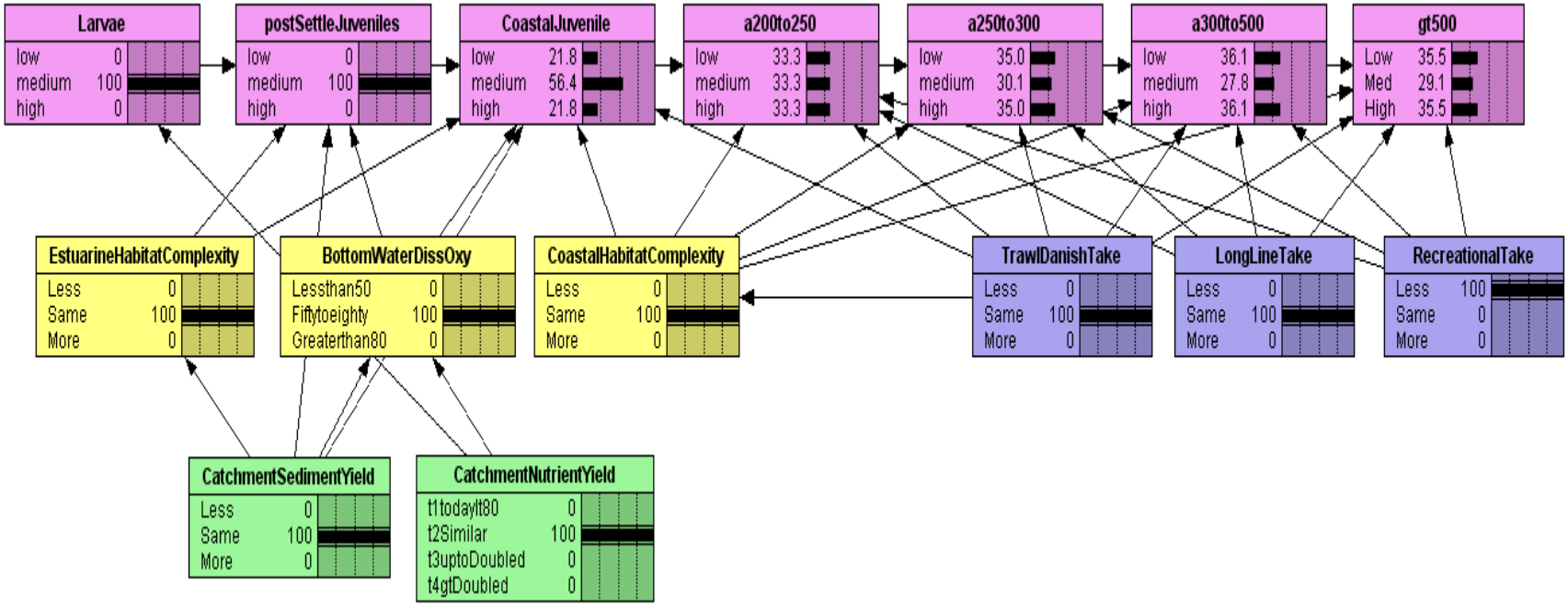
BN model structure



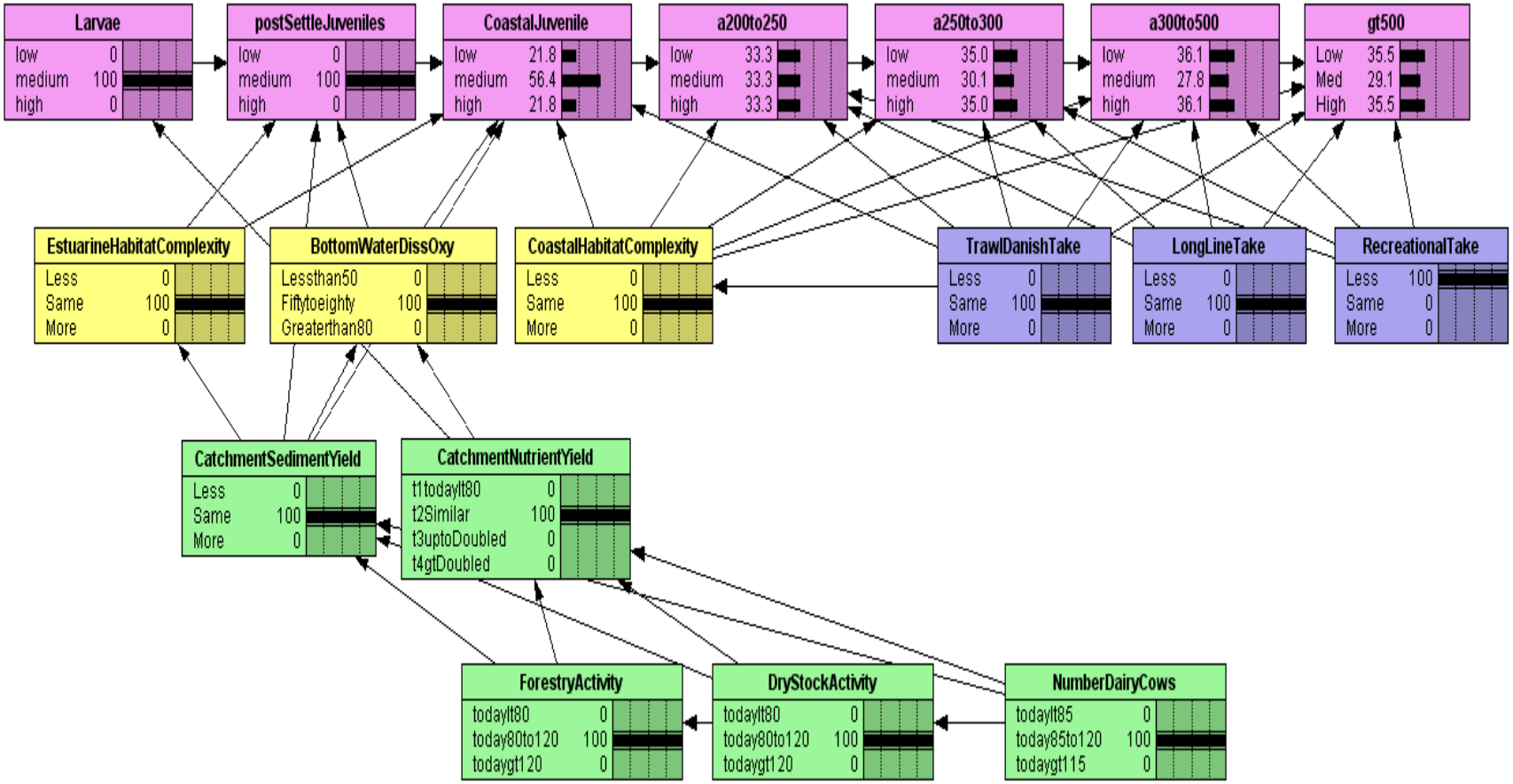
BN model structure



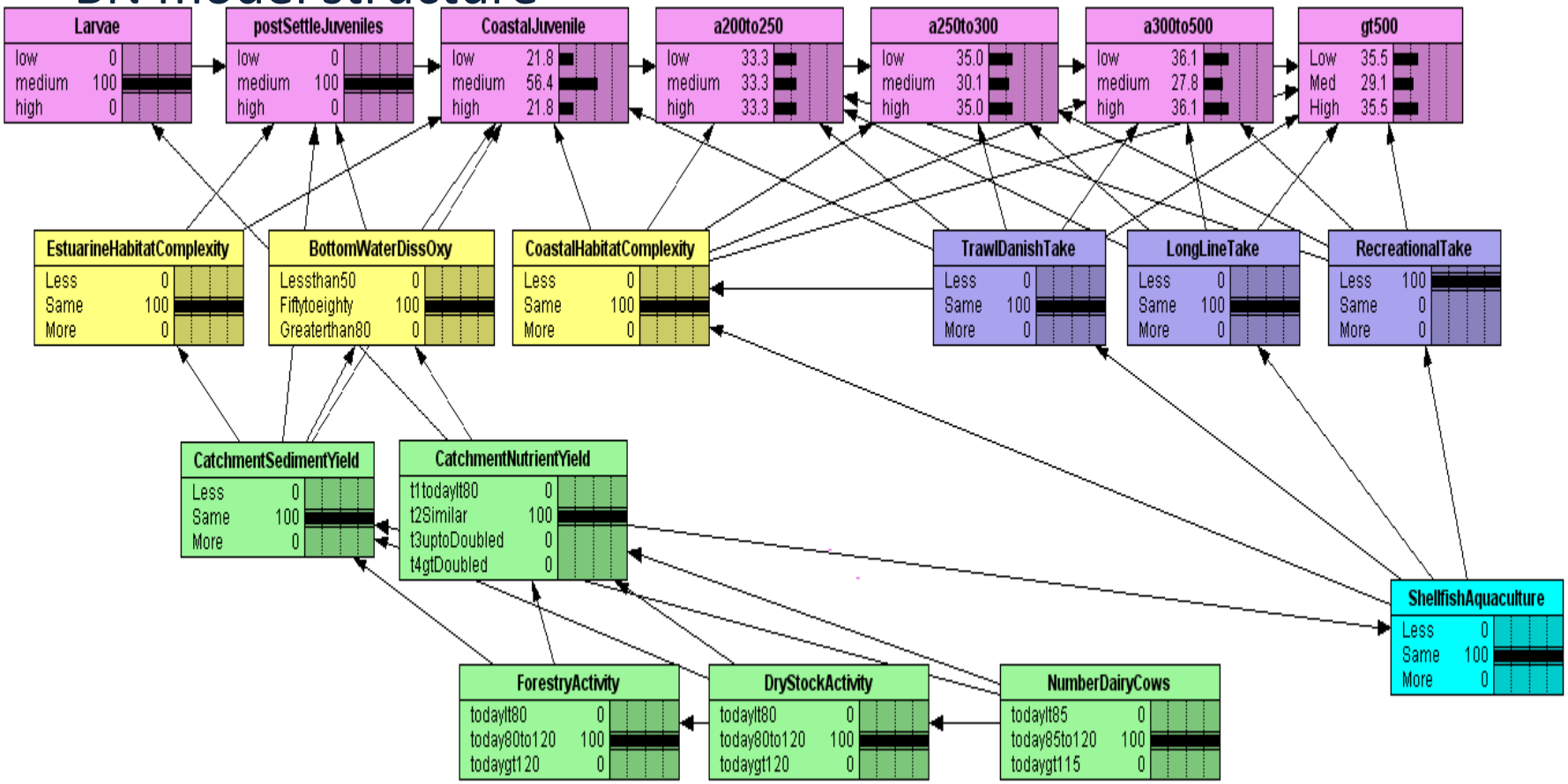
BN model structure



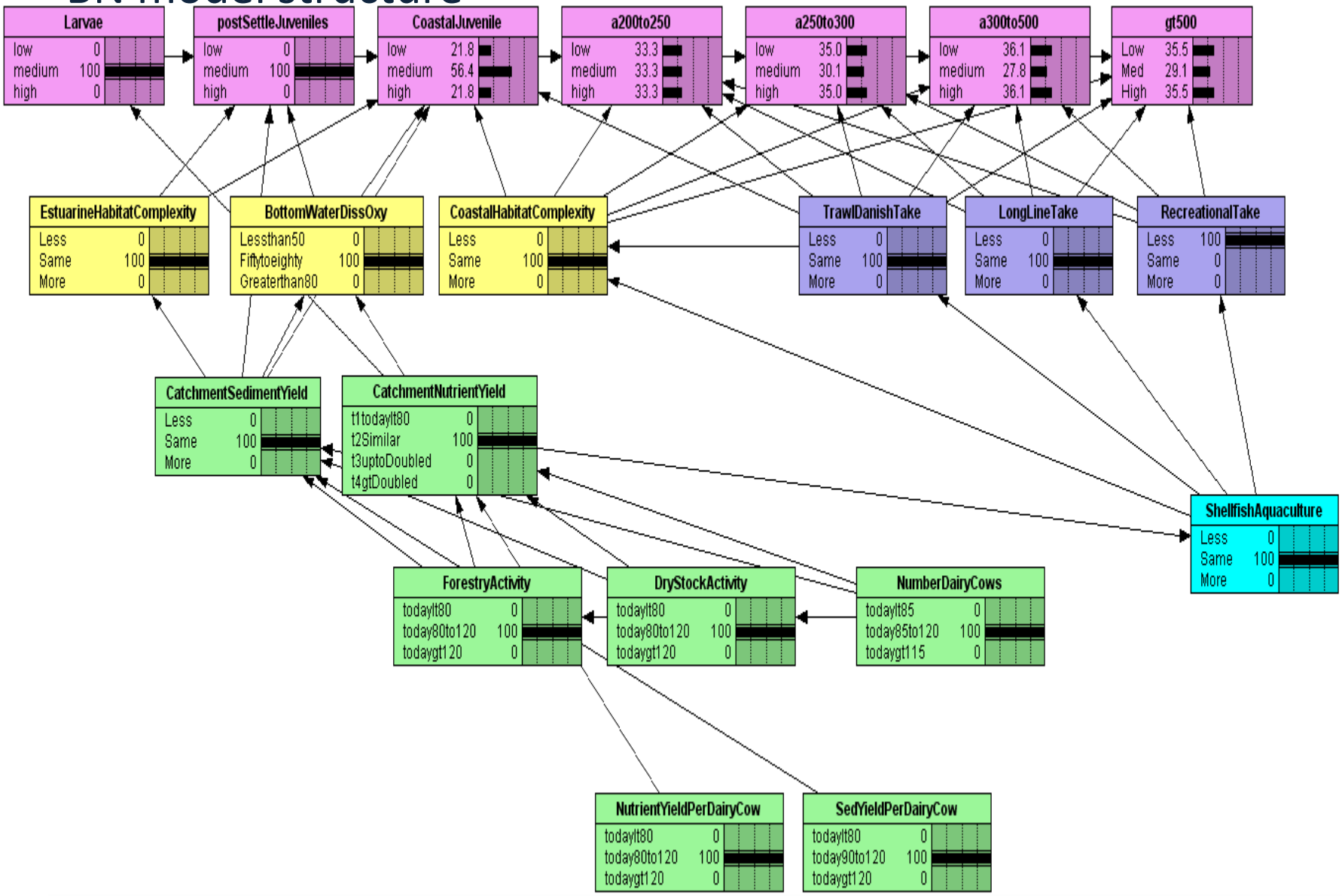
BN model structure



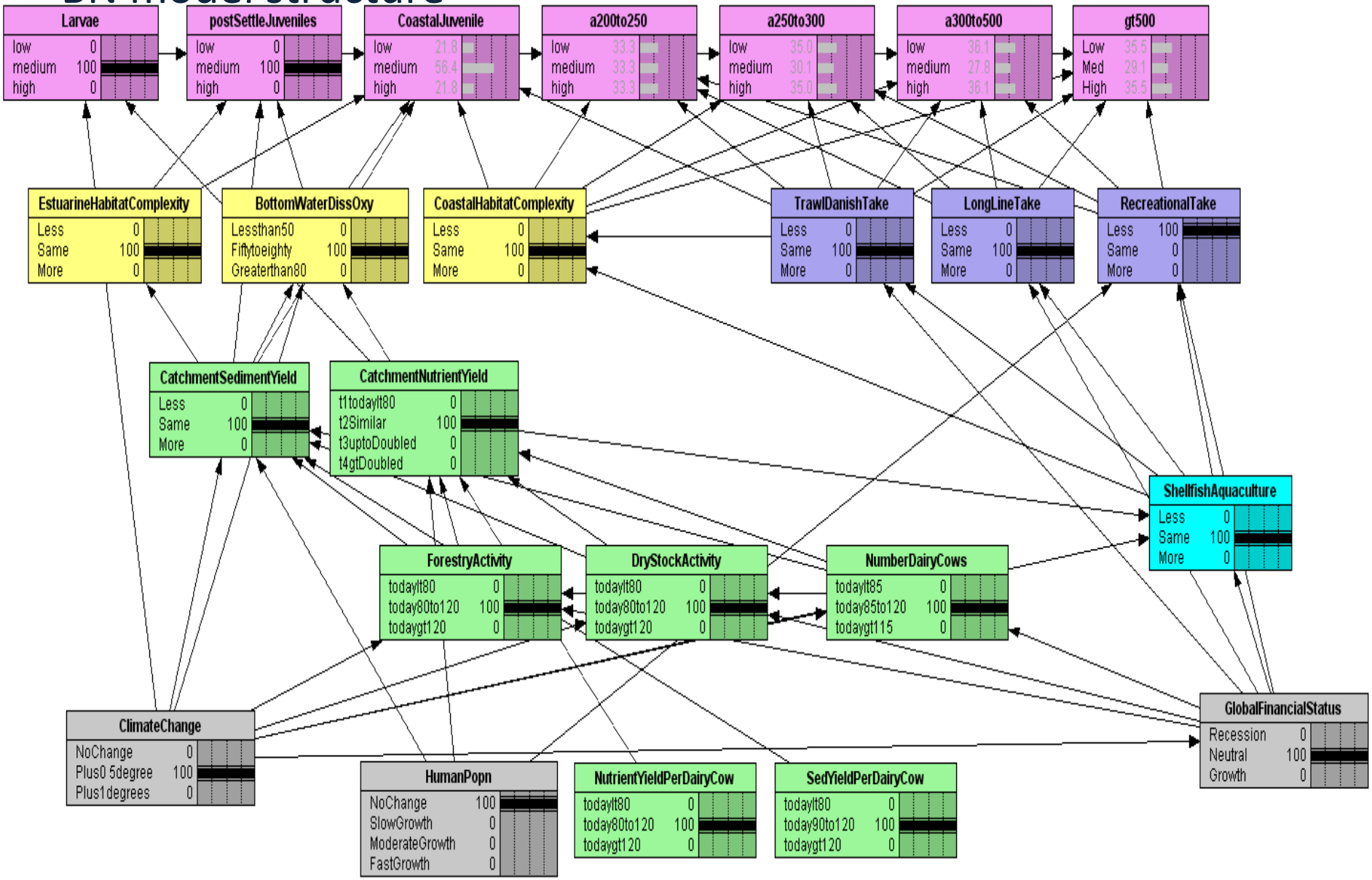
BN model structure



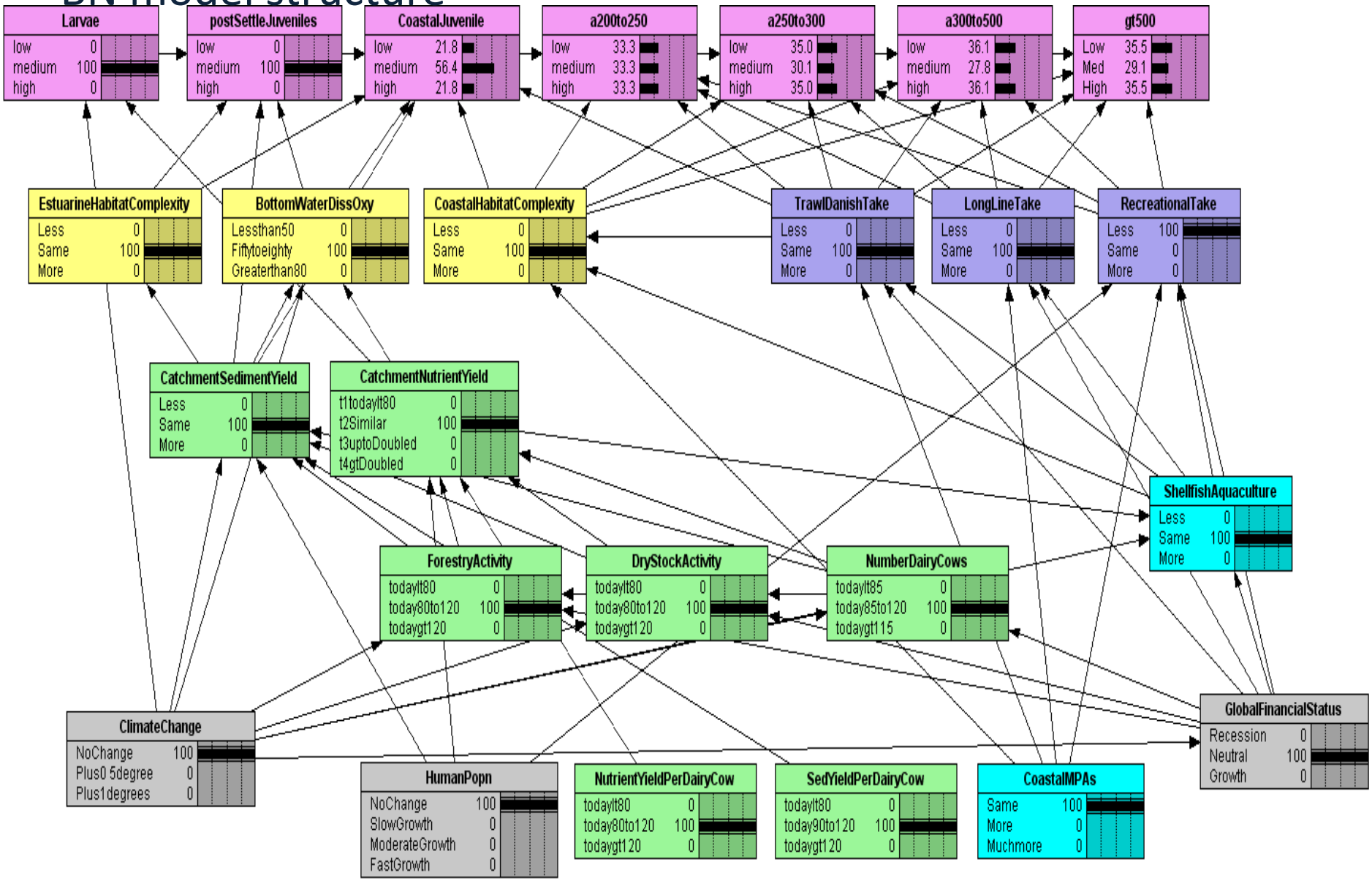
BN model structure



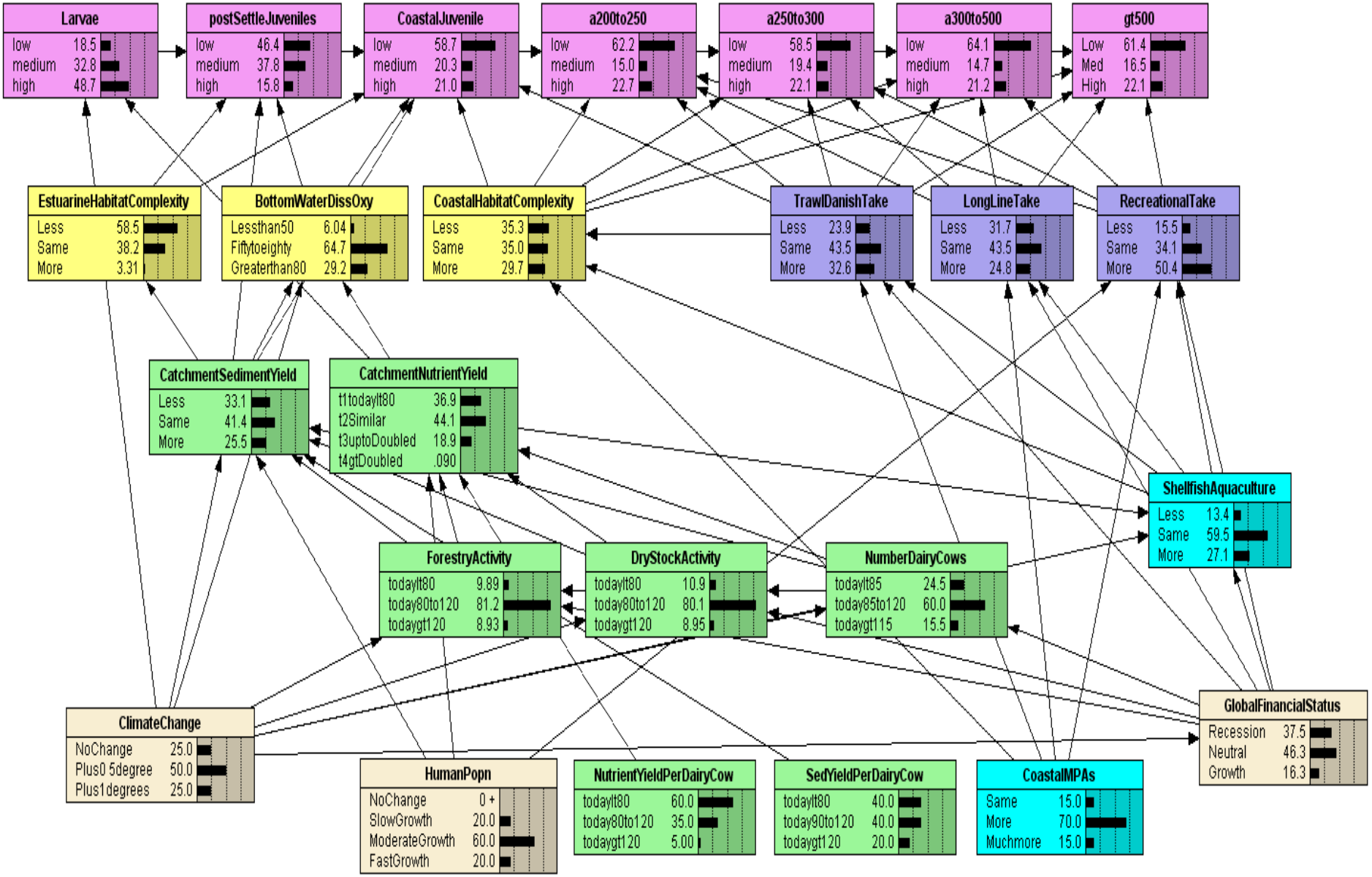
BN model structure



BN model structure

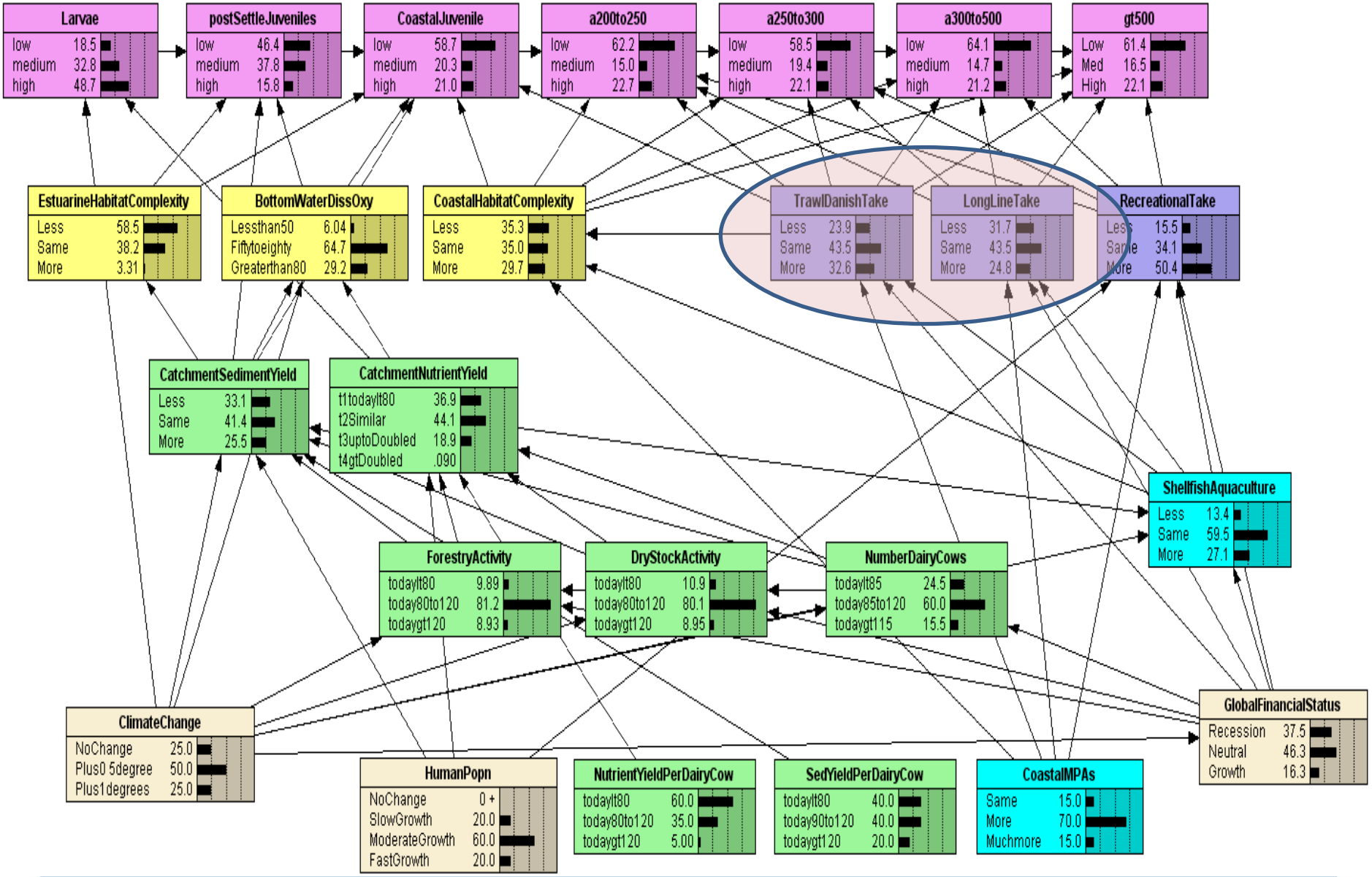


Some model predictions

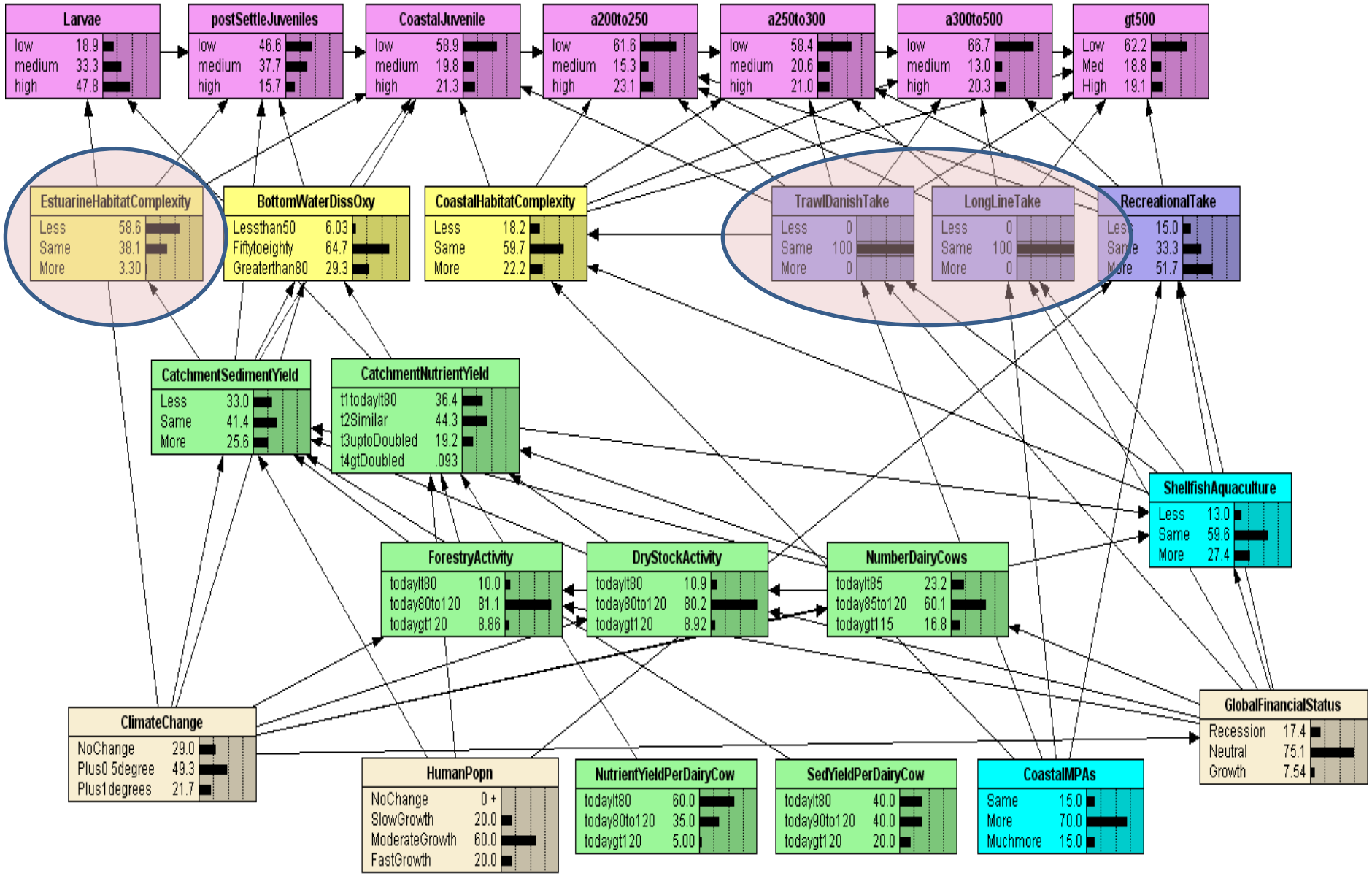


BBN resolved state

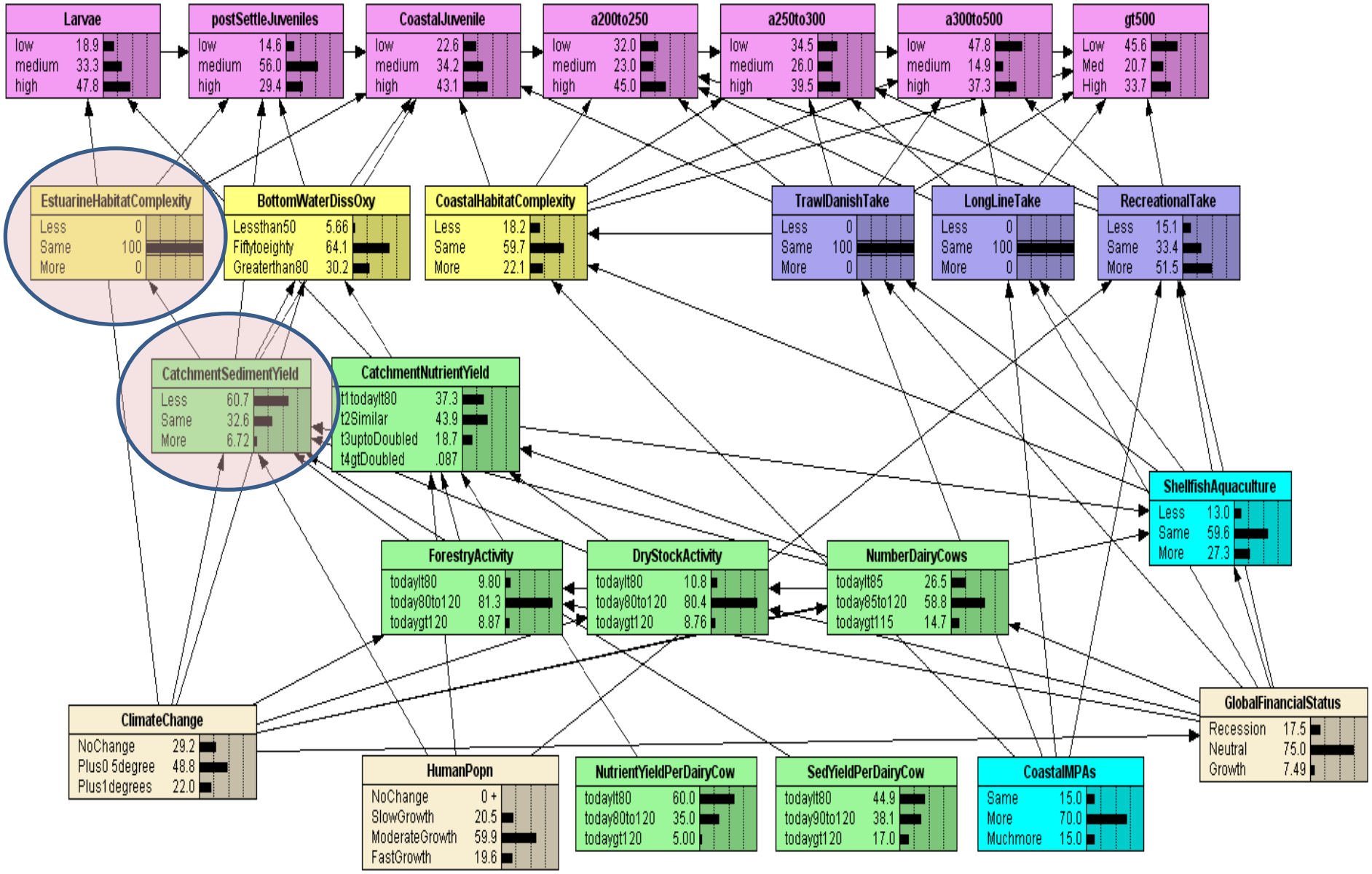
Some model predictions



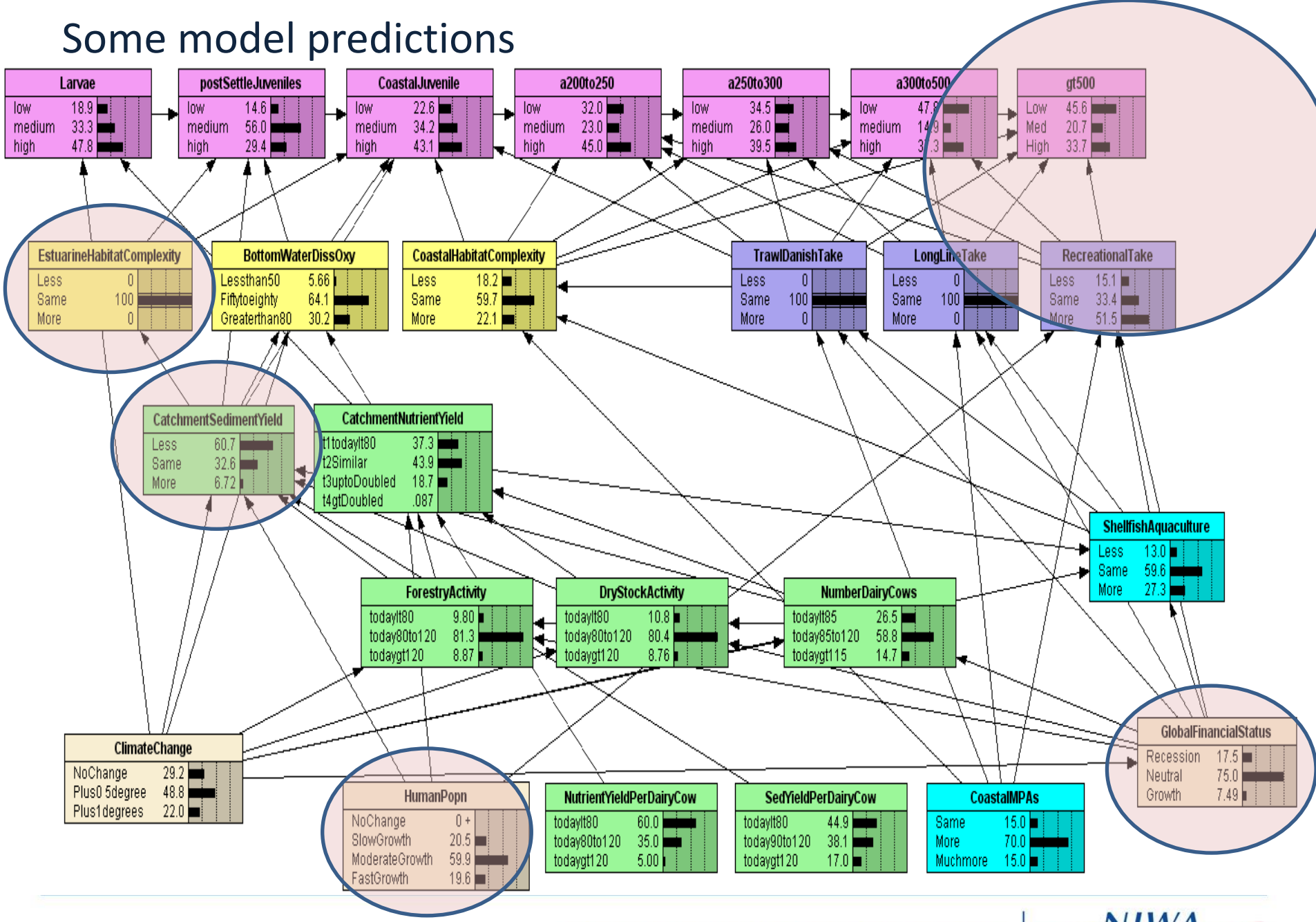
Some model predictions



Some model predictions

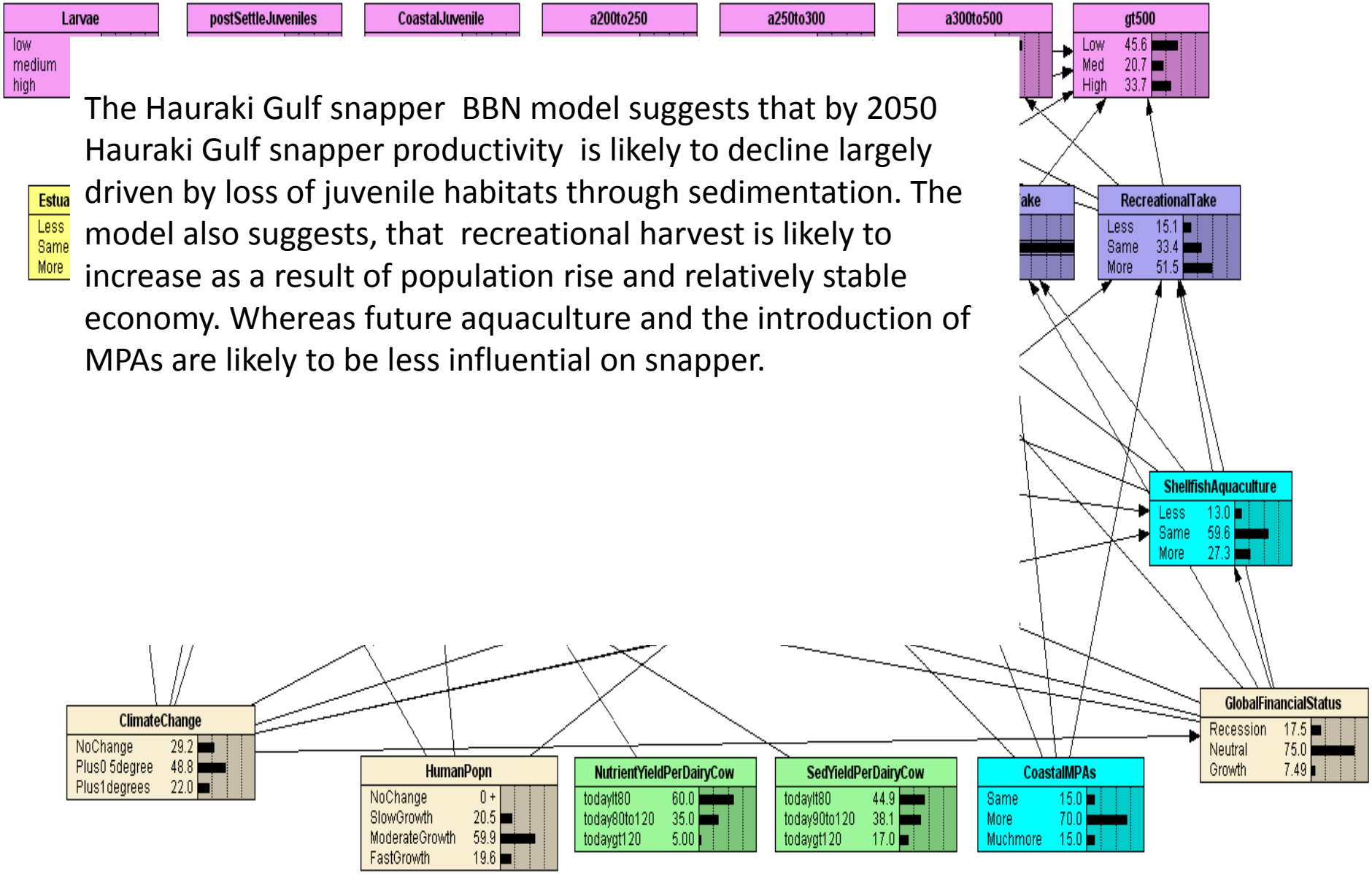


Some model predictions



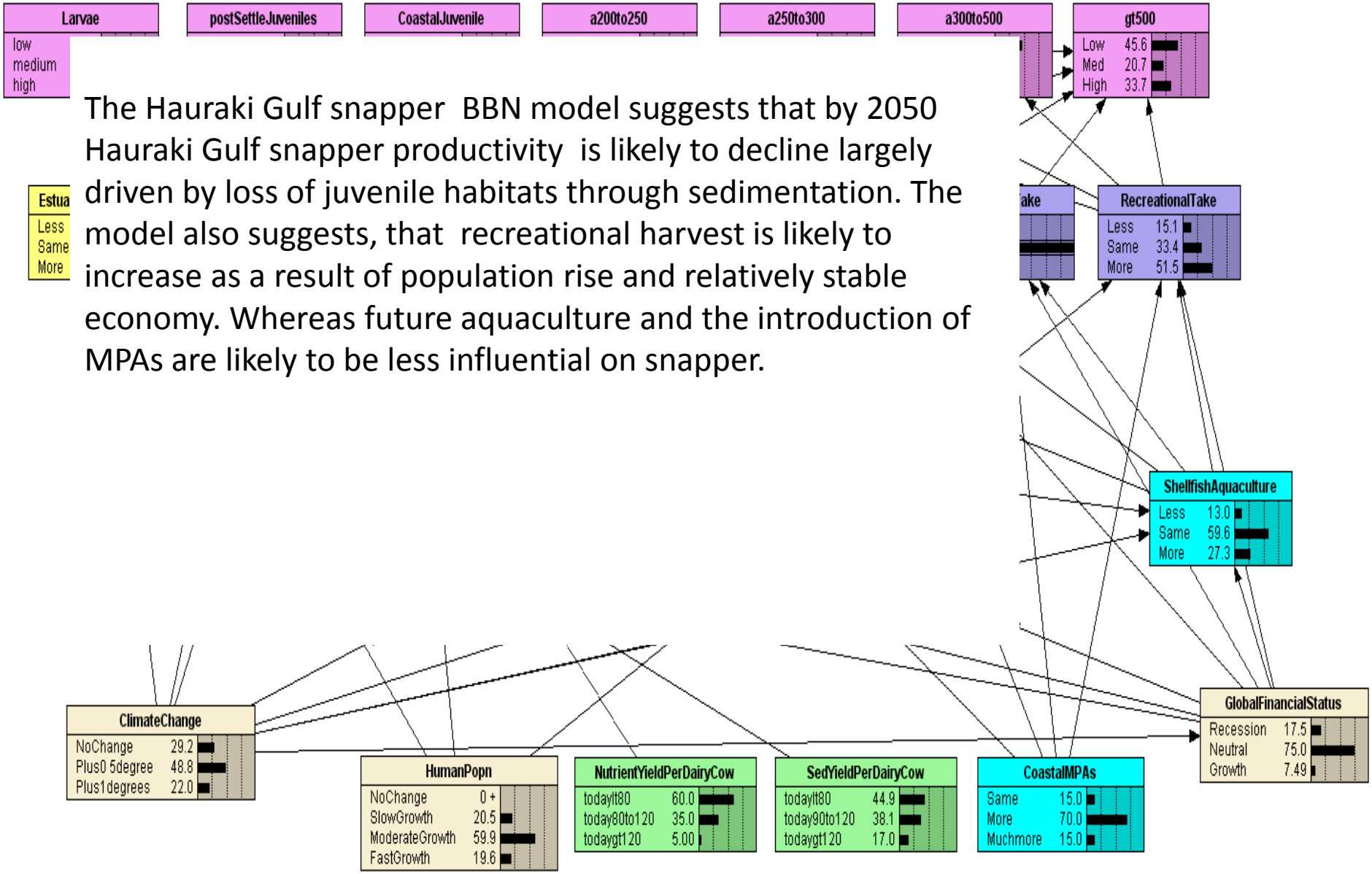
Some model predictions

The Hauraki Gulf snapper BBN model suggests that by 2050 Hauraki Gulf snapper productivity is likely to decline largely driven by loss of juvenile habitats through sedimentation. The model also suggests, that recreational harvest is likely to increase as a result of population rise and relatively stable economy. Whereas future aquaculture and the introduction of MPAs are likely to be less influential on snapper.



Some model predictions

The Hauraki Gulf snapper BBN model suggests that by 2050 Hauraki Gulf snapper productivity is likely to decline largely driven by loss of juvenile habitats through sedimentation. The model also suggests, that recreational harvest is likely to increase as a result of population rise and relatively stable economy. Whereas future aquaculture and the introduction of MPAs are likely to be less influential on snapper.



5. Conclusions

For us this has been a proof on concept exercise the model conclusions although interesting are less import.

The true test will be how well our BN can convey key management concepts to stakeholders

Specifically:

- multiple factors influence can snapper populations
- That the actions of one stakeholder group can impact another.
- That ecosystem change is important to snapper management
- knowledge gaps (e.g. no predator prey dynamics in current model should there be?)

To date there has only been limited use of the BN with stakeholders

Our intention is to further evolve the model in conjunction with stakeholders