ICES WGNAS Working Paper 2008/34
Galway, Ireland 1-10 April 2008

Modeling dynamics of Atlantic salmon in the NAC and NEAC areas

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INTRODUCTION

Atlantic salmon (*Salmo salar* L.) from eastern North America and the northeast Atlantic countries of Europe undertake feeding migrations to the North Atlantic and have the potential to be harvested in the fisheries at West Greenland and the Faroes. These mixed stock high seas fisheries were of sufficient concern that an international body (the North Atlantic Salmon Conservation Organization (NASCO)) was formed in 1982 and a treaty subsequently signed by participating countries to manage the marine fisheries on Atlantic salmon. As in the homewater Atlantic salmon fisheries of eastern North America, NASCO has adopted a fixed escapement management strategy. Management advice, in a currency of harvest tonnage, is predicated on a forecast of salmon abundance prior to the fisheries and the management of the harvests with the objective of achieving the spawner requirements (biomass limits) for the contributing stocks. Crozier et al. (2003) have examined approaches for providing and improving catch advice in a mixed stock fisheries context but fell short of developing appropriate forecast models and applied management frameworks.

The models and approach currently used for the provision of management advice incorporate some of the observation error, model uncertainty and apparent shifts in the productivity of Atlantic salmon and the advice is presented in a risk analysis framework (Chaput et al. 2005). The catch advice is presently only provided for two of the stock components, it does not incorporate the complete uncertainty in the observations, and the dynamic in relative recruitment is difficult to track under the presently used forecast models (Chaput and Prevost 2006). In addition, multi-year catch advice was requested by NASCO in 2006 with an assessment of the minimum information needed which would signal a significant change in the previously provided advice.

Ó Maoiléidigh et al. (2004) and Prévost et al. (2005) described a dynamic model which could be applied to Atlantic salmon forecasting whereas Rivot et al. (2005) have described the state space model context for the life cycle of Atlantic salmon. Further work on the issue of mixed stock fisheries has been reported by Michielsens et al. (2006). The purpose of this project is to develop forecast and management models in a Bayesian context which allows the incorporation of the temporal dynamic of the recruitment process, the uncertainty in the observations and in the processes, with the objective of providing a structure for multi-year catch advice in a risk analysis framework consistent with the precautionary approach (McAllister and Kirkwood 1998). Forecast models need to be developed for three of four stock areas in the northeast Atlantic while alternative projections models and catch advice summaries for the North American stock complex need to be reviewed.

Presently used models

For the provision of the catch advice for West Greenland, two forecast models are used in the risk analysis; one for the non-maturing 1SW salmon of North American origin, the other for 1SW non-maturing salmon from the southern NEAC complex (one of the four stock complexes in NEAC but the only one which is affected by the West Greenland fishery).

Both models are based on generally similar data, including a lagged spawner variable to define the spawning stock, and a recruitment variable termed the PFA (Pre-Fishery Abundance), with a function relating the spawning component to the recruitment.

$PFA_t \sim f(LS_t, \theta)$

There are differences between the two components which do not directly affect the exploration of forecast models for the NAC and NEAC stocks.

North American Commission model

Chaput et al. (2005) describe the forecast and risk analysis model used for the development of catch advice for the West Greenland Commission. The forecast model consists of:

1 - estimation of the abundance of salmon prior to the fishery at Greenland (PFA),
2 - estimation of the spawning stock (LS) which would have contributed to the PFA,
3-– the development of a model to forecast abundance of PFA in the year of interest, and
4 – the development of the catch advice in a risk analysis framework.

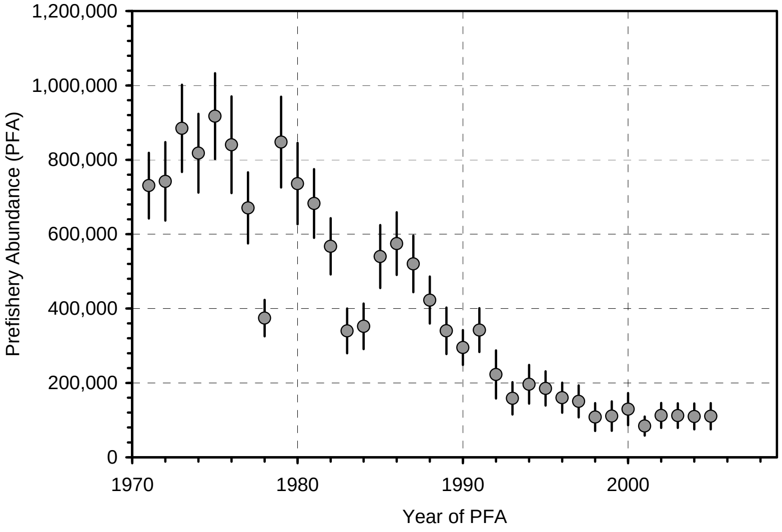
1) The estimation of abundance prior to the fishery (PFA) is done using the run-reconstruction model developed by Rago *et al.* (1993):

$$PFA_{year(i)} = [NR2_{year(i+1)} * e^{M*1} + NC2_{year(i+1)}] * e^{M*10} + NC1_{year(i)} + NG1_{year(i)} \quad \mathbf{(1)}$$

Where $NR2_{year(i+1)}$ is the sum of 2SW returns to six regions of North America in year i+1,
$NC2_{year(i+1)}$ is the catch of 2SW salmon in Newfoundland and Labrador commercial fisheries in year i+1,
$NC1_{year(i)}$ is the catch of 1SW non-maturing salmon in Newfoundland and Labrador commercial fisheries in year i,
$NG1_{year(i)}$ is the catch of 1SW non-maturing salmon of North American origin in the Greenland fishery in year i, and
M is the monthly instantaneous natural mortality of 0.03.

Note that PFA refers to the number of fish of one-sea-winter age which are non-maturing, i.e. would be destined to return mostly as 2SW maiden salmon. The PFA is estimated for August 1 of the second year at sea, just prior to the start of the West Greenland fishery.

Figure 1. Estimated PFA (midpoint, minimum to maximum range) for non-maturing 1SW salmon for North America, 1971 to 2006.



PFA estimates (midpoint, minimum to maximum range)

2) The spawners are defined in terms of only the 2SW salmon to each region because the PFA recruitment age group of interest is the 2SW maiden component. This makes the broad assumption that the recruitment of 2SW salmon is conditioned primarily by the 2SW salmon escapement. The spawning stock of 2SW salmon contributing to the PFA recruitment of the year of interest is calculated by lagging forward the spawners (lagged spawners, LS) based on the smolt age distributions in each region (Rago, 2001). The lag consists of the smolt age plus two years (one for the year of egg deposition plus one for the first year at sea), with the smolt age proportions assumed constant for each region for the entire time series.

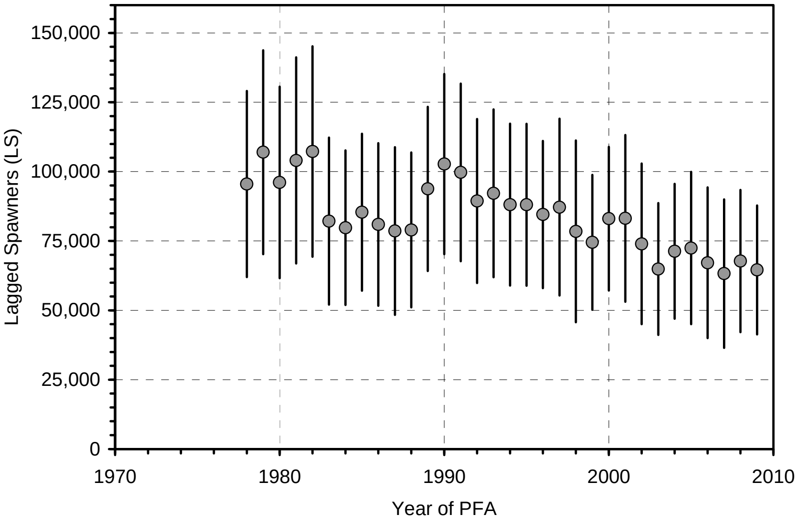
$$LS_t = \sum_{t=1971}^{T} \sum_{j} \sum_{k=1}^{6} 2SWSpawners_{t+k+2,j} * \Pr op_{k,j} \qquad \textbf{(2)}$$

t = 1971 to most recently available year (T) for 2SW salmon returns

j = 6 geographic areas of North America (Labrador, Newfoundland, Quebec, Gulf, Scotia-Fundy, US)

k = smolt age 1 to 6

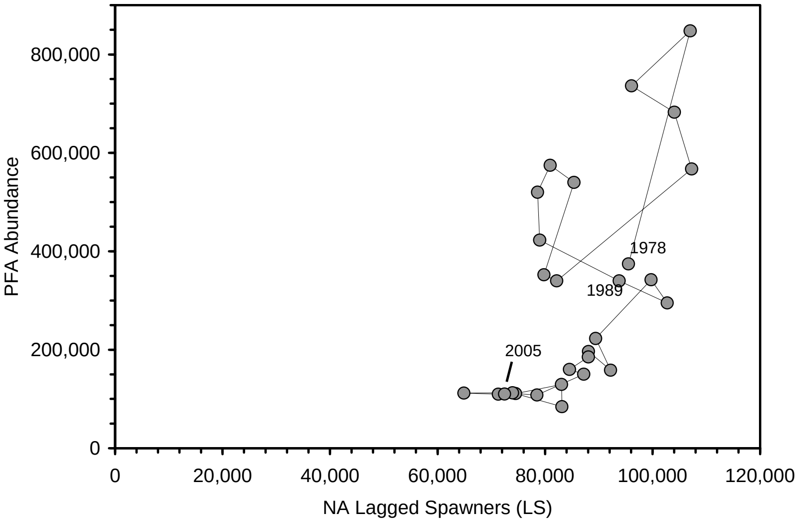
Figure 2. Lagged spawners (LS) for the NAC stock complex for 1978 to 2006. Ranges are minimum and maximum LS based on minimum and maximum 2SW spawners lagged forward using the same smolt age proportions.



Lagged spawner values (midpoint, minimum to maximum range)

3) A preliminary plot of the annual midpoint estimates of PFA relative to the LS suggested two periods of productivity: a high productivity period during 1977 to 1988 and a low productivity period during 1990 to the present with intermediate productivity in 1978 and 1989.

Figure 3. Relationship (based on mid-points) between PFA abundance and corresponding LS for North America, 1978 to 2006.



A series of models relating PFA to LS and to assess the presence of two phases of productivity have been used by the Working Group. The PFA and LS variables were natural log transformed before analysis and the linearized form of the model was:

$$Ln(PFA) = \alpha + \beta{*}Ph + (\gamma + \delta{*}Ph){*}Ln(LS) + \xi \qquad \textbf{(3)}$$

Seven nested models (parameters = p) were evaluated.

(0) Null model (p = 2) $Ln(PFA) = \alpha + \xi$
(1) No phase shift (p = 3) $Ln(PFA) = \alpha + \gamma{*}Ln(LS) + \xi$
(2) Only phase shift (p = 3) $Ln(PFA) = \alpha + \beta{*}Ph + \xi$
(3) Shifted intercept (p = 4) $Ln(PFA) = \alpha + \beta{*}Ph + \gamma{*}Ln(LS) + \xi$
(4) No intercept (p = 3) $Ln(PFA) = (\gamma + \delta{*}Ph){*}Ln(LS) + \xi$
(5) Shifted slope (p = 4) $Ln(PFA) = \alpha + (\gamma + \delta{*}Ph){*}Ln(LS) + \xi$
(6) Full model (p = 5) $Ln(PFA) = \alpha + \beta{*}Ph + (\gamma + \delta{*}Ph){*}Ln(LS) + \xi$

Chaput et al. (2005) selected the parsimonious model and break point year using the Akaike information criterion ($AIC = L(Y \mid m) + 2p$).

North-East Atlantic Commission model

As with the North American Commission, the process for the development of the forecast model occurs in three steps:

1 - estimation of the abundance of salmon prior to the fisheries (PFA),

2 - estimation of the spawning stock (LS) which would have contributed to the PFA, and

3-– the development of a model to forecast abundance of PFA in the year of interest.

1) The pre-fishery abundance (PFA) of salmon from countries in the NEAC area is based on a run reconstruction model described by Potter et al. (1998, 2004).

PFA in the NEAC area is defined as the number of 1SW recruits on January 1st in the first sea winter. The model estimates the PFA from the catch in numbers of 1SW and MSW salmon in each country. These are raised to take account of minimum and maximum estimates of non-reported catches and exploitation rates of these two sea-age groups. Finally these values are raised to take account of the natural mortality between January 1st in the first sea winter and the mid-point of the respective national fisheries. A natural mortality value of 0.03 (range 0.02–0.04) per month is assumed.

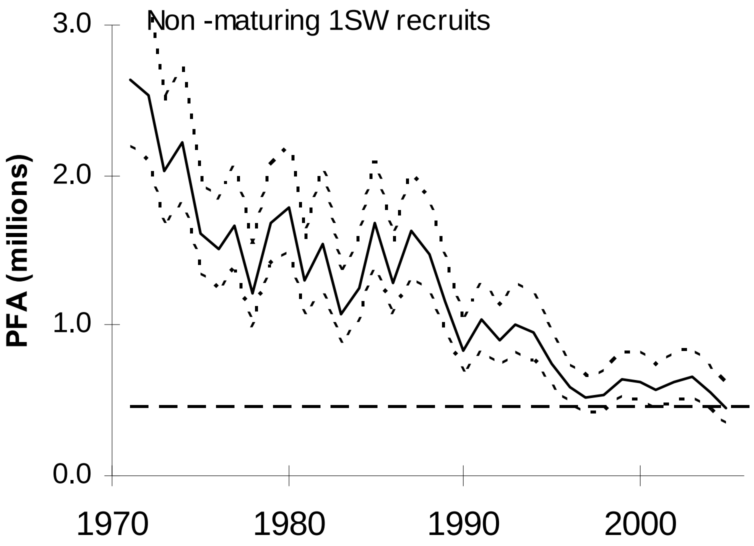
PFA estimates are developed for the maturing 1SW and non-maturing 1SW components from the southern and northern NEAC stock complexes. The national compositions of the southern and northern NEAC stock complexes are presented in Table 1.

Table 1. Stocks by country composed within the southern and northern stock complexes.

Southern NEAC	Northern NEAC
Spain	Iceland (west and north)
France	Sweden
Ireland	Norway
UK (N. Ireland)	Finland
UK (England and Wales)	Russia
UK (Scotland)	
Iceland (	

Monte Carlo simulation (10 000 trials) using 'Crystal Ball v7.2.1' in Excel (Decisioneering, 1996) is used to estimate confidence limits on the PFA values.

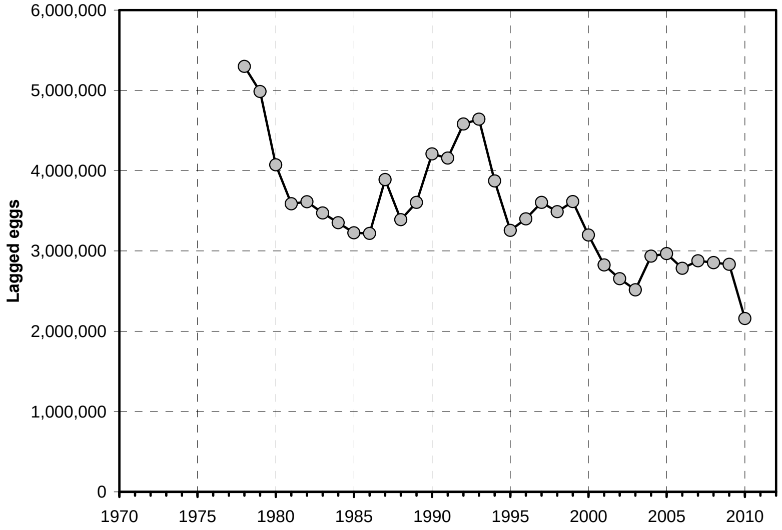
Figure 4. Estimated PFA (midpoint, minimum to maximum range) for non-maturing 1SW salmon for North America, 1971 to 2006.



PFA estimates for southern NEAC non-maturing 1SW

2) The spawner variable is defined in terms of the total eggs which would have contributed to the PFA abundance. The spawner abundances by age group (1SW, MSW) are converted to eggs based on biological characteristics of the age groups specific to each country. As with the North American model, the eggs are lagged forward based on the smolt age distributions of the spawners in each country. The lag consists of the smolt age plus two years (one for the year of egg deposition plus one for the first year at sea), with the smolt age proportions assumed constant for each region and age group. To date, only the midpoints of the lagged eggs have been developed based on the midpoints of the estimated spawners.

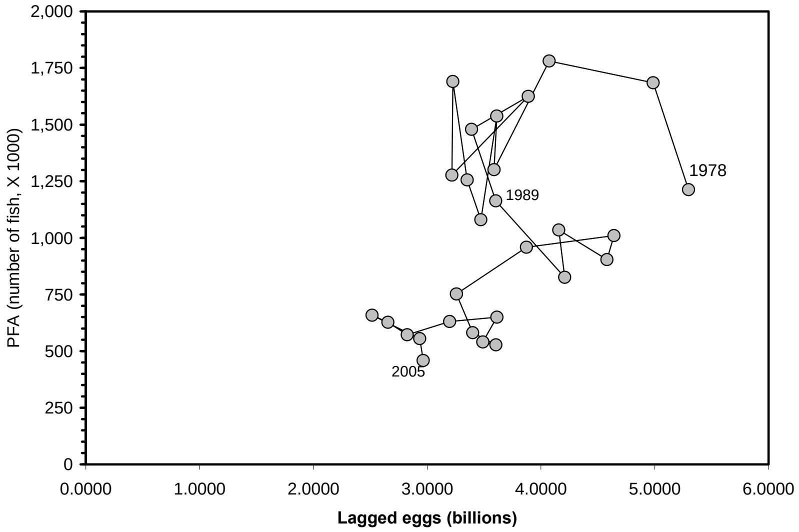
Figure 5. Lagged eggs (X1000) for the southern NEAC stock complex, 1978 to 2010.



Lagged eggs for the PFA year for southern NEAC non-maturing stock

3) A preliminary plot of the annual midpoint estimates of PFA relative to the LS for the southern NEAC non-maturing complex suggests two periods of productivity as noted for NAC: a high productivity period during 1979 to 1989 and a low productivity period during 1978 and 1990 to the present. However, this has not been explored by the Working Group.

Figure 6. Relationship (based on mid-points) between PFA for southern NEAC non-maturing 1SW abundance and corresponding lagged eggs from all spawners, 1978 to 2006.



The WGNAS considered rather the development of a non-phase shift model to forecast the PFA of non-maturing (potential MSW) salmon from the Southern European stock group (ICES, 2002, 2003). The full model takes the form:

$$PFA = Spawners^{\lambda} \times e^{\beta_0 + \beta_2 \log(PFAm) + \beta_3 Year + \xi} \qquad \textbf{(4)}$$

where *Spawners* are expressed as lagged egg numbers (all age groups),

PFAm is pre-fishery abundance of maturing 1SW salmon

The number of years for which forecasts may be provided is limited by the *Spawner* (lagged egg) parameter within the model. The time series for this parameter extends only as far as those lagged eggs assigned to 1-year old smolts from the most recent available spawning year, currently lagged eggs for 2009 derived from 2006 spawner estimates. To allow PFA forecasts for 2010, lagged egg production assigned to 1-year old smolts for 2010 for each home water country was estimated by taking the average of the previous 5 years.

In previous years, parameter selection was achieved by adding variables (Spawners, PFAm and Year) until the addition of others did not result in an increase in the explanatory power of the model. The model was fitted to data from 1978 to 2005 and, as in previous years, the parameters selected were *Spawners* (LSeggs)and *Year*. The final model took the form:

$$\text{Ln}(PFA_t/LSeggs_t) = \alpha + \beta * \text{Ln}(LSeggs_t) + \delta * Year_t + \varepsilon \qquad \textbf{(5)}$$

ALTERNATE MODELS FOR NAC AND NEAC

At the 2006 WGNAS meeting, Chaput and Prévost (2006) explored an alternate forecast model based on the dynamic model described by Prévost et al. (2005). In that formulation, a monotonically increasing function relating LS and PFA was assumed (i.e if LS = 0 then PFA = 0, as LS increases then average PFA increases) but the production rate from spawners to PFA could vary with time. Any model developed must provide predictions of PFA into the future.

A number of functional relationships between PFA and spawners can be explored. It was assumed that PFA estimates are described by a lognormal distribution. PFA abundance was modelled as a log-linear function of lagged spawners or lagged eggs (LS).

$$PFA) \sim LogNormal(E(logPFA_t), \sigma_{PFA}) \qquad \textbf{(6)}$$

$$E(logPFA_t) = \log(LS_t) + \alpha_t \qquad \textbf{(7)}$$

α_t is a “production rate” that can be modelled in different ways.

a) constant through time

$$\alpha_t = Constant \qquad \textbf{(8)}$$

b) simple random walk trough time (dynamic model of Prévost et al. 2005)

$$\alpha_t = \alpha_{t-1} + \omega_t$$

$$\omega_t \overset{iid}{\sim} N(0,\sigma_{\omega}) \quad \textbf{(9)}$$

c) random walk with a trend

$$\alpha_t = \beta * \alpha_{t-1} + \omega_t$$

$$\omega_t \overset{iid}{\sim} N(0,\sigma_{\omega}) \quad \textbf{(10)}$$

d) phase shift model with 2 production levels

$$\begin{cases} t < t_{shift} : \alpha_t = \alpha_1 \\ t \geq t_{shift} : \alpha_t = \alpha_2 \end{cases} \quad \textbf{(11)}$$

e) random shift with 2 production levels

$$I_t \sim bernoulli(p)$$

$$\begin{cases} I_t = 0 : \alpha_t = \alpha_1 \\ I_t = 1 : \alpha_t = \alpha_2 \end{cases} \quad \textbf{(12)}$$

f) random shift with 2 production levels but with autocorrelation in the probability of being in high state (1) or lower state (2)

$$I_t \sim Bernoulli(p_t)$$

$$\log it(p_t) = \log it(p_{t-1}) + \omega_t$$

$$\omega_t \overset{iid}{\sim} N(0,\sigma_{\omega}) \quad \textbf{(13)}$$

$$\begin{cases} I_t = 0 : \alpha_t = \alpha_1 \\ I_t = 1 : \alpha_t = \alpha_2 \end{cases}$$

None of the above formulations match those described by Chaput et al. (2005) or used by the WGNAS for southern NEAC non-maturing salmon. As with the models used by Chaput et al. (2005), two of the phase shift models above (equation 11 and 12) require alternate assumptions to be used in the development of catch advice, i.e. a way to determine the phase of productivity for the years of interest. The other production rate models are not hampered by this requirement (equations 8, 9, 10) or a parameter for determining the probability of being in a specific phase is estimated in the model (equation 13).

With the objective of providing catch advice, the only models which were explored further were those of equations 9 (dynamic model) and 13 (two phase of productivity with estimated autocorrelated probability of being in a given phase).

Preliminary fits of the alternate models to the midpoint estimates of PFA and LS

The exploration of these models was done using the midpoints of the PFA and LS data for both the NAC and southern NEAC non-maturing component. The Winbugs code for these is shown in Appendix 1. The data for the time series 1971 to 2006 are shown in Appendix 2.

There has been a decrease in the productivity for **NAC** beginning in 1989 and declining into 1997 and remaining low (1.5 PFA per LS) thereafter (Fig. 8). The phase shift model suggests a decline in productivity between 1988 and 1994 and productivity remaining low from 1993 to the present (Fig. 8). The probability of being in the high phase of production is low (<10% chance 75% of the time) from 1995 to the present and remains low for the forecast years 2006 to 2009 (Fig. 9). The phase shift model is slightly more optimistic for PFA abundance for 2006 to 2009, with no chance of further declines whereas the dynamic model forecasts have greater uncertainty over the 4 years of forecast with chance of further decline in the future (Fig. 8).

The results of the model fitting to the **NEAC** data set indicates a rapid decline in productivity during 1987 to 1992 with the biggest change over the period 1988 to 1990 (Fig. 10). The phase shift model suggests a rapid decline in productivity during 1989 and productivity remaining low from 1990 to the present (Fig. 10). The probability of being in the high phase of production is low (<10% chance 75% of the time) from 1993 to the present but becomes uncertain for the later forecast years 2009 and 2010 (Fig. 9). The phase shift model is more optimistic for PFA abundance for 2006 to 2010, with no chance of further declines whereas the dynamic model forecasts have greater uncertainty over the five years of forecast with a chance of further decline in the future (Fig. 9).

The parallel declines in productivity for both the NAC and NEAC stock complexes during 1988 to 1993 is striking (Fig. 8 to 10). Crozier et al. (2003) identified possible non-stationarity in the stock and recruitment time series of several NEAC stocks during the mid 1980s and Chaput et al. (2005) modelled production of the NAC stock complex using a phase shift model. The productivity parameter in the models explored does not allow a determination of whether the change in productivity has occurred in freshwater, in the first year at sea survival or both.

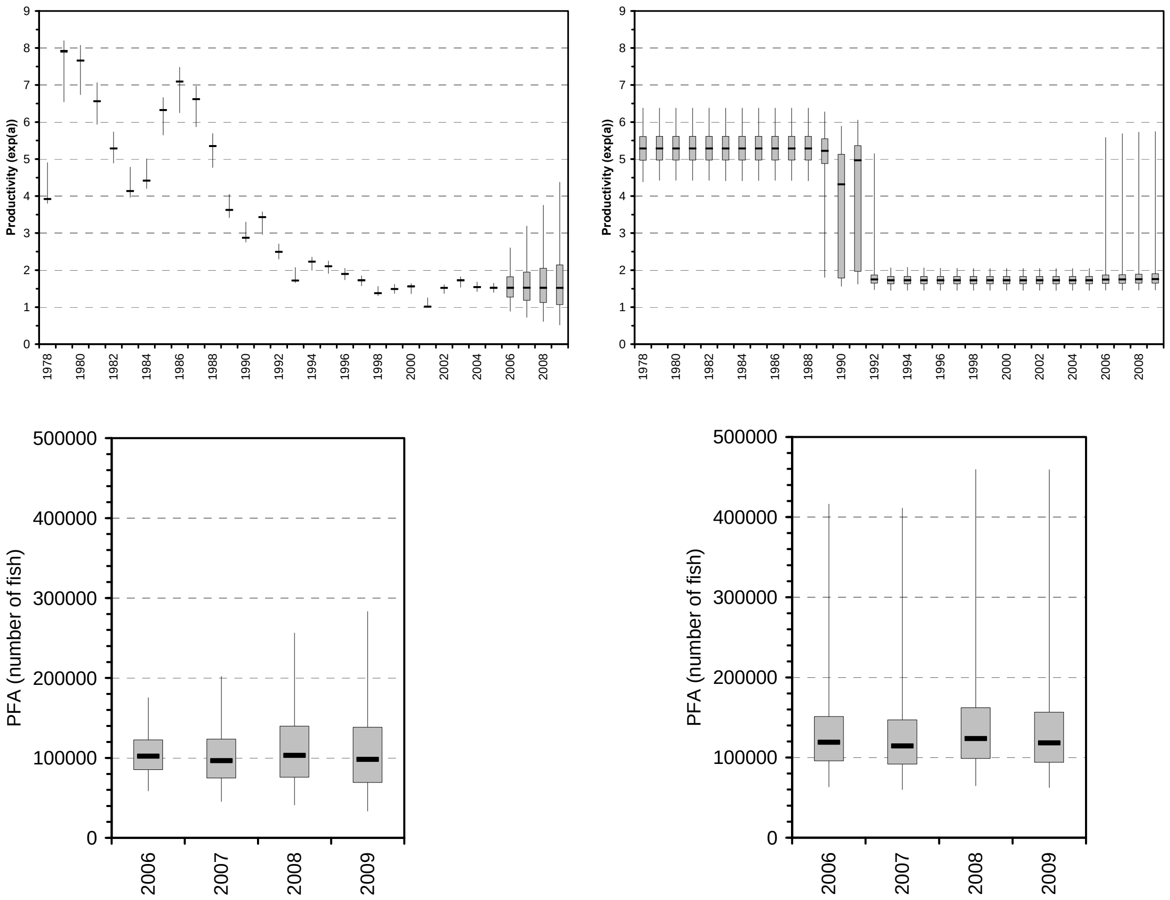


Figure 8. Estimates of productivity parameter (exp^a) for the dynamic model (upper left) and the phase shift model (upper right), predicted PFA for 2006 to 2009 from the dynamic (lower left) and the phase-shift (lower right) models for the NAC area.

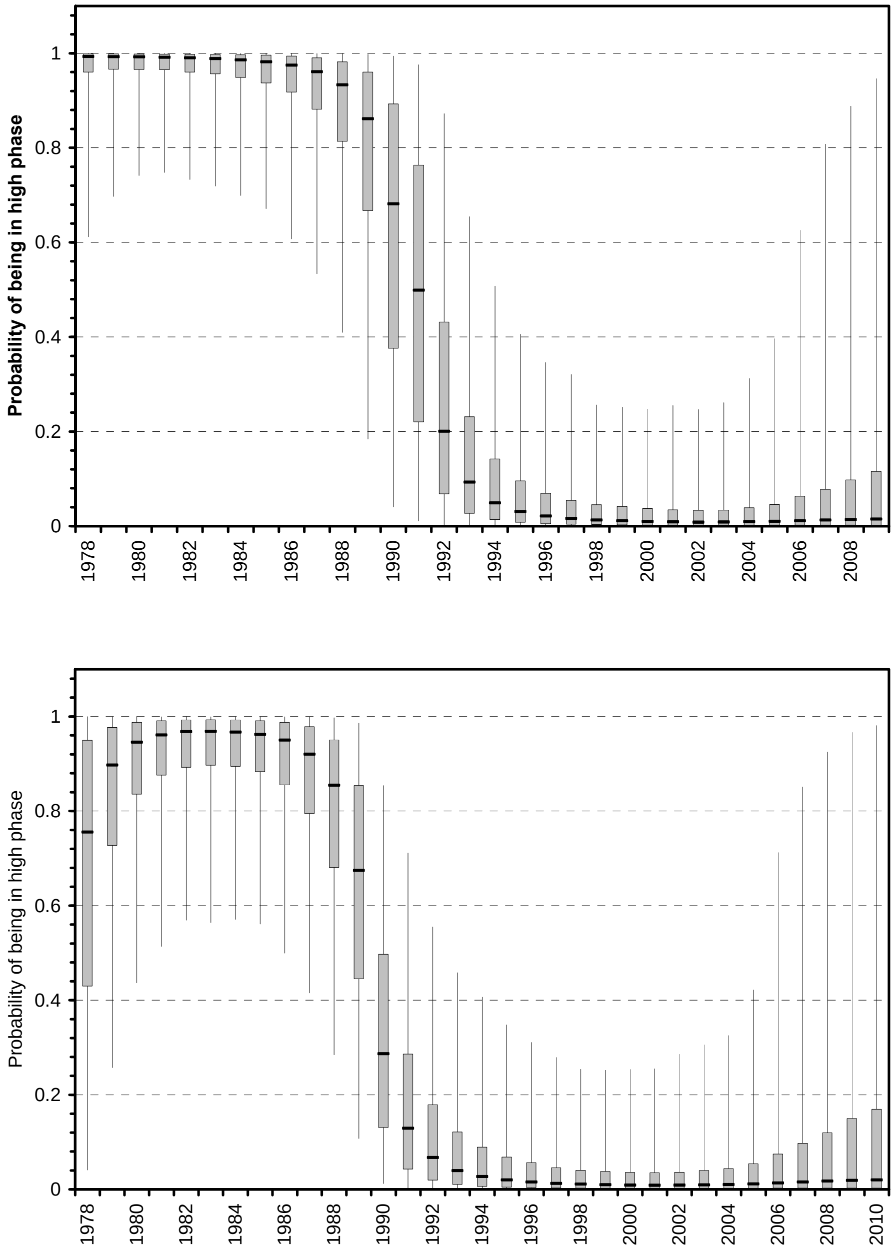


Figure 9. The probability of the productivity being in the high phase for the NAC model (upper panel) and for the NEAC model (lower panel).

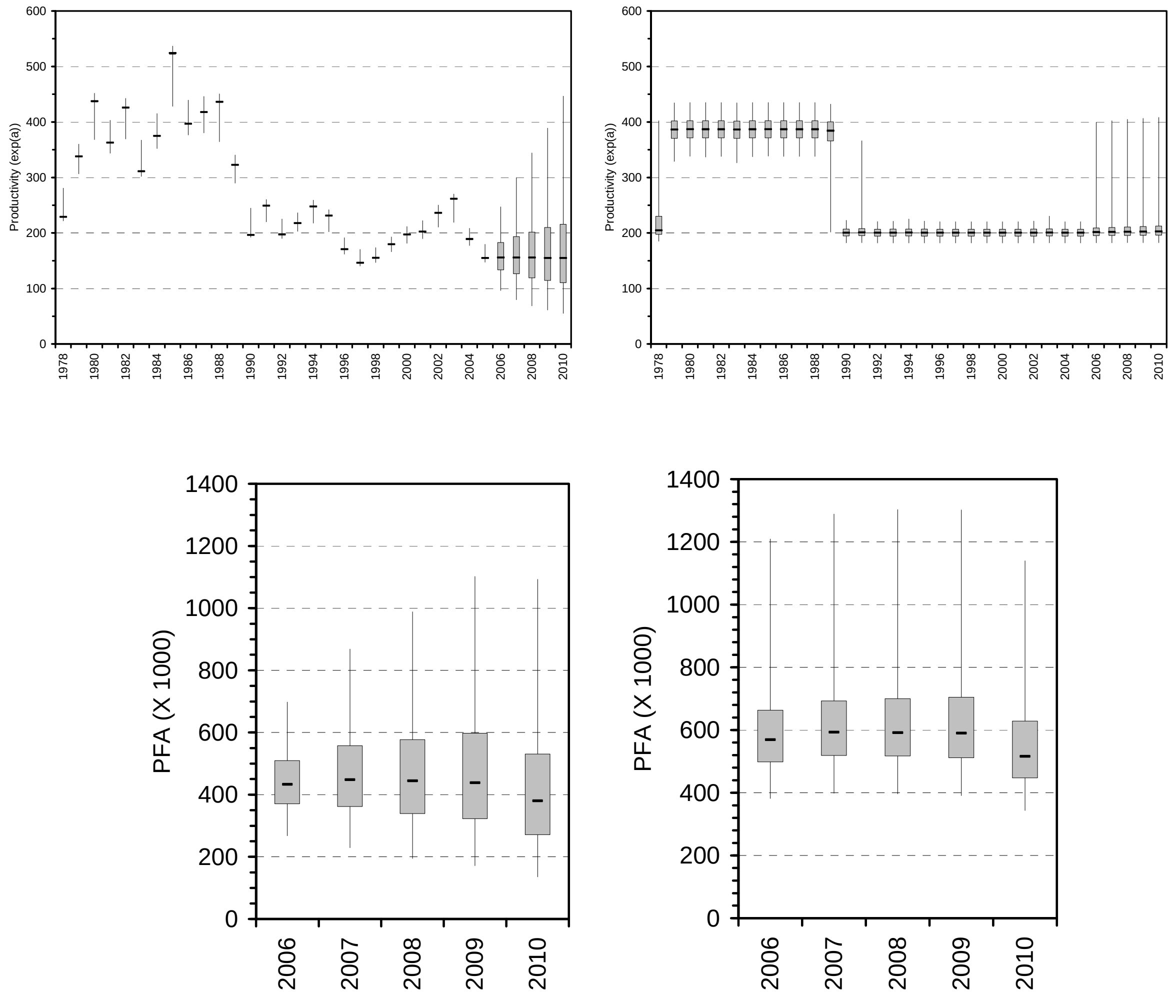


Figure 10. Estimates of productivity parameter ($\exp^{a}$) for the dynamic model (upper left) and the phase shift model (upper right) with the probability of the productivity being in the high phase (middle panel), and predicted PFA for 2006 to 2010 from the dynamic (left lower) and the phase-shift (lower right) models for the southern NEAC area.

Exploration of dynamic model to other stock complexes in NEAC

The dynamic model described above was applied to the data series for the southern NEAC maturing PFA.

Southern NEAC maturing 1SW salmon

The PFA and lagged eggs data for this complex are summarized in Appendix 5. The Winbugs code is in Appendix 1 and the data are in Appendix 2.

The lagged eggs to maturing 1SW PFA for the southern NEAC complex does show some temporal structuring suggestive of two ranges of productivities, a high and variable level during 1982 to 1989 and a lower and equally variable level between 1978 to 1981; 1990 to 2006 (Fig. 14). There was a doubling of productivity between 1982 and 1984 followed by a rapid decline during 1988 to 1993 (Fig. 14).

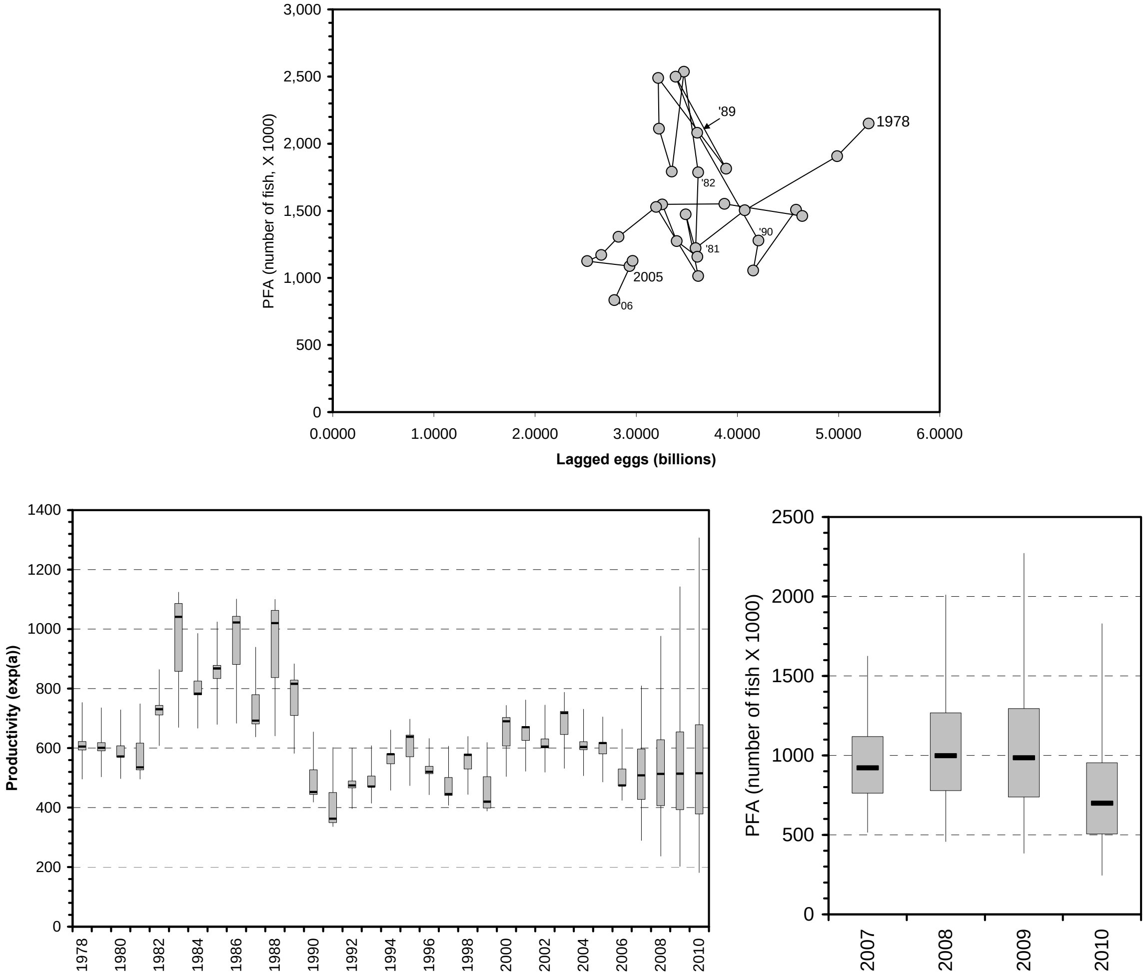


Figure 14. PFA of maturing 1SW salmon for the southern NEAC complex relative to lagged eggs of all age groups (upper panel), productivity (exp(a)) from the dynamic model (lower left) and predicted PFA for 2007 to 2010 based on lagged eggs and productivity.

NEXT STEPS

PFA and LS are estimated from a number of other data sources, each of which has associated uncertainties.

In order to use these models in a catch advice framework, disaggregated data for PFA reconstruction must be used. The model structure is shown in the DAG in Figure 15. Under this structure, the catches are modelled as covariates which act as controls on the abundance of salmon at different points at sea. Additional parameters are required to partition the returns to the regions (ϕ_j), to convert tons of fish in each of the fisheries (WGt; Ct; Fat; SPMt) to number of 1SW and 2SW fish. Finally, the returns to regions post-fisheries are evaluated relative to the objective of meeting the management objectives for different catch levels in all the fisheries.

For both the NAC and NEAC stocks, some of the fisheries exploit both maturing and non-maturing 1SW salmon. As the PFA is for the combined North American or NEAC stock complexes, it must be partitioned further into regional returns by maturity group. A combined life cycle model structure is shown in Figure 16.

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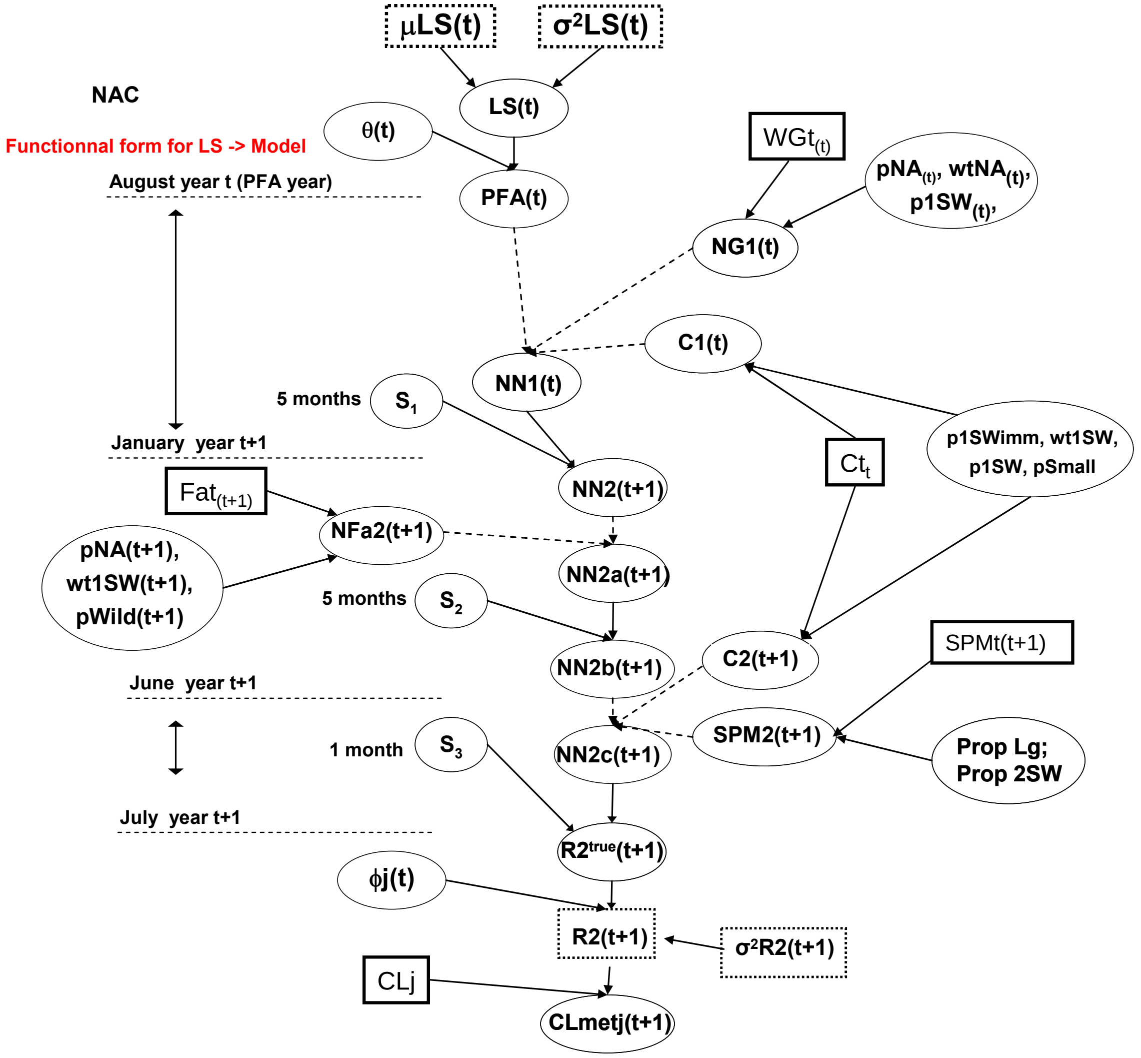

Figure 15. Directed Acyclic Graph of the PFA reconstruction, forecast and catch advice model for North America. Items in rectangles are observations, pseudo-observations or covariates.

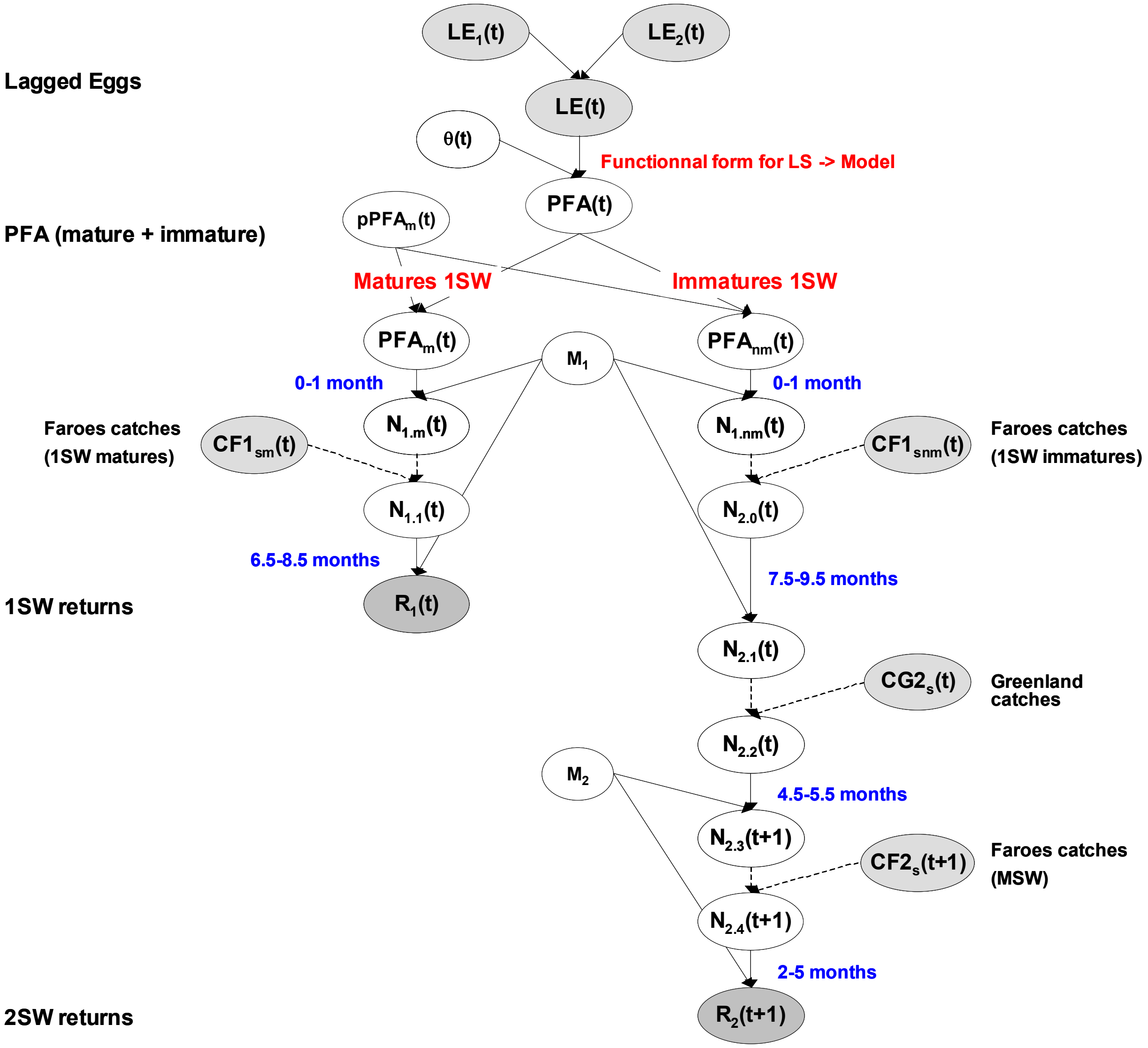

Figure 16. Directed Acyclic Graph of the PFA reconstruction, forecast and catch advice model for both maturity groups for southern NEAC.

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Appendix 1. Winbugs code for the exploration of alternate models for the productivity parameter relating lagged spawners to PFA, based on midpoint values of each (no observation error).

```
# ----------------------------------------------------------------------------------------------------------------
#                  Different formulation of a[t] in PFA[t] = LS[t].exp(a[t])
# ----------------------------------------------------------------------------------------------------------------
MODEL {
# LS to PFA model with process error
for (t in 1:(n.data+n.proj))  {
PFA[t] ~ dlnorm(ElogPFA[t],tau.PFA)
ElogPFA[t] <- log(LE[t]) + a[t]
prod[t] <- exp(a[t])}

# Variance of Process LS --> PFA
log.var.PFA ~ dunif(-20,10)
var.PFA <- exp(log.var.PFA)
tau.PFA <- 1/var.PFA

# begin productivity function code
 a0 ~ dnorm(0,0.001)
 a[1] <- a0
for (t in 1:(n.data+n.proj))  {
a[t+1] ~ dnorm(a[t],tau.a)
  }
 log.var.a ~ dunif(-20,10)
 var.a <- exp(log.var.a)
 tau.a <- 1/var.a
# end productivity function code
}

# Constant production coef (poor interest)
# a0 ~ dnorm(0,0.001)
# a0 ~ dnorm(0,0.1)
# for (t in 1:n.data)  { a[t] <- a0 }

# Autocorrelated production
## a0 ~ dnorm(0,0.001)
# a[1] <- a0
# for (t in 1:n.data)  {
# a[t+1] ~ dnorm(a[t],tau.a)
# }
# log.var.a ~ dunif(-20,10)
# var.a <- exp(log.var.a)
# tau.a <- 1/var.a
```

```
# Regime shift in the production a1 and a2
# t < t.shift ==> a[t] = a1 ; t >= t.shift ==> a[t] = a2
# a1 ~ dnorm(0,0.001)
# a2 ~ dnorm(0,0.001)
# n.tot <- n.data
# t.shift.cont ~ dunif(1,n.tot)
# t.shift <- round(t.shift.cont)
# for (t in 1:n.data)  {
# a[t] <- (1-step(t-t.shift))*a1 + step(t-t.shift)*a2
# }
```

```
# Mixture model with 2 coeficients - Random shift between a1 and a2
# Probability  p.shift[t] --> a[t] = a1 : (1-p.shift[t]) --> a[t] = a2
# a1 ~ dnorm(0,0.001) ;  k ~ dunif(-5,0) ;
# a2 <- a1 + k
# p.a1 ~ dbeta(2,2)
# for (t in 1:n.data)
# {
# I[t] ~ dbern(p.shift) ; a[t] <- I[t]*a1 + (1-I[t])*a2
# }
```

```
# Mixture model with 2 coefficients - Autocorrelation in shift probability
# Probability  p.shift[t] --> a[t] = a1 : (1-p.shift[t]) --> a[t] = a2
# p.shift[t+1] = p.shift[t] + eps[t]
# a1 ~ dnorm(0,0.001) ;  k ~ dunif(-5,0) ;
# a2 <- a1 + k
# logit.p.a1[1] ~ dnorm(0,0.001)
# log.var.logit.p.a1 ~ dunif(-20,20) ; tau.logit.p.a1 <- 1/(exp(log.var.logit.p.a1))
# for (t in 1:n.data)
# {
# logit.p.a1[t+1] ~ dnorm(logit.p.a1[t],tau.logit.p.a1)C(-10,10)
# }
# for (t in 1:n.data)
#{
# logit(p.a1[t]) <- logit.p.a1[t]
#I[t] ~ dbern(p.a1[t]) ; a[t] <- I[t]*a1 + (1-I[t])*a2
# }
```

Appendix 2. Midpoint data used in the modelling of the NAC and southern NEAC areas.

	NAC		Southern NEAC		
Year	PFA	LS	1SW non-maturing PFA (X 1000)	1SW maturing PFA	All age groups LS (billion eggs)
1971	730732		2641	2699	
1972	742060		2527	2676	
1973	884679		2022	2916	
1974	817732		2219	3079	
1975	917282		1605	3145	
1976	840510		1503	2259	
1977	670646		1671	2134	
1978	374325	95524	1212	2150	5.297
1979	847626	107013	1685	1906	4.985
1980	736023	96086	1781	1504	4.072
1981	682597	104065	1301	1221	3.587
1982	567290	107269	1537	1785	3.612
1983	339893	82167	1079	2536	3.472
1984	352236	79786	1255	1791	3.351
1985	539963	85392	1690	2111	3.225
1986	574509	80959	1276	2489	3.217
1987	520156	78592	1624	1814	3.888
1988	422740	79004	1479	2498	3.389
1989	340070	93796	1163	2081	3.603
1990	295155	102732	825	1278	4.208
1991	342105	99735	1034	1054	4.157
1992	222815	89423	904	1507	4.580
1993	158550	92185	1010	1461	4.642
1994	196412	88099	958	1551	3.872
1995	185151	88063	752	1547	3.257
1996	160167	84548	581	1274	3.399
1997	150243	87195	527	1157	3.604
1998	108059	78484	540	1473	3.489
1999	110907	74528	649	1014	3.614
2000	129596	83070	630	1527	3.197
2001	84145	83141	572	1305	2.824
2002	112382	73964	627	1170	2.655
2003	111911	64892	658	1124	2.516
2004	109813	71300	554	1087	2.935
2005	110251	72473	458	1126	2.965
2006		67154		834	2.783
2007		63252			2.877
2008		67756			2.855
2009		64579			2.833
2010					2.457