Political overfishing: Social-economic drivers in TAC setting decisions

Rudi Voss[1*], Julia Hoffmann[1], Marcos Llope[2], Jörn O. Schmidt[1], Christian Möllmann[3], Martin F. Quaas[1]

Sustainable use of marine resources, as targeted by Ecosystem-Based Fishery Management (EBFM), is a highly ranked policy goal. However, many marine fish stocks are still overused, challenging sustainability goals. Reasons for this policy failure are disputed and they might be manifold, including economic, institutional, and social drivers. We use Generalized Additive Models (GAMs) to empirically determine and quantify the importance of interacting ecological, economic, and social drivers in a political decision making process, i.e. the setting of annual Total Allowable Catch (TAC) limits. GAMs allow non linear relationships between response and explanatory variables and due to their flexibility have successfully been applied to investigate ecosystem dynamics. Here, we use this modeling approach in a novel way to quantify social-economic-ecological feed-backs on policy decisions. European fisheries policy agreed in most cases to TACs higher than scientifically advised. We recorded this deviation for all managed European fish stocks for the time-series 1987-2013. Additionally, we make use of available time-series of socio-economic and ecological variables potentially influencing the decision, including national unemployment rates, stock status, economic growth rates, and employment in fisheries. We show that political decisions on TACs are not only driven by scientific advice on the ecological state of the stock, but that socio-economic variables have a significant effect on TACs – however not related to sound scientific advice. We conclude that scientific advice for a successful implementation of EBFM will have to address socio-economic driving forces more explicitly.

Keywords: GAM, TAC setting, economic drivers, social drivers, interaction, decision making, fisheries,

[1]Department of Economics, University of Kiel, Wilhelm-Seelig-Platz 1, 24118 Kiel, Germany
[2]Instituto Español de Oceanografía, Centro Oceanográfico de Cádiz, Puerto Pesquero, Muelle de Levante, Cadiz 11006, Spain
[3]Institute for Hydrobiology and Fisheries Science, University of Hamburg, Große Elbstraße 133, 22767 Hamburg, Germany

*corresp. author; tel. +49 431 8805634; fax +49 431 8803150; email: voss@economics.uni-kiel.de

Introduction

The most important instrument in fisheries management is setting total allowable catches (TACs). TACs limit the amount of fish that can be caught legally from a certain stock in a year. Evidence shows that some countries have implemented a quite successful TAC management, for example Iceland and New Zealand (Hilborn, 2007), where fish stocks have increased and fisheries have become highly profitable after the implementation of the management schemes. However, in other regions the TAC management failed and fish stocks continue to be overexploited. That is the case in the European Union (European Commission, 2009b; Khalilian et al.,2010; Quaas et al., 2012).

The failure of the European TAC management is often traced back to too high TAC levels that fail to sufficiently restrict fishing activities (European Commission 2009, Greenbook). To explain this failure it is widely assumed that decision-makers (mostly politicians) act in favor of their personal short-term interests instead of focusing on the long-term benefits of sustainable fishing (Froese, 2011; Mardle and Pascoe, 2002). Accordingly, they would push towards high TAC levels to increase fishing benefits in the short run, at the costs of continued overfishing. For the European Common Fisheries Policy, Franchino and Rahming (2003) examine the internal structure of the European Council of Ministers for Agriculture and Fisheries and show that the ministers, despite their obligation to implement sustainable fishery, are more concerned with short-run benefits for the fishery than with environmental issues. In addition, the decision-makers' lack of acceptance of scientific recommendations also contributes to the choice of high TAC levels (Daw and Gray, 2005). This discrepancy between scientific and political positions is an important aspect when it comes to ineffective fisheries management (Delaney and Hastie, 2007). The reason for this discrepancy is that the scientific advice considers biological and ecological components while the decision-makers focus on socio-economic factors in addition to the advice. As a consequence, TACs are set on levels that often considerably exceed the scientific advice.

Material and methods

Time series

Advice to TAC ratio (ATR): We used panel data for 73 fish stocks from European and Non-European waters in the Baltic Sea, North Sea and North East Atlantic. These 73 stocks represent 15 species: cod, haddock, herring, plaice, sole, whiting, anchovy, capelin, hake, horse mackerel, mackerel, megrim, Norway pout, saithe, sandeel and sprat as well as 7 eco-regions (see Tab 1). For each stock a TAC is set each year. The time series of observations run from 1987 to 2013. Data is available for the advice, agreed TAC, and eco-region as defined by ICES. The data stem from the ICES advice sheets from 2014 (ICES, 2014). The advice sheets are used in the preparation of TAC proposals from the European Commission to the European Council of Ministers. For the majority of the stocks data is available for the whole period. However, in some cases the time series starts later, e.g. because the TAC management was not introduced for all stocks at the same time. For each year and

stock, we calculated the advice to TAC ratio (ATR), resulting in a ratio of 1 when the scientific advice is followed by politics, and values <1 in cases when politically agreed TAC is higher than scientifically advised. Values of 0 indicate an agreed TAC, even if the scientific advice was zero catch (Tab. 1).
Advice to TAC difference (ATD): For the GAM analysis we used the difference between advised TAC and agreed TAC in tons.
Stock status indicator: The (perceived) stock status might influence the political decision making. Politicians might accept higher than advised TACs, if the stock is perceived to be in good condition. To account for this, we calculated a simple stock status indicator: The indicator measures the deviation between estimated total stock biomass in a given year as compared to long-term (1987-2013) mean total stock biomass.

Additionally, we collected a number of socio-economic time-series, which potentially reflect factors influencing the political decision making process. We always focused on the country with the highest TAC share of the stock in question.
Fish consumption: We calculated the per capita consumption of fish (kg/year), excluding shellfish and crustaceans. The data are derived from FAO 12/2014.
Fisheries Employment and Employment rate: Employment gives the total number of men and woman, aged 15-64, being employed in the fishing sector (EUROSTAT, 12/2014). Employment rate gives the % of people working in the fishing sector (EUROSTAT 01/2015).
Unemployment rate: This variable refers to the total unemployment rate, given as a yearly average in %, (EUROSTAT 12/2014).
Economic growth rate: Economic growth rate gives the percental change of total economic growth as compared to the base year of 2005 (EUROSTAT 12/2014).
Number of countries: We also included a variable giving the number of countries, which are fishing for a certain stock.

<u>GAM analysis</u>
Generalized Additive Models (GAMs) were used to identify factors affecting the political decision making (i.e. the deviation from scientific advice). A GAM is a non-parametric regression model blending properties of multiple regressions (a special case of general linear model) with additive models. In a GAM the parameter terms a_jX_{ji} of multiple regression are replaced with smooth functions $f_j(X_{ji})$. The advantage of using smoothers is that one does not need to specify the form of the relationships between the response and the covariate, the data tell us the shape of that function. Prior to the analysis ATD and total stock status were logged transformed.
In the first step, all variables were initially included as covariates in an additive GAM model. The Generalized Cross Validation (GCV, Wood 2000) was used as the criterion for model selection: all combinations of covariates were tested, potentially excluding non-significant ($p > 0.05$) covariates and minimizing the GCV. The GCV is a measure of predictive error of the model and thus takes into account not only the fit, but also the model complexity. It therefore does penalize excessively complex models as a result of greater prediction error. All analyses were conducted using the R-software (version 3.2.1), and the package “mgcv” (1.8-6).
In a second step, we tested for the explanatory power of socio-economic variables when the stock-size effect was controlled for. We took the ratio between the ATD and

the total stock biomass. The models were re-evaluated following the procedure described above.

Results

Political implementation of scientific recommendations

In most cases agreed TACs exceeded the scientific recommendations. Averaged over all stocks, highest deviations between advice and implemented TAC occurred in the combined eco-region “Bay of Biscay and the Iberian Coast” (Fig. 1a). Here, agreed TACs were on average 164% higher than the scientific advice. Lowest average values were recorded in the Baltic as well as for the “Widely ranging” stocks. These average values might, however, be misleading. When focused on the three economically most important stocks within each eco-region, highest deviation are found in the Baltic, followed by the Bay of Biscay / Iberian waters eco-region (Fig. 1b). The agreed TAC was within 90-110% of the scientifically advised TAC in 41% of the cases (Fig. 2). Remaining variability between stocks inside a single eco-region as well as within a stock is high (Tab. 1). In 6 out of 7 eco-regions TACs were agreed, although the scientific advice was to close the fishery. On the other hand, for single stocks TACs were set far below the scientific advice for maximum catches, e.g. Baltic plaice in sub-divisions 21-23.

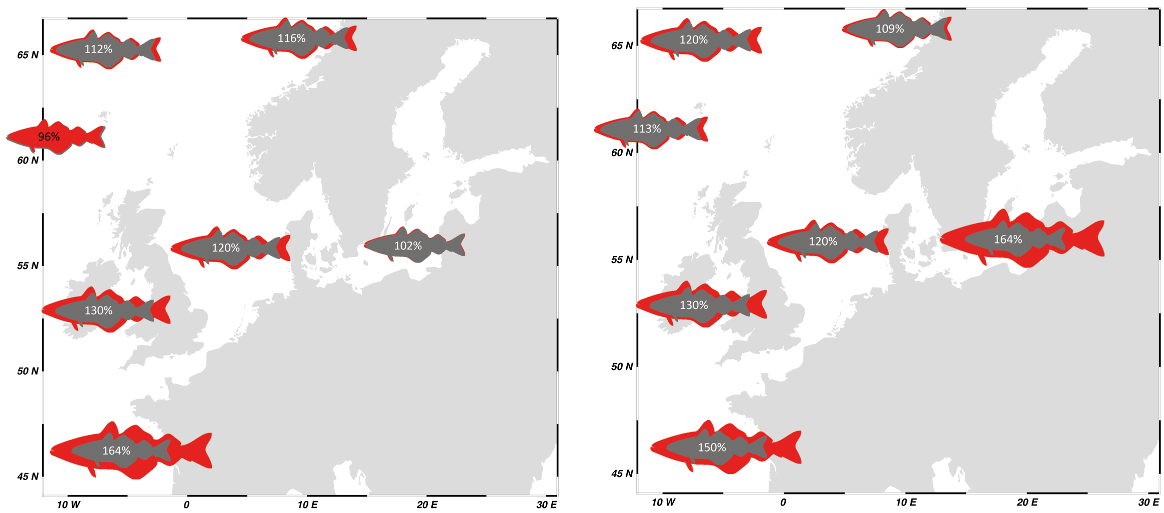

Fig. 1. “Political overfishing”. Mean deviation of agreed TAC to scientifically advised TAC in the period 1987-2013, by ICES eco-region. Left: all species within eco-region; right: 3 economically most important species. Size of the grey silhouette symbolizes the scientific advice, red silhouettes symbolize politically agreed TAC.

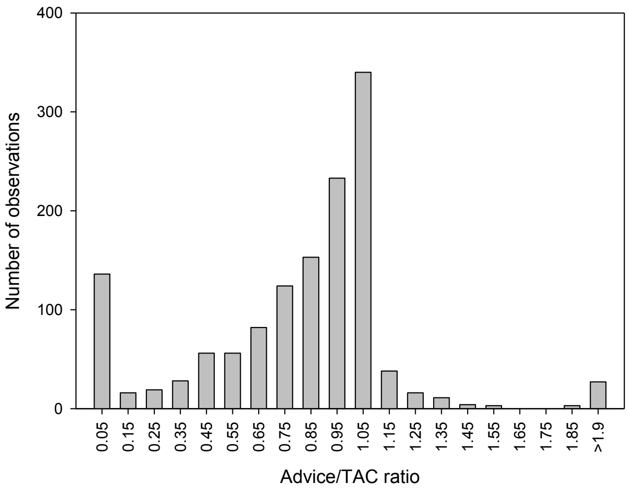

Fig. 2. Frequency distribution of scientific advice to politically agreed TACs. Values < 1 indicate political overfishing, values >1 indicate TACs set below scientifically acceptable limits.

Tab. 1. Stock-specific deviation of agreed TAC to scientifically advised TAC, divided by ICES eco-region. Given are the mean, standard deviation (STDV), maximum value (MAX), minimum value (Min), as well as the median for the period 1987-2013.

EcoRegion	Stock	Mean	STDV	Max	Min	Median
Baltic	cod-2224	0.582	0.362	1.04	0.04	0.48
Baltic	cod-2532	0.495	0.368	1.01	0.00	0.46
Baltic	her-2532-gor	0.734	0.340	1.30	0.20	0.70
Baltic	her-30	0.742	0.227	1.10	0.38	0.74
Baltic	her-31	0.065	0.048	0.17	0.02	0.05
Baltic	her-3a22	0.987	0.202	1.43	0.71	0.95
Baltic	her-riga	0.916	0.082	1.01	0.76	0.92
Baltic	ple-2123	4.375	1.020	6.13	1.59	4.23
Baltic	ple-skag	1.152	0.214	1.77	0.98	1.06
Baltic	sol-kask	0.904	0.155	1.20	0.59	0.94
Baltic	spr-2232	0.802	0.244	1.13	0.41	0.82
Baltic	spr-kask	0.542	0.409	1.00	0.16	0.41
		0.98	**1.02**	**6.13**	**0**	**0.86**
NBS	cap-bars	0.993	0.053	1.11	0.76	1.00
NBS	cod-arct	0.881	0.219	1.18	0.28	0.94
NBS	cod-coas	0.098	0.185	0.55	0.00	0.00
NBS	had-arct	0.894	0.154	1.19	0.56	0.92
NBS	had-iceg	0.977	0.145	1.34	0.60	1.00
		0.86	**0.30**	**1.34**	**0**	**1.00**
BoB	ane-bisc	0.597	0.497	1.58	0.00	0.48
BoB	ane-pore	0.556	0.079	0.61	0.35	0.59
BoB	hke-soth	0.497	0.407	1.16	0.00	0.54
BoB	hom-soth	0.745	0.181	1.00	0.43	0.80
BoB	mgb-8c9a	0.394	0.406	1.03	0.00	0.32
BoB	sol-bisc	0.918	0.153	1.27	0.56	0.93

		0.61	**0.37**	**1.58**	**0**	**0.65**
Celtic	cod-7e-k	0.452	0.292	1.00	0.00	0.42
Celtic	cod-iris	0.425	0.430	1.00	0.00	0.43
Celtic	cod-scow	0.455	0.452	1.00	0.00	0.46
Celtic	had-7b-k	0.804	0.115	0.88	0.67	0.80
Celtic	had-iris	0.859	0.399	1.40	0.15	0.84
Celtic	had-rock	1.024	0.887	1.54	0.00	1.02
Celtic	her-irls	0.944	0.203	1.29	0.47	0.95
Celtic	her-irlw	0.948	0.244	1.29	0.00	1.00
Celtic	her-nirs	0.894	0.113	1.02	0.71	0.92
Celtic	meg-4a6a	0.562	0.152	0.88	0.32	0.58
Celtic	meg-rock	0.794	0.305	1.11	0.05	0.80
Celtic	ple-7h-k	0.653	0.072	0.77	0.58	0.64
Celtic	ple-celt	0.801	0.206	1.00	0.38	0.85
Celtic	ple-iris	1.315	0.832	3.67	0.30	1.00
Celtic	sol-7h-k	0.602	0.181	0.92	0.44	0.53
Celtic	sol-celt	0.926	0.073	1.04	0.79	0.93
Celtic	sol-iris	0.723	0.375	1.04	0.00	0.88
Celtic	whg-47d	0.652	0.176	1.07	0.40	0.64
Celtic	whg-scow	0.586	0.475	1.31	0.00	0.68
		0.77	**0.44**	**3.67**	**0.00**	**0.86**
Iceland	cap-icel	0.658	0.749	3.60	0.00	0.67
Iceland	cod-iceg	0.948	0.089	1.17	0.75	0.97
Iceland	had-iceg	0.956	0.096	1.20	0.73	0.93
Iceland	her-vasu	0.981	0.212	1.88	0.64	1.00
		0.89	**0.40**	**3.60**	**0**	**0.94**
North Sea	cod-347d	0.646	0.681	2.60	0.00	0.68
North Sea	cod-3	0.852	1.679	6.88	0.00	0.78
North Sea	cod-4	0.550	0.517	1.17	0.00	0.60
North Sea	cod-7d	n.a.	n.a.	n.a.	n.a.	n.a.
North Sea	had-34	0.767	0.324	1.28	0.06	0.82
North Sea	had-3	0.710	0.255	1.00	0.40	0.65
North Sea	had-4	0.686	0.470	1.39	0.00	0.84
North Sea	had-6a	0.860	0.320	1.88	0.43	0.79
North Sea	her-47d3	0.962	0.076	1.02	0.79	0.99
North Sea	her-noss	0.890	0.316	1.30	0.00	1.00
North Sea	her-vian	0.874	0.247	1.37	0.35	0.91
North Sea	nop-34	1.655	1.513	3.74	0.00	1.42
North Sea	ple-ech-comb	0.813	0.222	1.00	0.07	0.82
North Sea	ple-nsea	0.888	0.125	1.04	0.59	0.92
North Sea	sai-3a46	0.928	0.203	1.10	0.00	0.97
North Sea	sai-3a4	0.989	0.072	1.14	0.74	1.00
North Sea	sai-6	0.878	0.185	1.12	0.44	0.93
North Sea	san-nsea	38.231	64.837	113.10	0.57	38.23
North Sea	sol-eche	0.953	0.117	1.34	0.76	0.99
North Sea	sol-echw	0.787	0.306	1.08	0.00	0.93
North Sea	sol-nsea	0.913	0.101	1.05	0.67	0.93

North Sea	spr-ech	n.a.	n.a.	n.a.	n.a.	n.a.
North Sea	whg-4	0.831	0.383	1.82	0.00	0.83
North Sea	whg-7d	0.371	0.293	0.87	0.00	0.29
North Sea	whg-7e-k	0.498	0.175	0.87	0.27	0.50
		0.83	**0.49**	**6.88**	**0**	**0.93**
Widely ranging	hke-noth	0.813	0.179	1.00	0.35	0.85
Widely ranging	hke-soth	1.411	2.390	11.53	0.47	0.97
Widely ranging	hom-soth	0.853	0.156	1.05	0.57	0.88
Widely ranging	whb-comb	1.083	1.156	4.54	0.53	0.77
		1.04	**1.37**	**11.53**	**0.35**	**0.88**

GAM analysis

In the first GAM (model including stock size) three variables were retained in the final model formulation: stock size, number of countries, and fish consumption. This confirms that TAC setting is influenced by combined socio-ecological variables. Stock status, however, was rejected as insignificant variable. All retained variables had a significant ($p < 0.001$) effect on the deviation between advised and agreed TACs (ATD). The model accounted for 64.4% of the variance. Increase in stock biomass as well as number of countries had a positive, slightly concave effect on ATD (Fig. 3a-b), whereas the effect of fish consumption followed a s-type relationship (Fig. 3c). An increase in stock biomass had the strongest, increasingly positive effect. Number of countries significantly increased the deviation between advised and agreed TAC (ATD) if more than 5 countries were involved in the fishery For per capita fish consumption values greater than 28 kg/year increased ATD.
In summary, the additive model, including stock size, suggest that the highest values of political overfishing, i.e. deviations between advised and agreed TACs, occurred when a stock is large, many countries are involved in the fishery, and when fish is an important part of the diet in society.

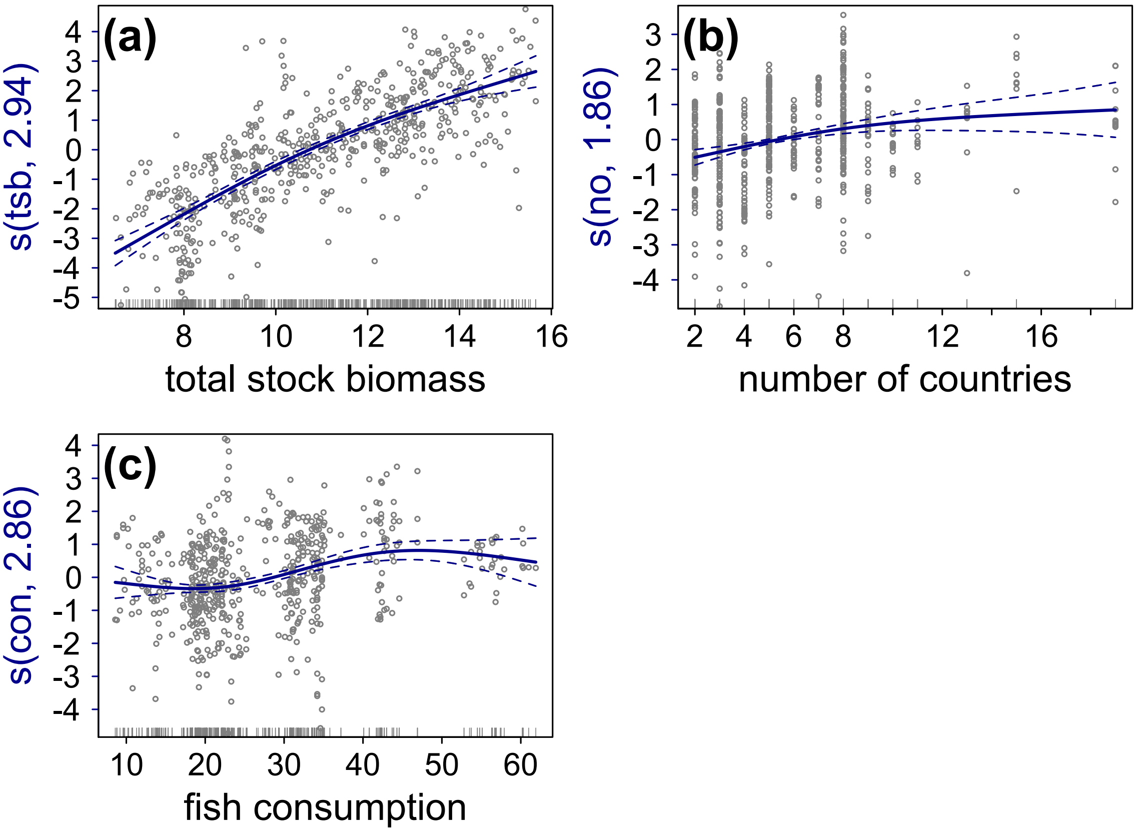

Fig. 3. Partial effects of socio-ecological-economic factors in the first Generalized additive model (GAM) including stock size explaining the deviation between advised and agreed TACs. The solid lines represent the estimated smooth function and the dashed lines the corresponding 95% confidence limits. The rug plots along the x-axis show the values of the covariates for each smooth and the number in each y-axis caption is the effective degrees of freedom of each term. From left to right and from top to bottom: total stock biomass (panel a), number of countries (b), per capita fish consumption (c, kg/year).

To further elaborate the effect of socio-economic factors, we controlled for stock size, and re-run the analysis. Three socio-economic variables were retained in the final model. As before, “number of countries” and “fish consumption” were statistically highly significant ($p<0.001$). Additionally we found an effect of the unemployment rate ($p<0.001$), which was not revealed before. The model still described 12.5% of the variance. A moderately high number of countries involved in the fishery (4-7 countries) positively affected ATD. As before, per capita fish consumption above a certain value (23.8 kg/year) increased the agreed TACs. Relatively low unemployment rates of 5.3-9.4% decrease the difference between advise and agreed TACs, while for values >9.4% a clear positive effect was found.

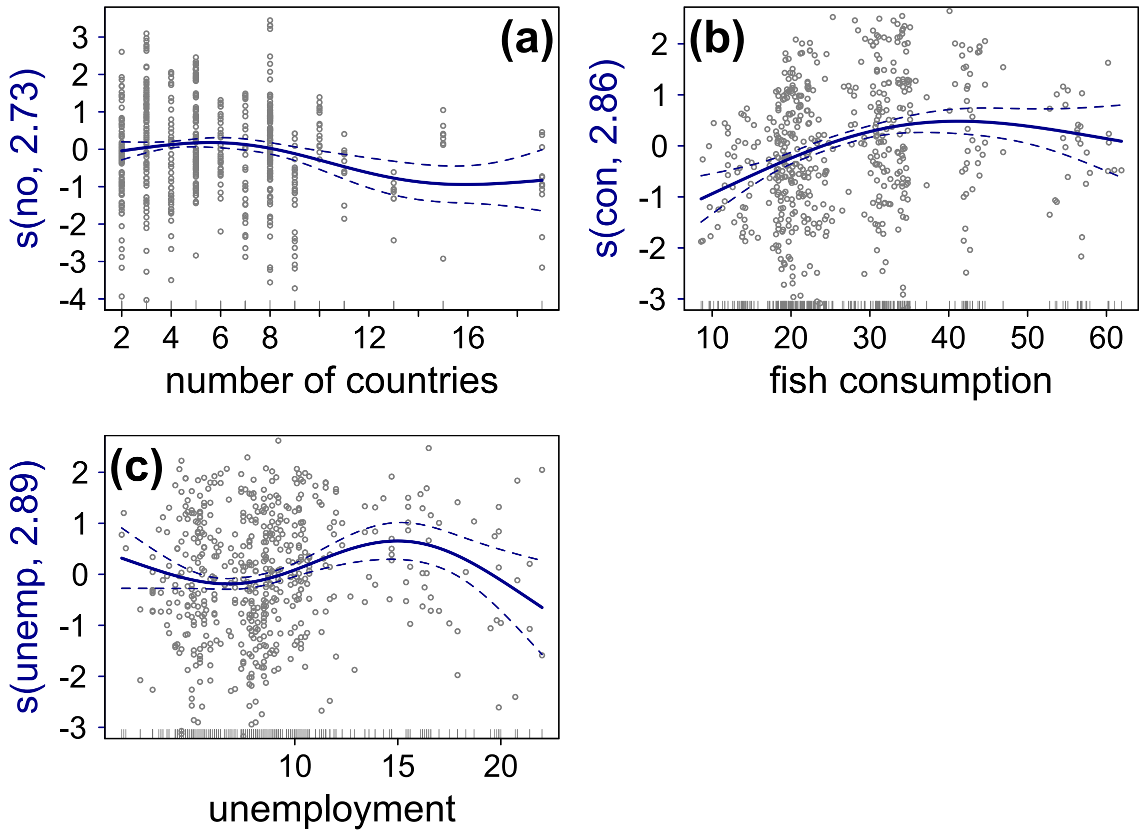

Fig. 4. Partial effects of socio-ecological-economic factors in the second Generalized additive model (GAM) controlling for stock size, explaining the deviation between advised and agreed TACs. The solid lines represent the estimated smooth function and the dashed lines the corresponding 95% confidence limits. The rug plots along the x-axis show the values of the covariates for each smooth and the number in each y-axis caption is the effective degrees of freedom of each term. From left to right and from top to bottom: number of countries (a), per capita fish consumption (b, kg/year), unemployment rate (c, %).

Discussion

This paper shows that political overfishing has been and still is a serious problem in the European Common Fisheries Policy.

In the European Union, TACs are set by the Council of Minsters which consists of national representatives of the EU member states. The European Commission usually develops a proposal for TACs based on scientific recommendations from the ICES and hands it over the Council of Ministers. Regarding the TAC, the ministers have the final say. For the majority of the stocks is it evident that the political decision-makers in the Council tend to ignore the scientific advice and set TACs to levels greater than the scientific recommendation.
In our analysis we identify four factors that influence the gap between TACs and scientific advice.
The first finding is that political overfishing increases with the stock size. It could be argued that from the decision-makers point of view a large stock does not seem to be

endangered and therefore does not need a sustainable, i.e. restrictive, TAC. As a consequence, the scientific advice is not sufficiently considered.

The number of countries also affects the gap between TAC and scientific advice. The more countries fish for a stock the greater the deviation. If many countries have fishing interests in a specific stock the pressure on decision-makers to enforce high TACs for that stock increases. This fits with the findings of McWhinnie (2009) who states that stocks fished by a large number of countries are more likely to be overexploited than stocks fished by a small number of countries.

The level of fish consumption and the unemployment rate also have the potential to increase the gap between TACs and advice if they reach sufficiently large values. If the level of fish consumption (per capita and year) exceeds 23.8kg it clearly increases the deviation between TAC and advice. The same holds for an unemployment rate of more than 9,4%.

It can be assumed that a high level of fish consumption of a country indicates importance of fishery for the population, e.g. for historic or cultural as well as for economic reasons. Hence, countries with a higher fish consumption will have a greater interest in high TACs and therefore are more likely to ignore the scientific advice when it comes to TAC decisions.

If the unemployment rate is sufficiently high a country will put more effort on avoiding a further increase in unemployment. Since employment in the fishing sector is decreasing all over Europe people working in that sector are prone to unemployment. By arguing for high TACs countries (or their national representative on EU level) can increase the probability of fishermen to stay employed.

We conclude that socio-economic variables have an important influence on the TAC level. So far, this kind of factors is not considered in the development of the scientific advice. In order to implement a more successful ecosystem-based fishery management in the European Union it will be necessary to include socio-economic factors more explicitly, i.e. on a regular scientific basis, in the future. Otherwise, fisheries management will be strongly influenced by in-transparent, personal, and in the worst case bad-informed opinions, and not based on science.