Some consideration toward the selection of a management procedure

管理方式の選択に向けての考察

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Abstract

This paper explores several procedures to synthesize the current set of performance statistics (PS) for the comparison of performance of candidate management procedures (MP). The current set of PS was classified into three categories according to the management objectives. Several potential procedures to reduce the number of PS either by dropping some PS with similar behaviors or by unifying the current PS were proposed. We consider it critical to establish one or two PS corresponding to each management objectives to make a comparison of large number of MP candidates objectively. Additional PS are also proposed.

要旨

本論文では、管理方式（MP）の比較のために、現在の performance statistics (PS)を統合する方法について検討した。まず PS を管理目的に対応する 3 種類のカテゴリーに分類した。そして、同様の挙動をしめす PS の削除や、PS の統合により、PS 数の削減に利用できそうな幾つかの方法を示した。多くの MP を客観的に比較するには、それぞれの管理目標に対応した１，２の PS を確立することが重要であると考えられる。さらに追加すべき PS についても提案した。

1. Introduction

A large number of candidate management procedures (MP) are now being developed by national scientists. We consider it important to compare trajectories of TAC and biomass of simulation trials when selecting and discriminating among various MPs. At the same time, the qualitative comparison of trajectories is difficult to lead to an objective judgment. Although performance statistics (PS) are convenient for quantitative comparison of candidate MPs, it is not so easy to examine and compare the current agreed set of 14 PS all together. Still, we may have to expect additional PS, since we found that the current set of PS is not adequate to cover all the necessary aspects of stock and TAC trajectories. On the other hand, it is preferable to reduce the total number of statistics to examine when comparing overall performance of candidate MPs.

The management objectives can be classified into three categories; conservation of stock, the stability of fisheries, and optimizing yield. If we can select one or two PS for each management objective, the comparison of candidate MPs becomes simpler. Following approaches can be applied to reduce the number of PS;
1) to select one PS from a group of PS showing similar behavior（correlation coefficient, graphical comparison etc.）
2) to unify the PS by weighting（AHP）

This paper explores several procedures to reduce the number of PS. First, we classify the current set of PS into three categories according to the management objectives that each PS aims to examine. We also proposed additional PS. Next, we present several methods to unify those PS under each management objective.

2. Reconsideration of PS

2-1. Classification of PS

Based on the character of PS, we tentatively classified PS into three categories corresponding to the three management objectives mentioned above. PS for proportion of surface catch was ignored here.

- Conservation of stock
  S2007/S2002, S2022/S2002, S2020/S1980, NB2022/NB2002, Min[S/S2002], S2020/Smsy
- Stability of fisheries
  AAV, A-statistics, dTAC, dS×dTAC
- Catch optimization
  C5yr, C20yr, C-to-TB ratio

2-2. Potential new PS

Tsuji et al.(2003) indicates several aspects required in judging performance of MP but not covered well by the present PS. We proposed to include additional robustness trails or new PS as follows.

・Maximum change in TAC

AAV shows average yearly change in TAC. Simulation results show that large change in TAC can occur in specific years (for example, the first year of management). From the standpoint of the stability of fisheries, the large change in TAC should be avoided. We proposed to introduce maximum change in TAC or maximum decrease in TAC as a statistics detecting large TAC change.

・PS for long-term stability

Tsuji et al. (2003) presents an example of simulation results showing a reasonable performance for 20 years with a drastic decline of stock afterwards and considers that the 20 years projection period is not enough for final judgment of the MP performance. PS in year 2052, such as S2052/S1980 or S2052/Smsy, is one of the ways to address this issue.

3. Selection of PS with similar performance

This section presents several methods for selecting PS with similar behaviors.

3-1.Correlation coefficient

Some PS show similar behaviors. Table 1 shows fairly typical example of the correlation coefficient between PS for one simulation run with a certain MP. This Table indicates that some PS are highly correlated. It will be possible to reduce the total number of PS by dropping one of PS showing very high correlation. For example, the correlation between S2022/S2002 and NB2022/NB2002 is 0.96 and hence either of PS may be dropped.

3-2.Graphical comparison

Fig.1 shows the values of all PS among five different MPs. Here, the PS values are normalized with mean for each PS. This type of graphical comparison would help to extract a group of PS showing similar behaviors. Although the basic idea is the same as the correlation coefficient, this method is more convenient to enable a comparison among all PS at one time.

3-3.Graphical modeling

Graphical modeling is a convenient tool to detect the correlation among many factors automatically (Edwards, 2000). In this method, every path coefficient can be estimated based on the partial correlation coefficients. The procedure of calculation for the partial correlation matrix is as follow:

1. Compute inverse matrix $R^{-1} = (r_{ij}^{-1})$ of sample correlation matrix $R = (r_{ij})$.

2. Normalize this matrix. i.e. $$R^{*} = (r_{ij}^{*}),\ r_{ij}^{*} = \frac{-r_{ij}^{-1}}{\sqrt{r_{ii}^{-1}}\sqrt{r_{jj}^{-1}}}(i \neq j)$$

The calculation using the graphical modeling seems to be a little difficult. However, it is efficient to utilize only the partial correlation matrix instead of sample correlation one because this coefficients can be delete the influence of the apparent correlation.

3-4.Bayesian network

There are some feelings that the cause-and-effect relationship among PS should be taken into account when selecting more representative PS with similar behaviors. A Bayesian networks is known as an effective statistical method to estimate the cause-and-effect relationship automatically about many variables (both observed and latent variables) using the conditional probability based on the entropy of the constructed model. This method can be theoretically utilized to synthesize these PS instead of structural equation modeling (SEM) which is difficult to apply because there is no observed response variable.

4. Unification of PS by weighting

The Analytic Hierarchy Process (AHP) is considered as one candidate to unify PS. Brief description of AHP with a simple example is attached as Appendix.

The AHP is an efficient way for decision-making. This method enables us to compare a number of scenarios (in this case, candidate MPs) for decision-making by calculating eigenvalues and eigenvector of the matrix based on the pair-wise comparison between two effects. The advantage is as follows:

- It is possible to incorporate our subjectivity into the models.
- We can get the unique solution with no statistical errors.
- We can assume the flexible model with hierarchical structure.

An example of application of this technique to comparison of MP performance is shown in Appendix. Although this method requires subjective judgment especially in determining relative importance among PS, this decision may not be too difficult.

5. Proposal

We consider it critical to establish one or two PS corresponding to each management objectives to make a comparison of large number of MP candidates objectively. This document proposes several potential procedures to reduce the number of PS either by dropping some PS with similar behaviors or by unifying the current PS.

We intentionally avoid combining PS between multiple management objectives. It has been noted that Members, and industries, varied in their views on relative importance among three general management objectives. Presenting overall performance for each objective separately is considered to be the most appropriate way to show the performance characteristics of candidate MP to the audience with various views on priority of management objectives. Unifying views on priority of objectives should be the task of the Commission.

References

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Jensen, E., V. (1996). *An Introduction to Baysian Networks.* UCL Press, London.

Saaty, T. L. (1980). *The Analytic Hierarchy Process*, Mcgraw-Hill, NewYork.

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Table 1. Correlation coefficient between PS.　Data used here is based on the simulation trails using HK5.

	C5yr	C20yr	S07/S02	S22/S02	S20/S80	NB	AAV	Min[S/S02]	S20/Smsy	C-to-TB	A_statistic	dTAC
C5yr	1.00											
C20yr	0.82	1.00										
S07/S02	0.80	0.71	1.00									
S22/S02	0.26	0.62	0.51	1.00								
S20/S80	0.26	0.67	0.39	0.92	1.00							
NB	0.25	0.62	0.47	0.96	0.90	1.00						
AAV	-0.66	-0.65	-0.77	-0.65	-0.52	-0.70	1.00					
Min[S/S02]	0.64	0.73	0.86	0.71	0.59	0.74	-0.75	1.00				
S20/Smsy	0.48	0.83	0.48	0.74	0.84	0.72	-0.43	0.62	1.00			
C-to-TB	-0.10	-0.41	-0.35	-0.75	-0.66	-0.81	0.38	-0.76	-0.59	1.00		
A_statistic	0.58	0.78	0.70	0.72	0.66	0.72	-0.71	0.79	0.59	-0.54	1.00	
dTAC	0.43	0.47	0.55	0.55	0.42	0.60	-0.73	0.65	0.22	-0.44	0.67	1.00
dS*dTAC	0.15	0.19	0.20	0.36	0.16	0.44	-0.46	0.42	0.18	-0.48	0.30	0.41

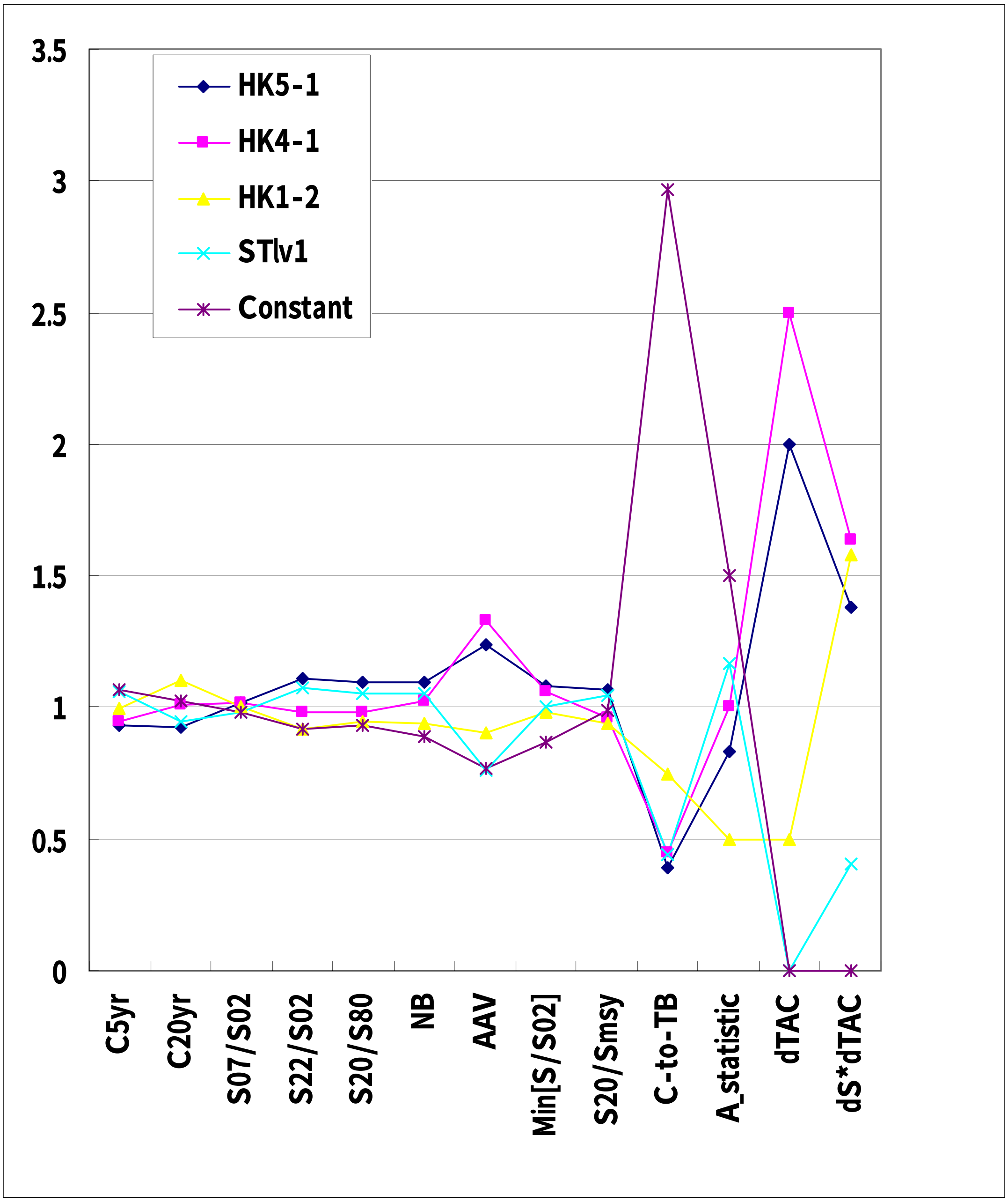

Figure 1. Graphical comparison of PS using five candidate MPs. Values shown are the average of PS of nine reference trails (hierarchy 1, Q0-option) and normalized with mean for each PS. See Tsuji et al. (2003) for the abbreviation of candidate MP. Constant means constant catch at 15,380t.

Appendix: The procedure of weighting of performance statistics (PS) by AHP

This Appendix describes one explored example to compare various MP with AHP. We compared three MP ("HStanaka(HStnk)", "NTlg1-w2" and "HK5-1"). The PS were classified into three categories. Although we did these classifications based on our common sense, it is also possible to use statistical procedures based on explanatory factor analysis. We consider three models (model-1, model-2, and model-3) corresponding to three categories. These are shown in Figures A1-A3.

-Conservation of stock:

S2007/S2002 (PS4), S2022/S2002 (PS5), S2020/S1980 (PS6), NB2022/NB2002 (PS7), Min[S/S2002] (PS9), S2020/Smsy (PS10)

-Stability of fisheries:

AAV (PS8), A-statistics (PS12), dTAC (PS13), dS×dTAC (PS14)

-Catch optimization:

C5yr (PS1), C20yr (PS2), C-to-TB ratio (PS11)

Remark) PS3 (proportion of surface catch) was not used because there is no difference among the MPs.

At first, the pairwise comparisons were made between every PS in each model based on the level of importance (Table A1-A3). However, it can be done on the basis of estimated path coefficient by confirmatory factor analysis. We used the constraint that the consistency index (C. I.) is less than 0.1. These assumed values were also subjective.

Next, rating of one to ten is assigned to each PS of all candidate MPs (shown in Table B1-B3) according to judgment on how well those MPs performed. Here, judgment was made based on the mean values of PS out of nine scenarios of reference sets corresponding to hierarchy 3 and Q0-option. It is also possible to use the weighted mean when relative importance (or plausibility) differs among scenarios. However, the weighting among different operating models should be discussed in the other context outside of this procedure.

On the basis of the eigenvalues and eigenvectors of pairwise matrix, the weight in each stratum can be calculated. AHP integrates every processes based on these weighted values obtained from the matrix. Thus, we can get the final results (i.e. total weight: Tw) shown in Figures B1-B3. These calculations were performed through

“*Nemawashikun*(V.3.0)” (Trial-version) made by JUSE (The Institute of Japanese Union of Scientists and Engineers).

Table A shows the summary of the results. The best MP in this case depends on which management objectives are the most important.

Table A. Summary of the results of comparison among three MPs by AHP.

Model	Concept	C.I.	HStanaka	NTlg1-w2	HK5-1
1	Conservation of stock (Soundness of stock)	0.049	0.415	0.267	0.318
2	Stability of fisheries	0.038	0.316	0.394	0.290
3	Catch optimization (Maximization of catch)	0.019	0.251	0.351	0.398

Remark) Filled values means the best MP in the corresponding models.

Model-1: Conservation of stock.

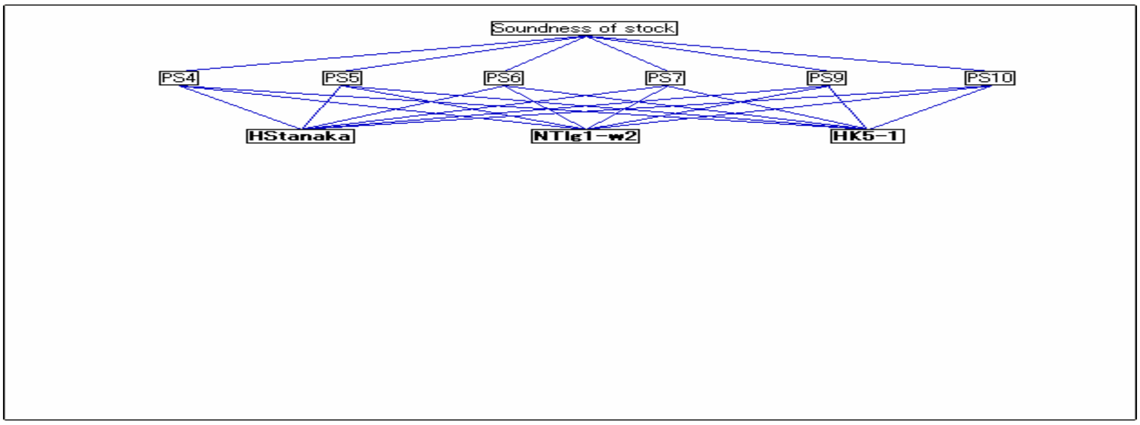

Figure A1. Hierarchical structure of model-1.

Pair-test	PS4	PS5	PS6	PS7	PS9	PS10
PS4	1	1/9	1/7	1/3	1/5	1/5
PS5	9	1	3	7	5	5
PS6	7	1/3	1	5	3	3
PS7	3	1/7	1/5	1	1/3	1/3
PS9	5	1/5	1/3	3	1	1
PS10	5	1/5	1/3	3	1	1

Table A1. Pair-wise matrix in the middle layer of model-1.

Score	PS4	PS5	PS6	PS7	PS9	PS10
HStanaka	6	8	8	8	8	8
NTlg1-w2	5	5	5	5	6	5
HK5-1	5	6	6	6	7	6

Table B1. Absolute evaluations in the bottom layer of model-1.

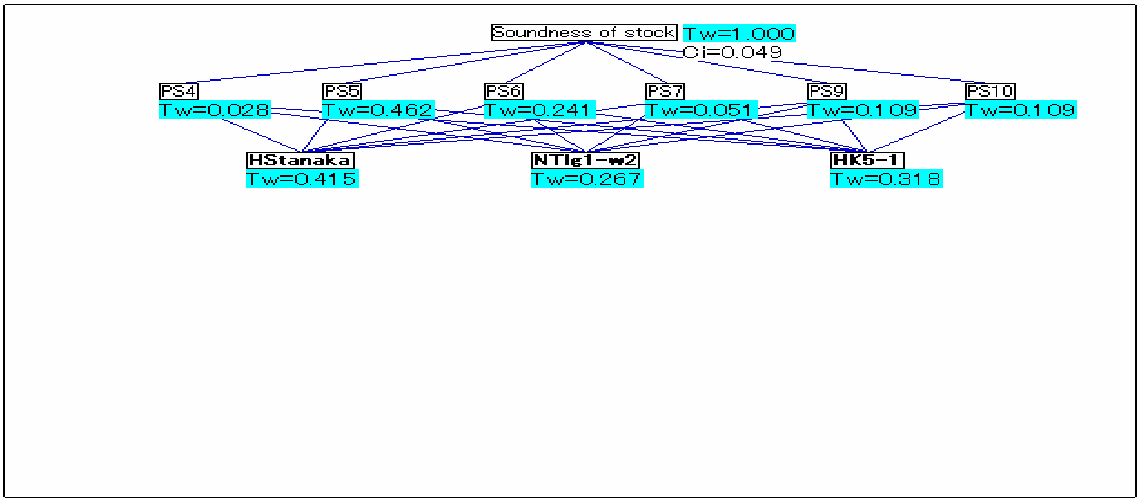

Figure B1. Results of model-1 by AHP.

Model-2: Stability of fisheries.

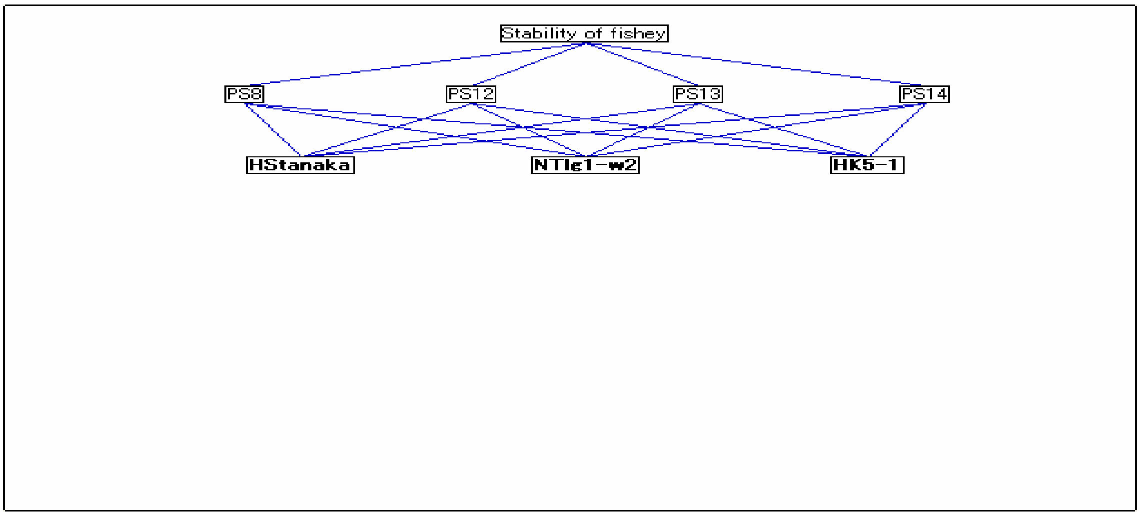

Figure A2. Hierarchical structure of model-2.

Pair-test	PS8	PS12	PS13	PS14
PS8	1	7	5	3
PS12	1/7	1	1/3	1/5
PS13	1/5	3	1	1/3
PS14	1/3	5	3	1

Table A2. Pair-wise matrix in the middle layer of model-2.

Score	PS8	PS12	PS13	PS14
HStanaka	5	3	8	5
NTlg1-w2	7	6	6	6
HK5-1	6	4	2	4

Table B2. Absolute evaluations in the bottom layer of model-2.

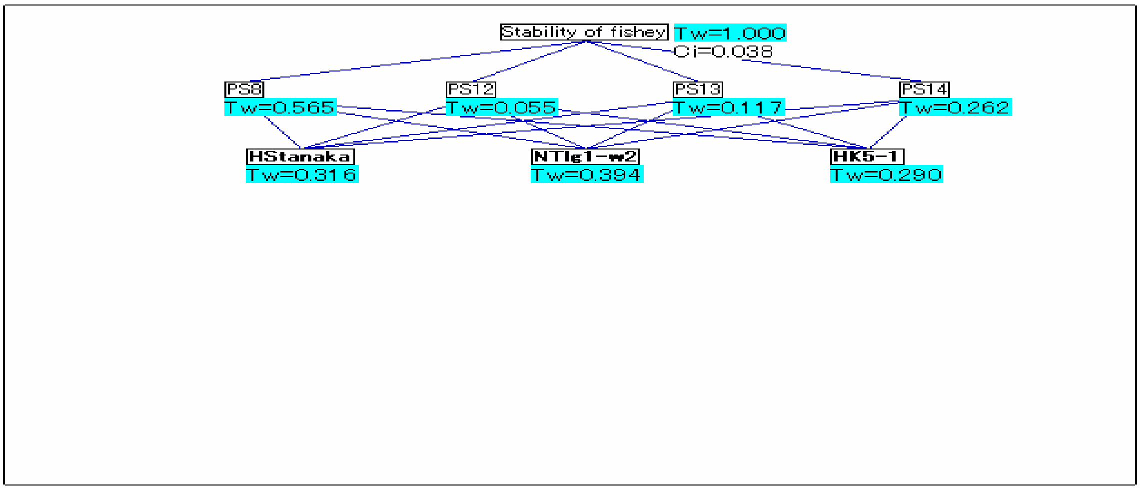

Figure B2. Results of model-2 by AHP.

Model-3: Catch optimization.

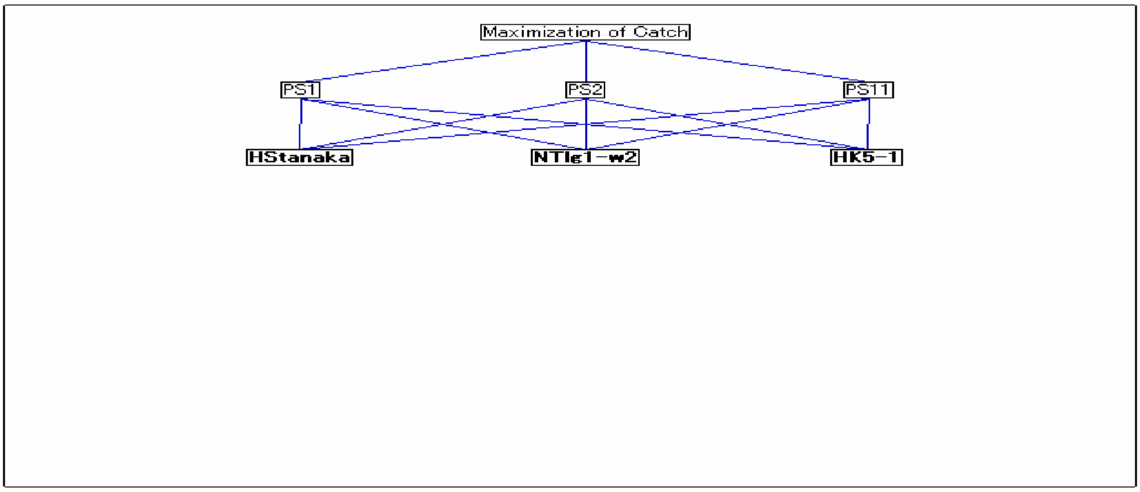

Figure A3.　Hierarchical structure of model-3.

Pair-test	PS1	PS2	PS11
PS1	1	1/5	1/3
PS2	5	1	3
PS11	3	1/3	1

Table A3.　Pair-wise matrix in the middle layer of model-3.

Score	PS1	PS2	PS11
HStanaka	5	4	4
NTlg1-w2	7	5	7
HK5-1	7	7	5

Table B3. Absolute evaluations in the bottom layer of model-3.

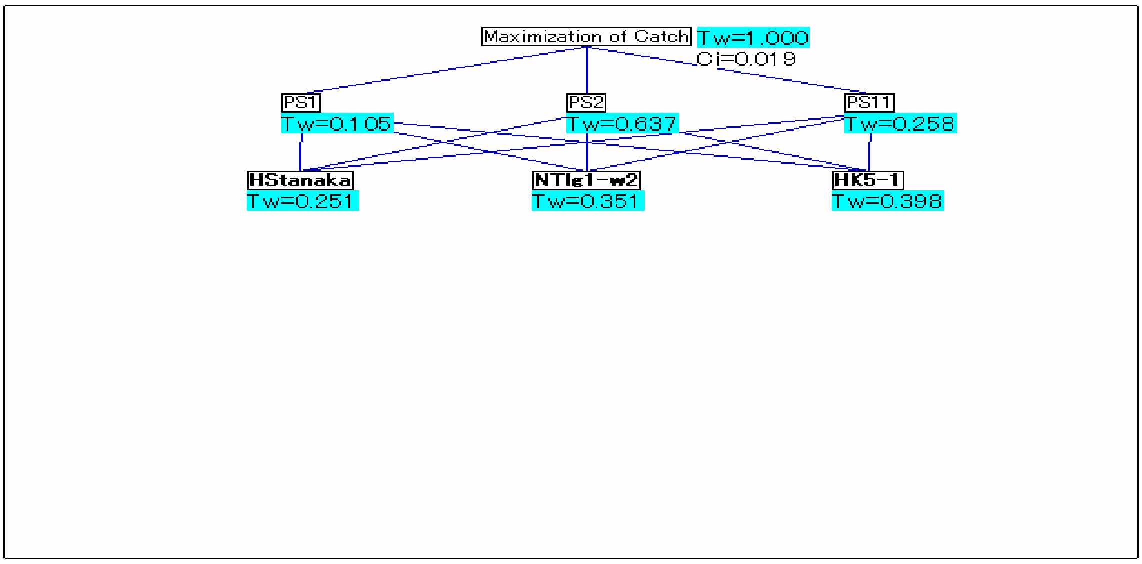

Figure B3. Results of model-3 by AHP