Northwest Atlantic Fisheries Organization

Serial No. N4806 **NAFO SCR Doc. 03/2**

SCIENTIFIC COUNCIL MEETING – JUNE 2003

On the TAC Estimates Compliance with Some Commercial Fish Stocks in NAFO Area: Retrospective Analysis and Improvement Possibilities

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ABSTRACT

The attempt has been made to reveal the compliance of TAC values adopted in ICNAF-NAFO area in 1973-2000 for the following stock units: Div. 2+3KLMNO Greenland halibut, Div. 3LNO American plaice, Div. 3LNO yellowtail flounder, 3M beaked redfish, Div. 2J+3KL, Div. 3M, Div. 3NO cod and Div. 4VWX silver hake. The introduction of stock state categories became the methodical basis of the analysis. The latter were further compared to actual TAC values. The plots of the relationship between the values considered and correlation coefficients allowed to conclude that in most cases TACs adopted were not adequate to the actual stock state. The limits of "improved" TACs were estimated for each category. The results obtained became the basis of so-called conservative approach (CA) to assessment of a stock state and allowable catches for a year ahead. The examples of CA application in practice are presented. The application terms of the proposed approach, which can be assigned to the group of non-parametric semi-quantitative methods, are formulated.

INTRODUCTION

The strategy of living resources fishery management in NAFO area is based on TACs assessment the values of which are assumed to vary by years in compliance with particular stocks fluctuations. Theoretically it should be the case. However in practice the adequacy of these processes is doubtful. As the experience of ICNAF and NAFO evidences, the reliability of abundance and biomass estimates of the basic commercial species have always raised (and will raise) doubts of scientists working in this field. Respectively, considerations of the general nature and researches' intuition played an important role in scientific recommendations development. Besides, sometimes various political and economical considerations could affect the final TAC values agreed by Fisheries Commissions. Naturally, that the extent of TACs correspondence to the actual stocks state can vary within a wide range. Any considerable improvement in this field could be hardly expected in the nearest future. Therefore the analysis of TACs correspondence to their aim for the period considered and the attempt to find out any ways to eliminate any serious discrepancies (if revealed) or at least to reduce them seem to be very important.

MATERIAL AND METHODS

The following stocks – Div. 2+3KLMNO Greenland halibut, Div. 3LNO American plaice, Div. 3LNO yellowtail flounder, Div. 3M redfish, Div. 2J+3KL, Div. 3M, Div. 3NO cod and Div. 4VWX silver hake were selected as the study objects. Both estimates based on the analytical models (SPA) (Mahe J.-C., and Bowering, 2002; Morgan *et al*., 2002; Showell, 1997; Stansbury et al., 2001), and abundance indices of trawling surveys (Avila de Melo *et al*., 2002; Lilly *et al*., 2001; Vazquez and Cervino, 2002, Walsh *et al*., 2002) were used as the fishable biomass characteristics. The data on TACs adopted by ICNAF and NAFO during 1973-2000 were obtained from the book by Chepel (2002) and some NAFO Scientific Council Reports (1989, 1993, 1997).

It was taken into consideration that at present analytical estimates should be often interpreted as illustrative or relative, while the basic source of information about fish stocks state became trawling surveys indices characterized with significant interannual fluctuations. The attempt was made to smooth the latter by means of introducing a stock state category, each including the range of biomass (abundance) indices estimated in percent (see below) of the mean long-term level. The categories were selected in such a way as to cover all basic phases of stocks state, in particular:

1. More than by 80% lower than the mean long-term level
2. By 20-80% lower than the mean long-term level
3. Within ± 20% of the mean long-term level
4. By 20-80% higher than the mean long-term level
5. More than by 80% higher than the mean long-term level

The percent intervals were assessed not entirely arbitrarily. The purpose was to mask as far as possible any sharp fluctuations of abundance indices often being artifacts, and at the same time to retain the actual trends of the fishable biomass changes. The above said intervals and limits were used to convert the actual indices of a stock state into categories and in subsequent correlation analysis. Most likely that in future more distinct criteria will be found to assess the ranges implying opportunity (and inevitability) of the latter correction.

TACs for stock units with moratorium were assumed equal to 1 thous.t. In estimation of correlation coefficients only the first year of the moratorium was included in the case when directed moratorium adopted in 1990s continued to 2000 inclusive without interruption.

RESULTS AND DISCUSSION

Solution of the task presented in Introduction, was begun with the actual stock indices conversion into categories and stock status, and comparison of those with the actual TAC values for 8 stock units. The data presented in Table 1 became the basis of the subsequent analysis.

For the illustrative purposes eight plots of the relationship between the values considered are made (Fig. 1-8) and briefly commented below.

Divisions 2+3KLMNO Greenland halibut (Fig. 1)

In 1975-80 the stock status was characterized mainly with category 3, while TAC was adopted at a low level. The total allowable catch was increased in 1981-85, in spite of the fact that the biomass level in this period decreased to category 2. In 1986-88 the stock increased and reached category 4. At the same time TAC values were at the maximum level. However, in 1990-92 TAC was sharply decreased, though the stock biomass remained in category 4. The above said reduction did not prevent subsequent stock transfer into category 1 (1993-95), causing the necessity further decreased the catch. However it did not come down to the moratorium introduction, though there were good reasons to do so. Finally, in 1996-2000 a sustainable increase of the stock biomass up to category 5 occurred accompanied with a smooth and insignificant TAC increase.

Divisions 3LNO American plaice (Fig. 2)

In this case relatively good correspondence is observed between stock fluctuations and TAC values. However TAC reduction in due time did not prevent biomass decrease to category 1 in 1995 with subsequent stabilization at this level during the next years.

Divisions 3LNO yellowtail flounder (Fig. 3)

In 1984-87 this stock was decreasing rapidly and transferred from category 5 to category 3. At the same time TAC value remained constant and high. In 1988 the biomass transferred into category 2 and remained in this status up to 1995 inclusive. The allowable catch was significantly reduced, and in 1995 the ban of this species directed fishery was introduced. In 1996-2000 the stock was permanently increasing and approached category 5.

Nevertheless, in 1996-97 the moratorium was maintained. Afterwards TAC system had been resumed and TAC values were increased in compliance with the biomass increase.

Division 3M redfish (Fig. 4)

In 1979-89 biomass varied within categories 3-5, while TAC remained constant during the entire period and amounted to 20 thous. t. However, in 1990-91 the allowable catch was unreasonably increased sharply. Besides, the actual catch in 1989-1990 significantly exceeded TAC level. The biomass transfer into category 2 (1991-99) evidently was caused by overfishing. The total allowable catch was decreased, however, still remained too high to provide the stock recovery. This process became evident only in 2000, which was undoubtedly contributed with sharp reduction of redfish catches since 1996.

Divisions 2J+3KL cod (Fig. 5)

In 1983-86 the biomass retained at the relatively high level, approaching category 5. During this period as a whole TAC values seemed to correspond the stock size. In 1987-89 the stock status began to cause a concern. Nevertheless TAC values remained rather high during these years. The catastrophe occurred in 1990-92 when this biomass transferred from category 4 into category 1. In these years TAC was reduced not so fast as it should be. Only in 1993 when collapse of this cod stock became an incontestable fact, the moratorium of its directed fishery was introduced.

Division 3M cod (Fig. 6)

In 1974-79 a short-term increase of the stock was observed with a rise to category 4 and subsequent sharp decrease. During the entire period TAC values remained at the maximum level. In 1980-86 the biomass remained in category 2, while TAC was significantly decreased. In 1987-89 the outburst of abundance was observed (categories 3 and 4). A ban of cod fishery was introduced for these years. In 1990-95 the biomass decreased again to category 2. However directed fishery was resumed, though TAC was adopted at a relatively low level. Fishery during the above said years probably became “the last straw” leading to the stock collapse in 1996-99. A sharp reduction of TAC and subsequent moratorium could not improve the situation.

Divisions 3NO cod (Fig. 7)

In 1973-77 actually simultaneous sharp reduction of the stock size and TAC was observed. The stock biomass decreased from category 5 to category 2. In subsequent period (1978-83) a sustainable increase of the stock occurred approaching again category 5. During these years TAC was at the very low level. In 1984-86 the stock status was still estimated as the highest category, while TAC slightly increased. Sustainable reduction of biomass occurred in 1987-92. In the beginning of this period TAC was firstly increased and later on decreased. In 1993-95 the stock reached category 1 and stabilized at this level. The directed fishery moratorium was introduced in 1995.

Divisions 4VWX silver hake (Fig. 8)

In 1979-82 the stock remained at the average level (category 3) and TAC value seemed to correspond it. Maximum abundance was observed in 1983-85 (category 4). TAC value was slightly increased. In 1986-1990 the stock biomass decreased to category 3. At the same time TAC was significantly increased. In 1991 the stock transferred to category 2 and remained in this status until 1995. TACs were reducing up to 1994, when the lowest TAC was adopted. During subsequent 2 years TAC value was increased. The stock status considerably improved in 1996-97 approaching category 4. However TACs were adopted at a progressively lower level.

As appears from the above figures and comments, adopted TAC values in many cases were inadequate to the actual stock status. The mean long-term TAC values and their range assigned by categories (Table 2) also evidence the unsatisfactory relationship, except of American plaice, between TACs adopted in the period considered and stock fluctuations. Estimation of correlation coefficients confirm these qualitative observations (Table 3), especially if we take into consideration the fact that statistically significant relationship, obtained for 2J3KL cod, actually does not imply sufficiently grounded TAC estimates. The latter were evidently overestimated in 1990-92. Regarding

American plaice, one of the reasons of the stock sharp reduction (in addition to overestimated TACs in some years) might become the actual rate of its exploitation, which sometimes significantly exceeded the agreed level.

The results obtained attract attention to searching ways of TAC estimates improvement in terms of the higher correspondence to the biomass dynamics of individual commercial species. For this purpose we apply the procedure already used in this work.

The mean long-term TAC values for the whole considered period were taken as the basis of new TAC intervals assessment by categories (Table 4) in compliance with percent intervals presented in MATERIAL AND METHODS. Besides, the upper limit of catches in category 5 was assumed to exceed twice the mean TAC value for the whole period considered.

Now the question is how to apply the results obtained in practice. Though the “improved” TAC estimates are in compliance with the stocks status, it is unclear what to do with the wide range of catches allowable to each category.

However, the situation does not seem hopeless. The curves of stocks status dynamics shown in the figures evidence the comparatively conservative pattern of the categories proposed, so they are likely to be used in assessment of stocks status and TAC for a year in advance. The first stage of prediction includes the assessment of biomass index and assigning appropriate category in the last year of researches. Then, in view of the above mentioned conservativeness, the assumption is made that the stock will be in the same status for subsequent 2 years. In relatively long-living fish species such assumption seems quite acceptable and is commonly applied in works by NAFO Scientific Council (every two years advice) (NAFO, 1999) in the latest years. Since the earlier obtained range of TAC values corresponds to each category, it remains only to assess in any way the level of TAC within the known interval. The available information allows to estimate 3 TAC levels: minimum, maximum and mean. However, to do so it is necessary to have an idea about the trends of the considered species biomass dynamics for one-two years ahead. Therefore, if the stock recruitment is expected to be weak and the stock biomass reduction is assumed, the minimum TAC should be recommended, if the strong recruitment is expected (the stock biomass will increase) maximum TAC may be adopted, if the recruitment level is average (the stock biomass will remain at the level of the last year estimation) – the middle of the interval should be chosen. If no reliable information about the expected trends is available, the lower limit of the interval should be preferred according to the precautionary approach (PA) principles. The proposed procedure of TAC forecast taking into account the principle assumption, evidently, may be named as conservative approach (CA).

Now for the illustrative purposes we try to obtain “improved” TAC estimates for 2003 by some stock units considered, applying the described procedure.

Divisions 2+3KLMNO Greenland halibut

At first we suppose that retrospective estimates of this stock abundance and biomass based on the analytical model (Mahe and Bowering, 2002) precisely reflect the actual dynamics of this species stock. The results obtained indicate the continuation of the total biomass growth also in 2001. The stock biomass amounted to 298 thous. t, i.e. corresponded to category 5. According to the above assumption, it means that the same stock status will also remain 2003. Further, in view of the fact that the recruitment level expected in the above year is considered as uncertain (NAFO, 2003), the lower TAC limit should be recommended in the respective category, i.e. 89 thous. t in this case (Table 4).

Divisions 3LNO yellowtail flounder

According to the trawling surveys data this species biomass amounted 352 thous. t in 2001 (Walsh *et al*, 2002), corresponding to category 5 in this case. The recruitment level in 2003 is predicted to be sufficiently high (NAFO, 2003). The increase of yellowtail flounder stock seems to continue. Therefore, TAC upper limit can be recommended within category 5, i.e. 16.2 thous. t for 2003.

3M beaked redfish

Based on EC trawling survey data, redfish biomass in 2001 decreased significantly and amounted to 59 thous. t (Vazqez, 2002), i.e. corresponded to category 2. Abundance of all year-classes at the age 4 years appeared after 1990 was significantly lower that the arithmetical mean in 1989-2001 (Avila de Melo *et al*., 2002). However, in the experts' opinion, for redfish in Div. 3M "… the prospective of a no return consistent increase of total biomass and SSB seems to consolidate under the present low exploitation regime". Since in this case the term "low exploitation regime" does not imply a specific estimate of the latter level, TAC for 2003 should be recommended in the range from the lower limit to the middle of category 2 interval (4.9-12.2 thous. t).

For the illustrative purposes the above research results are presented in the form of a simple procedure chart.

Procedure chart of TAC values estimation applying the conservative approach

Input data

↓

Indices conversion into stock state categories

↓

Retrospective TACs reassessment by categories
and "improved" estimates obtaining

↓

Assessment of commercial biomass in the last year of researches (index of biomass or abundance)

↓

Conversion of the latter index into respective category with subsequent extrapolation for two years ahead (assumption)

↓

TAC prediction in compliance with expected trends in the stock dynamics

It is reasonable that even with insignificant fluctuations of fished biomass the moment will occur when the stock transfers from one category into another as the presented illustrations confirm. The crucial moment in fishery management is approaching. At the same time, if biomass increases it will be in the spirit of PA to preserve the estimation of the latest stock state category and the upper limit of respective TAC for the year of prediction. It is quite another matter, if a stock is decreasing. In this case revealing the fact of category change in due time, which requires a correct assessment of subsequent stock reduction, is absolutely necessary. If the research results anticipate the possibility of the fishable biomass sharp reduction in the nearest future, for the purpose of TAC estimation in compliance with PA principles it is reasonable to use a lower category and middle of the interval corresponding to the allowable catch in order to avoid a risk of significant stock overestimation.

CONCLUSION

The results of researches carried out provide a possibility to formulate the terms of application of the proposed approach belonging to the group of non-parametric semi-quantitative methods and, naturally, not being a universal one.

Taking into account the categories conservatism, CA should be applied mainly in prediction of stocks state and allowable catch of long-living fish species biomass of which as a rule does not experience sharp fluctuations from year to year. Sufficiently long-term series of TAC estimates and trawling surveys indices provide the necessary data. Besides, the estimates based on the analytic models also can be used. However, this is reasonable only in the cases when the results (absolute abundance and biomass) are interpreted only as relative indices in view of certain reasons.

Application of a single and sufficiently valid assumption, simplicity and transparency of the calculation process, as well as flexibility allowing to use PA principles can be considered as advantages of CA.

The above considerations allow to hope that CA application will reduce gross errors probability in TACs assessment for a year ahead.

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Table 1. TAC (tous. t) and stocks state categories by years.

Year	2+3KLMNO Greenland halibut		3LNO American plaice		3LNO yellowtail flounder		3M beaked redfish		2J3KL cod		3M cod		3NO cod		4VWX silver hake	
	TAC	Categ.	TAC	Categ.	TAC	Categ.	TAC	Categ.	TAC	Categ.	TAC	Categ.	TAC	Categ.	TAC	Categ.
1973													104	5		
1974											40	2	101	4		
1975	40	3	60	4							40	2	88	2		
1976	30	3	47	4							40	4	43	2		
1977	30	3	47	4							25	4	30	2		
1978	30	3	47	4							40	3	15	3		
1979	30	3	47	4			20	3			40	2	25	3	70	3
1980	35	3	47	4			20	5			10.3	2	26	3	90	3
1981	55	2	55	4			20	4			12.8	2	26	4	80	3
1982	55	2	55	4			20	3			12.4	2	17	4	80	3
1983	55	2	55	3			20	4	260	4	12.4	2	17	5	80	4
1984	55	2	55	3	17	5	20	4	266	4	13	2	26	5	100	4
1985	75	3	49	3	15	3	20	3	266	2	13	2	33	5	100	4
1986	100	3	55	3	15	3	20	4	266	5	13	2	33	5	100	3
1987	100	3	48	3	15	3	20	4	256	2	13	3	33	4	100	3
1988	100	3	40	3	15	2	20	4	266	2	1	3	40	3	120	3
1989	100	3	30	3	5	2	20	5	235	4	1	4	25	3	135	3
1990	50	4	24.9	2	5	2	50	5	199	3	1	3	18.6	2	135	3
1991	50	4	25.8	2	7	2	50	4	190	2	13	2	13.6	2	100	2
1992	50	4	25.8	2	7	2	43	3	120	1	13	3	13.6	2	105	2
1993	50	3	10.5	2	7	2	30	2	1	1	13	2	10.2	1	86	2
1994	25	2	4.8	2	7	2	26	2	1	1	11	2	6	1	30	2
1995	27	2	1	1	1	2	26	2	1	1	11	2	1	1	60	3
1996	27	2	1	1	1	3	26	2	1	1	11	1	1	1	60	3
1997	27	2	2	2	2	4	26	2	1	1	6	1	1	1	50	4
1998	27	2	1	1	4	4	20	2	1	1	2	1	1	1		
1999	33	3	1	1	6	5	13	2	1	1	1	1	1	1		
2000	35	4	1	1	10	5	5	3	1	1	1	1	1	1		

Table 2. Actual TACs by unit stocks and state categories (on top – the range , below– the mean long-terms value , thous.t)

Stock category	2+3LMNO Greenland halibut	3LNO yellowtail flounder	3LNO American plaice	3M redfish	2J3KL cod	3NO cod	3M cod	4VWX silver hake
1	No directed fishery	"	"	"	"	"	"	"
2	26-75 (44.4)	1-15 (6.8)	4.8-25.8 (18.4)	13-50 (31)	190-266 (244.5)	13.6-88 (34.5)	10.3-40 (17.3)	30-105 (80.2)
3	27-100 (55.8)	1-15 (11.5)	30-55 (47.4)	5-20 (17)	199 (199)	25-40 (26.2)	1-40 (13.6)	63-135 (94.8)
4	50-100 (62.5)	1-4 (2.5)	47-60)	20 (20)	235-266 (253.7)	17-101 (44.2)	1-40 (22)	50-100 (86)
5	33-35 (34)	6-17 (11)	-	20 (20)	266 (266)	26-104 (42.6)	-	-

Table 3. Relationship between a stock state and TAC (+ and ++ mean reliable relationship at 95 и 99% probability respectively).

Correlation coefficient	2+3KLMNO Greenland halibut	3LNO yellowtail flounder	3LNO American plaice	3M redfish	2J3KL cod	3NO cod	3M cod	4VWX silver hake
r	0.266	0.167	0.833 ++	0.152	0.626 +	0.272	0.242	0.108

Table 4. "Improved " TACs by unit stocks and state categories (at top – the range, below – the middle of the range, thous.t).

Stock, category	2+3KLMNO Greenland halibut	3LNO yellowtail flounder	3LNO American plaice	3M redfish	2J3KL cod	3NO cod	3M cod	4VWX silver hake
2	9.9-39.7 24.8	1.6-6.5 4.0	7.9-31.6 19.8	4.9-19.4 12.2	42.3-169.1 105.7	6.1-24.5 15.3	3.1-12.6 7.8	17.5-69.9 43.7
3	39.7-59.5 49.6	6.5-9.7 8.1	31.6-47.4 39.5	19.4-29.2 24.3	169.1-253.7 211.4	24.5-36.7 30.6	12.6-18.8 15.7	69.9-104.9 87.4
4	59.5-89.3 74.4	9.7-14.6 12.2	47.4-71.1 59.2	29.2-43.7 36.4	253.7-380.5 317.1	36.7-55.1 45.9	18.8-28.3 23.6	104.9-157.3 131.1`
5	89.3-99.2 94.3	14.6-16.2 15.4	71.1-79.0 75.0	43.7-72.8 58.3	380.5-422.8 401.6	55.1-61.2 58.2	28.3-31.4 29.8	157.3-174.8 166.0

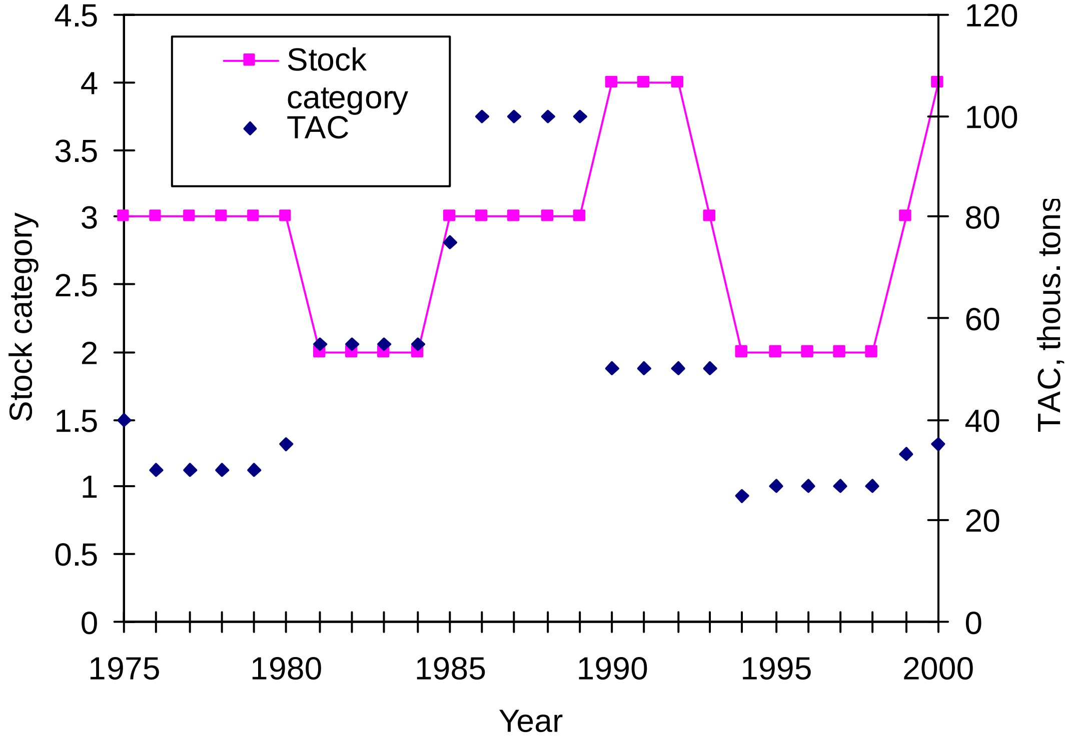

Fig. 1. Relationship between TAC and 2+3KLMNO Greenland halibut stock state categories.

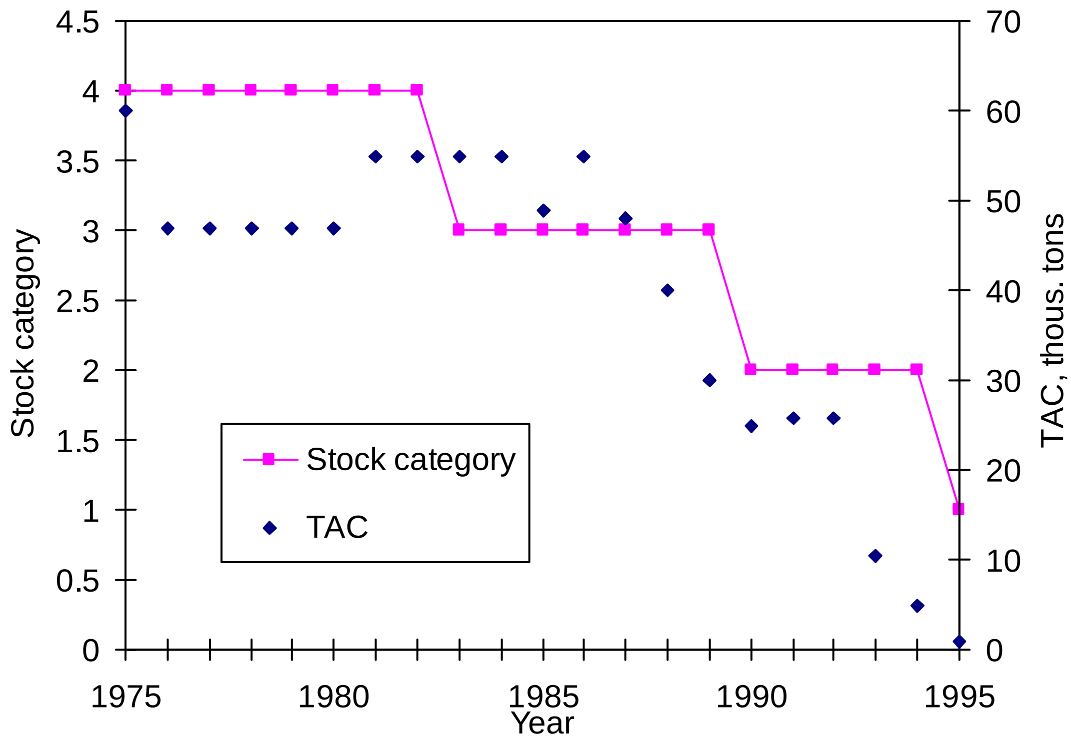

Fig. 2. Relationship between TAC and 3LNO American plaice stock state categories.

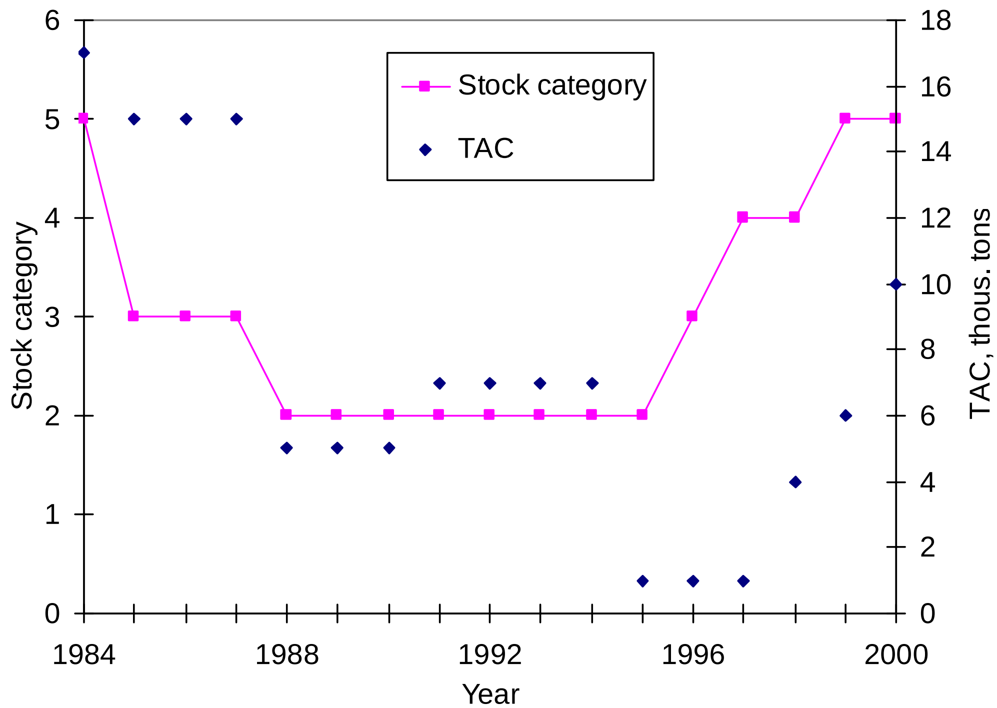

Fig. 3. Relationship between TAC and 3LNO yellowtail flounder stock state categories.

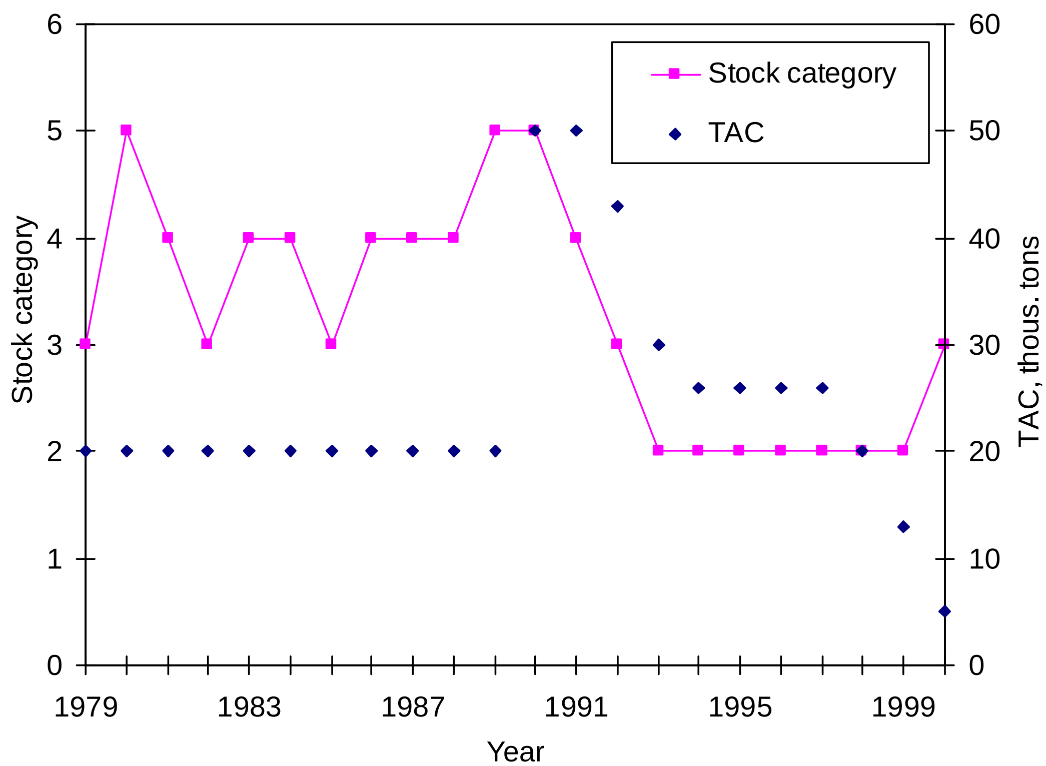

Fig. 4. Relationship between TAC and 3M beaked redfish stock state categories.

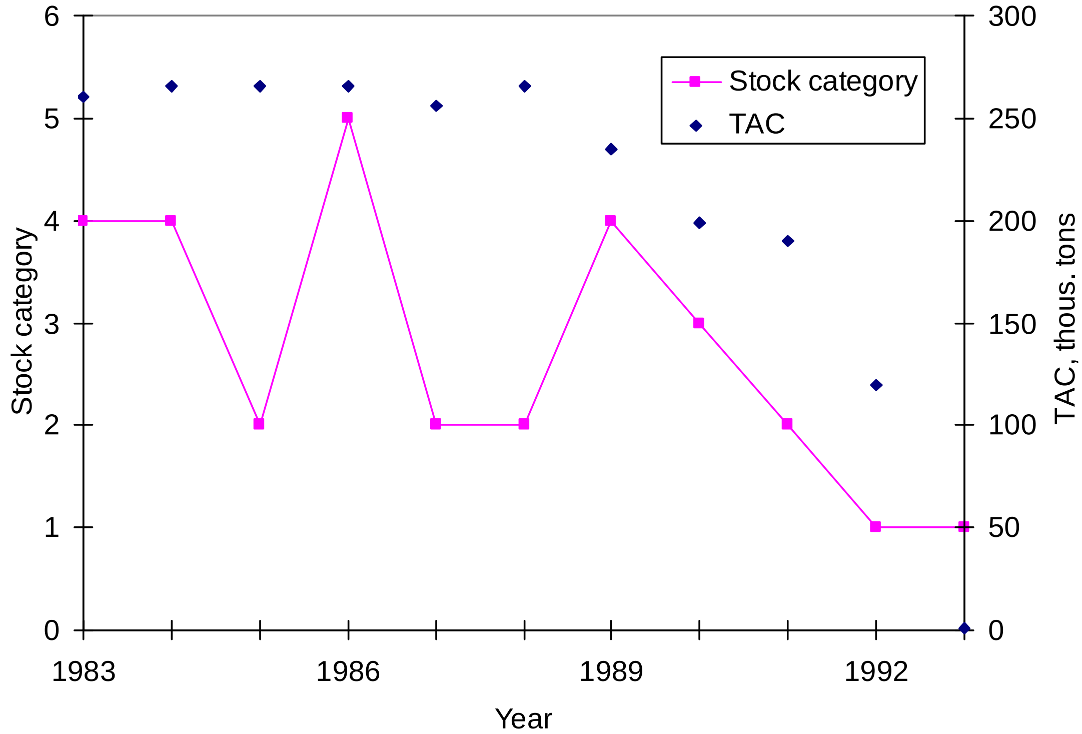

Fig. 5. Relationship between TAC and 2J3KL cod stock state categories.

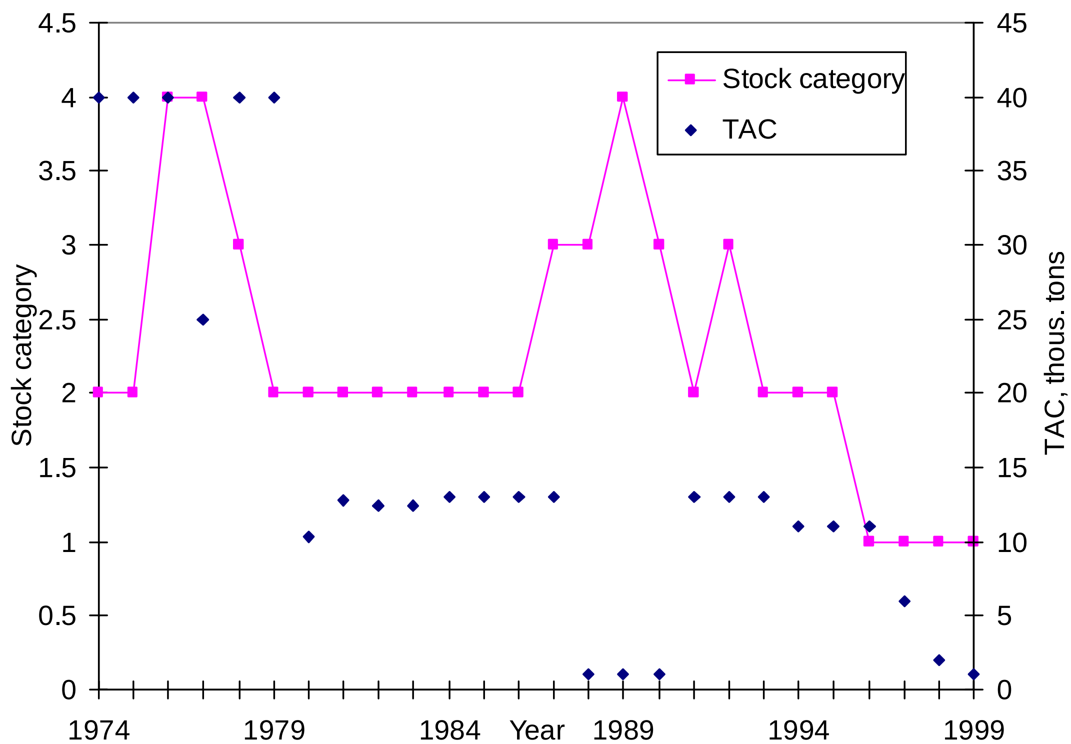

Fig. 6. Relationship between TAC and 3M cod stock state categories.

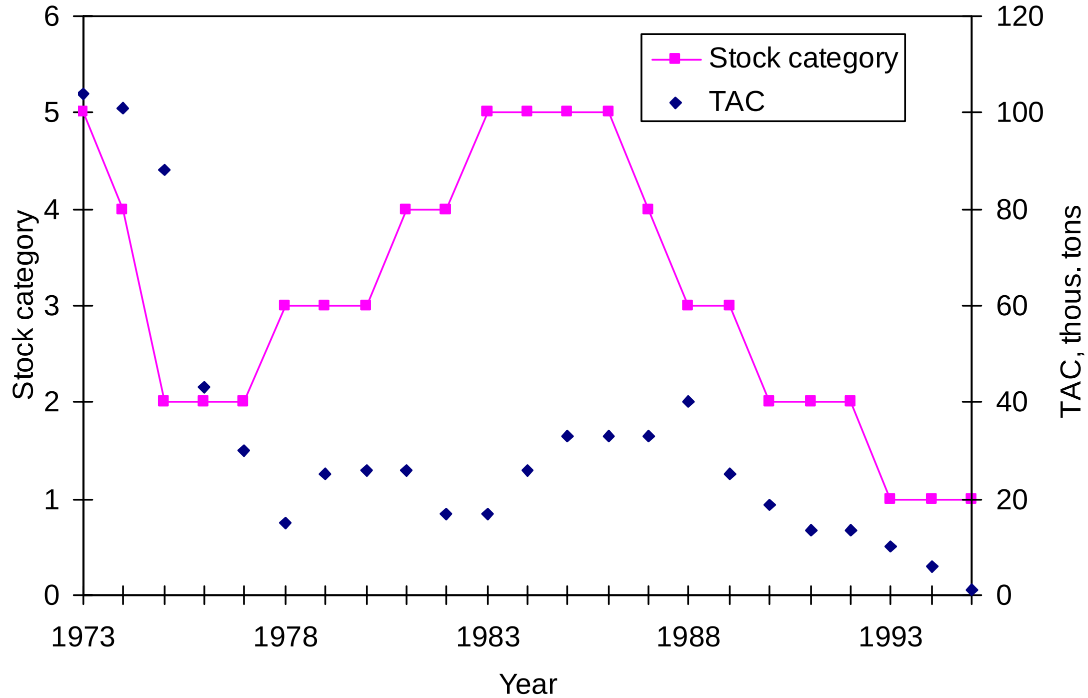

Fig. 7. Relationship between TAC and 3NO cod stock state categories.

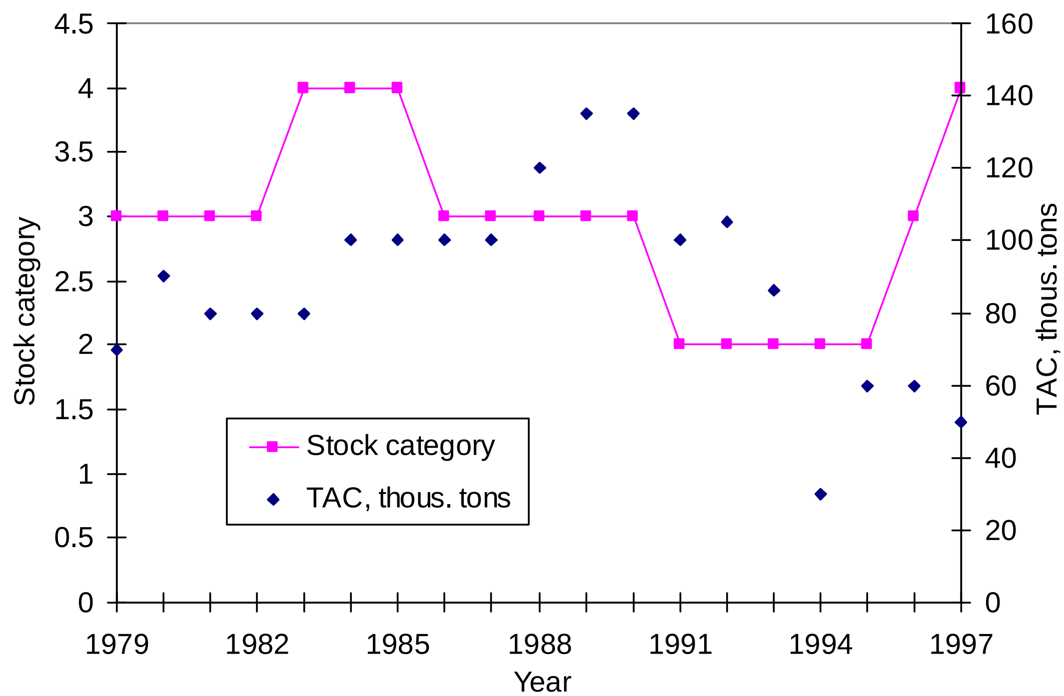

Fig. 8. Relationship between TAC and 4VWX silver hake stock state categories.