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Area-based Management and Virtual Population Units

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I. Introduction

Recently there has been increasing interest in area-based management systems. There are also increasing concern from conservation agencies, governments and the public for ecosystem-based fisheries management. Community-based management has been used for a long time in Japan[1]. Fishery management based on areas can accommodate area specific information such as fishing communities, ecosystem and local fishermen' s knowledge.

So far management using conventional assignment of TACs (Total Allowable Catches) to each area relied on historical landings of each area has been a major tool. Quota systems, as conventionally defined, lack flexibility in harvesting. In

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1) Yamamoto (1995) addresses Community Based Fisheries Management in Japan in his paper.

order to have more decentralized area-based management, more flexibility in management is needed. This paper describes a flexible quota management system using an accounting concept or social institution called Virtual Population Units (VPUs)[2]. A VPU system can be applied to assigning TACs to each area according to the contribution from each area to the whole fish stock. A VPU system traces the contribution to the stock and the ratio of individual virtual population (VP) from the aggregate VP can be used as a conversion ratio of individual quota to each area[3]. Because of its flexibility, a VPU system can be applied to different situations. If there is no flexibility, then a VPU system can be a TAC system for each area. With flexibility, a VPU system can be a flexible quota management system. The flexibility of a VPU system facilitates adaptive management to accommodate area specific information and interactions between fish and harvests.

II. Management with Virtual Population Units

Using the term "partial populations", Gavaris (1996) provided an intellectual basis for imagining a continuum from sole ownership to community-based management via appropriately defined use rights. However, his paper does not develop the concept in much detail, so much of what follows is our interpretation and extrapolation of his basic ideas. Partial population is a less descriptive term when a surplus production model is used. A better term, from our perspective, is "Virtual Populations (VPs)".

Exclusive access to a portion of a population is delegated to the care of fishermen or groups. A "Virtual Population (VP)" is a shadow of real population. As with abstract accounting humans learned to create an artificial firm on paper to measure and monitor the flow of funds through the real firm, a VP is an accounting unit which can be scaled arbitrarily. A legal entity (individual, port, region etc) is given sole right to manage its own virtual population. The holder of a VP we term a "Virtual Population Unit (VPU). A Virtual Population Unit

2) There is currently much discussion of methods increase the flexibility of quota systems. At a minimum, this paper is one such method.

3) This institution involving VPs and VPUs has no connection with the "VIrtual Population" analysis used in fish population dynamics

(VPU) is a sole owner of access rights to a Virtual Population (VP)[4]. This matters because the VPUs' incentive structure is based not on the behavior of everyone and but on own behavior. The size of a VP is dependent on the VPU's initial allocation, subsequent catches and contribution to growth of the resource.

The growth of real populations is diffused over all fishermen in the real fishery. Under a conventional quota management system, if one fisherman reduces his harvest, then the increased stock at later time periods does not belong only to the contributing fisherman. In this case other fishermen can benefit from the increased stock size without paying any additional costs. There is an incentive for other fishermen to free ride and this dilutes individual fishermen's conservation incentive. However, for a particular VPU, growth due to its conservation decisions is allocated to its own VP.

The basic VP model starts with the assumption of perfect information, no uncertainty, no biological and production interdependency which an idealized soleowner has[5]. These assumptions are based on a rather unrealistic but simple fishery for expository purposes. A soleowner has exclusive property rights for own stock. In the trivial case, the stock is separable into small stocks as in aquaculture. A soleowner's harvests on own stock do not cause any externality to any other producer. In a later section a more complex or realistic fishery with biological and production interdependency is introduced.

1. A Simple Fishery Model

The simplest model abstracts from no biological and production interdependency. Simple fishery assumptions with no biological and production interdependency are unrealistic but can be thought of as an idealized aquaculturist with complete property rights and exclusivity of other fishermen by physical separation and territorial rights on farms[6].

In this simplest case the resource population X can be partitioned into independent components, i.e[7].

4) It is assumed that the sum of individual VP is equal to the actual population.

5) Since fish stock is common pool resource, individual fishermen's production affects other fishermen's production. Stock is not separable into small stocks.

6) Each aquaculturist is a sole owner and individual stock change is affected by an individual growth function and harvest rate.

7) For the expository purpose, we use discrete time frame work throughout the paper.

$$X_t^T = \sum_i X_t^i \quad (1)$$

such that $$X_{t+1}^T = X_t^i - G_t^i - H_t^i \quad (2)$$

$$H_t^T = \sum_i H_t^i \quad (3)$$

where $H_t^i = qE_t^i X_t^i$ = individual harvests

subscript t denotes time periods and superscript T denotes total

X_t^T denotes biomass of fish stock at time t

G_t^i denotes growth rate of i[th] stock

E_t^i denotes i[th] fishing effort

q denotes catchability coefficient

Each partitioned population unit is assigned to a sole owner (individuals or groups of individuals) and harvest behavior depends on own fishing efforts and stock, i.e., there is no biological or harvest interdependency. Then each partitioned population unit is used according to the solution of maximizing profits for the soleowner as follows

$$\begin{aligned} &\text{Maximize} && \sum_i \pi_t^i (E_t^i, X_t^i, p) d_t \\ &\text{subject to} && X_{t+1}^i = X_t^i - G_t^i - H_t^i \\ &\text{and} && X_t^i, H_t^i \geq 0, \text{ all } i \end{aligned} \quad (4)$$

where π_t^i denotes profit function for a soleowner

p denotes price of unit harvest

d_t denotes discount factor $1/(1+r)^t$ where r denotes discount rate

A soleowner approach to management would provide maximum resource rents, cost-effective harvest costs and optimal resource conservation since there is no competition to fish which can lead to a race-to-fish, input stuffing, gear conflicts and market gluts.

2. A More Complex Fishery and Virtual Population

The fish stock is common pool resource since fish are mobile and property rights for fish are not well defined. The growth rate of stock depends on the total stock size and the stock has a biological interdependency since the stock is not separable into small stocks.

Since the fish stock is not separable and has biological and production interdependency it is not feasible to separate the stock and assign sole ownership to the stock. However, by introducing the accounting concept of a VP, it is feasible to separate the mobile stock and assign the stock to any legal entity such as fishing communities or industry sector and to relax the assumptions of a simple fishery model in the preceding section in which no biological and production interdependency were assumed. There is joint production from the resource stock according to the production function.

$$H_t^i = qE^i \sum_i X_t^i \tag{5}$$

In addition, the stock exhibits mixing, such that there is no feasible way to actually partition the real stock among resource users/harvesters. Since there is a biological interdependency and growth function is non-linear, individual growth function G_t^i cannot be calculated simply by dividing the aggregate growth rate G_t^T according to the initial ratio of stock assignment since

$\Sigma_i rXv_t^i(1 - Xv_t^i / K) \fallingdotseq rXv_t^T(1 - Xv_t^T / K)$.

However, by using virtual individual growth rate, we can preserve $\Sigma_i G_t^i \equiv G_t^T$.

$$G_t^i = \alpha_0^i G_0^T + \Delta G_t^T \frac{\Delta Xv_t^i}{\Delta Xv_t^T} \tag{6}$$

where $G_0^T = rXv_0^i(1 - Xv_0^T / K)$ = aggregate growth function evaluated at initial time
$G_t^T = rXv_t^T(1 - Xv_t^T / K)$ = aggregate growth function evaluated at time t
α_0^i = i[th] share of the initial aggregate virtual population
$\Delta G_t^T = G_t^T - G_0^T$ = aggregate growth change compared to the initial growth
$\Delta Xv_t^i = Xv_t^i - Xv_0^i$ = ith VPU' s stock change compared to the initial stock
$\Delta Xv_t^T = Xv_t^T - Xv_0^T$ = aggregate stock change compared to the initial stock
X_t^T denotes aggregate actual population at time t
K is carrying capacity and r is intrinsic growth rate for the stock

Growth of a VP includes the growth rate change imputed to individual VPU. In our model a VPU' s growth rate, G_t^i is set to be equal to the equation (6). Xv_0^T is the total initial virtual population and Xv_0^i is the i[th] VPU' s share of the total initial virtual population. This lets us measure the accumulative contribution of harvests by individual VPU from the initial endowment of VP. Initial VPUs can be decided in the same ways IQs or ITQs are allocated such as using historical harvests.

Since the sum of individual growth rate is equal to the aggregate growth rate,

$\sum_i \alpha_0^i = 1$ and $\sum_i {}^{\Delta X v_t^i}/_{\Delta X v_t^T} = 1$

Therefore VP at the next time period is

$$X_{t+1}^i = X_t^i + \alpha_0^i G_0^T + \Delta G_t^T \frac{\Delta X v_t^i}{\Delta X v_t^T} - H_t^i \quad (7)$$

$$\text{and } \sum_i X v_t^i = X v_t^T = X_t^T \quad (8)$$

ΔG_t^T ($\Delta X v_t^i$ / $\Delta X v_t^T$) in equation (7) measures the cumulative contribution of i[th] VPU to the aggregate cumulative virtual growth change. The contribution of an individual VPU' s harvest decisions to the growth rate increases or decreases own VP for the next period. This sharply penalizes a VPU if own VP is depleted below the initially assigned stock size. Equation (8) is required for accounting purposes. Under the assumption of perfect information and no stochastic events such as an oil spill and environmental changes, the sum of individual VPU is equal to the aggregate VP and aggregate actual population[8].

Therefore each VPU maximizes own profits as follows

$$\begin{aligned} &\text{Maximize} && \sum_i \pi_t^i (E_t^i, X v_t^i, p) d_t && (9) \\ &\text{subject to} && X v_{t+1}^i = X v_t^i + \alpha_0^i G_0^T + \Delta G_t^{T\,\Delta X v_t^i}/_{\Delta X v_t^T} - H_t^i \\ & && \text{initial stock is } X v_0^i \\ & && \text{and } X v_t^i, H^i \geq 0, \text{ all } i \\ &\text{where} && \sum_i X v_t^i = X v_t^T = X_t^T \\ & && \text{and } X_{t+1}^T = X_t^T - G_t^T - \sum_i H_t^i \end{aligned}$$

8) Stochastic events pose problems for any management regime, including a VP regime. Finding ways to deal with uncertainty is not fundamentally different here than, for example, a sole owner regime. Periodic re-calibration is necessary in both cases. The optimal harvest rate is also affected.

3. Harvest Function

Harvests are dichotomized into suggested harvests, Hs^i_{t+1}, and actual harvests, H^i_t. The suggested harvest for i[th] VPU, Hs^i_{t+1}, for the next time period is decided by VPU i' s contribution to own VP at time t. The suggested harvest in the next period increases if own VP for the next time period increases.

$$Hs^i_{t+1} = Hs^i_0 + \Delta Xv^i_{t+1} \tag{10}$$

Actual harvest, H^i_t, is what i[th] VPU really catches during the current time period t. The fishery management authority suggests harvests at the end of a time period considering the VP for the next time period. If a VP for the next time period decreases, its suggested harvest for the next time period will decrease and vice versa. Suggested harvests show how well the VPUs manage their own VP. VPUs are not obliged to follow the suggested harvests unless they decrease own VP below a safe minimum standard. If a VPU decreases its VP below this standard, suggested harvests will be binding and over time, this will return the population size to the initial endowment since the suggested harvests are based on the steady state condition. It may seem odd to suggest a policy that seeks only to sustain the status quo. However, this artifice is chosen intentionally. The logic of the VP regime is that self-interest will lead a VPU to rebuild toward an economic optimum; the suggested harvests serve only as a framework to enhance faith that the partially decentralized regime can work.

Although a VPU has some incentive to increase own VP, it might deplete own VP since VPUs are not obliged to follow the suggested harvests. In this case, upper bounds on actual harvests as a safe minimum standard could be used in connection with the minimum VPs. If $Xv^i_t \leq Xv^i_{safe}$, then an upper bound on the actual harvest is implied:

4. Stochastic Considerations

Successful implementation of VPUs in real world fisheries depends on the accuracy of VPs for the real population. VPs are the representation of real population as accounting represents the financial flows of real firms. If there is a huge discrepancy between the virtual population and real population, VPs do not represent real populations any more and this requires periodic recalibration of VPs[9].

There have been stochastic factors in the history of fisheries over the world such as misreporting, under-reporting of actual harvests, and exogenously induced collapse or bloom of biomass. When there is a significant difference between the virtual population and the real population, Xv_t^i can be adjusted to the real population according to the ratio of the individual virtual population for the time period. α_t^i measures this ratio.

$$\alpha_t^i = Xv_t^i / Xv_t^T \qquad (11)$$

Equation (11) could be used for bridging the possible discrepancy between the VPs and real population using the ratio of individual VPs from the aggregate VP. Adjusted individual virtual population is $Xv_t^i = \alpha_t^i X_t^T$.

III. Deterministic Simulation

For the illustrative purposes a hypothetical population is used with characteristics similar to those of Atlantic herring fishery. Carrying capacity for this stock is K= 1360 (thousand metric tons) and the intrinsic growth rate is r = 0.8. Aggregate initial virtual population is $Xv_0^T = 510$ (thousand mt). The initial aggregate growth rate, G_0^T, with the aggregate virtual population is 255 (thousand mt)[10]. For simplicity, the initial total VP size for the individual VPU is divided evenly and there are three VPUs: $Xv_0^i = Xv_0^T/3 = 510/3 = 170$.

Initial suggested harvest for an individual VPU, is $Hs_0^i = H_0^i$ is 85 (thousand mt) for the steady state condition. Therefore the sum of all three initial suggested harvests is 255 (thousand mt) and this is equal to the aggregate initial growth rate, G_0^T.

• Simulation for illustrative purpose

This section uses arbitrary scenarios to illustrate the calculations involved in accounting for the growth or decline of VPs.

9) The problem of recalibration is common to most fishery management regimes, including a sole owner regime.

10) $G_0^T = 0.8 \times 510 \times (1 - 510/1360) = 255$

- VPU 1 follows the suggested harvests over time
- VPU 2 catches much less than the suggested harvest level.
- VPU 3 catches significantly more than the suggested harvest at time period 4

(1) VPU 1

VPU 1 follows the suggested harvest levels and does not change its harvest amounts over time. Therefore its virtual population does not change over time and there is no contribution to the aggregate VP change compared to the aggregate initial VP.

(2) VPU 2

VPU 2 in general does not follow the suggested harvest amounts. At the time period 1, it catches less than the initial suggested harvest amount by 5 (80 thousand mt). This conservation behavior directly increases its population size for the next time period, Xv_2^2(175 thousand mt). At the second time period, VPU 2 increases its harvest by the amount that it reduced at the previous time period 1. Therefore actual average harvest for two time periods (years) is 85 (thousand mt) and this is the same as for VPU 1. However VPU' s suggested harvest, 86.0 (thousand mt) for the next time period 3, is higher than the one for VPU 1. Own catch reduction at the time period 1 for the stock increase is compensated with more suggested harvest amounts over time.

If VPU 2 catches the suggested harvest 86.0 (thousand mt) for the next time period, its VP will slowly converge to the initial population size.

VPU 2 follows the initial suggested harvest levels during time periods 3 and 4. Its VP and the suggested harvest keeps increasing because of the actual harvest reduction in time period 1. Later at time period 5, VPU 2 decreases own harvest again for the VP size increase (75 thousand mt). During the time period 6 and 7 the suggested harvests increased more than the cumulative harvest reduction. During time periods 7 and 8, VPU 2 follows the suggested harvest amounts and VP 2 ends with 170.7 (thousand mt) which is still slightly higher than VP 1. The sum of the actual harvests over time for VPU 2 is 772.8 (thousand mt) which is greater than for VPU 1, 765 (thousand mt). Even though VPU 2' s cumulative actual catch is higher than that of VPU 1, the terminal VP 2 is still slightly greater than is terminal VP 1.

Table 1. Simulation results using VPUs

Thousand metric tons

Time t	0	1	2	3	4	5	6	7	8	Total
VPUs for the next time period										
Xv^1_{t+1} (VP 1)	170	170	170	170	170	170	170	170	170	1530
Xv^2_{t+1} (VP 2)	170	175	171	171.2	171.5	181.8	184.5	173.4	170.7	1569
Xv^3_{t+1} (VP 3)	170	160	158	165.5	124.6	114.3	101.7	154.2	166.7	1315
Xv^T_{t+1} (VP total)	510	505	499	506.7	466	466.1	456.2	497.5	507.4	4414
Aggregate Growth										
G_t	255	255	254	252.7	254.3	245.1	245.1	242.5	252.4	2256.2
Growth change and Contribution[11]										
ΔG_t	0	0	-1	-2.3	-0.7	-9.9	-9.9	-12.5	-2.6	-38.8
VPU1	0	0	0	0	0	0	0	0	0	0
VPU2	0	0	1	0.2	0.2	0.3	2.7	3.4	0.7	8.6
VPU3	0	0	-2	-2.5	-0.9	-10.3	-12.6	-15.8	-3.3	-47.4
Actual Harvests										
H^1_t	85	85	85	85	85	85	85	85	85	765
H^2_t	85	80	90	85	85	75	85	99.5	88.4	772.8
H^3_t	85	95	85	75	125	85	85	16.7	69.2	720.9
Suggested Harvests for the next time period										
Hs^1_{t+1}	85	85	85	85	85	85	85	85	85	765
Hs^2_{t+1}	85	90	86	86.2	86.5	96.8	99.5	88.4	85.7	804
Hs^3_{t+1}	85	75	73	80.5	39.6	29.3	16.7	69.2	81.7	550

Figures are rounded to the first decimal place for convenient reading.
K = 1360, intrinsic growth rate = 0.8, total initial virtual population = 510, initial growth rate = 255

Under a quota management system a fisherman who catches less than his quota is not fully compensated in the later time periods. Even though this behavior increases the total stock size and the growth rate, there is no full compensation for his conservation effort since increased stock will be shared by all resource users. However, management using VPUs takes into account the individual resource user' s action and individual' s contribution for the

11) Each VPU' s contribution for growth rate is measured by $\Delta G_t^{T\,\Delta Xv^i_t} / \Delta Xv^i_t$

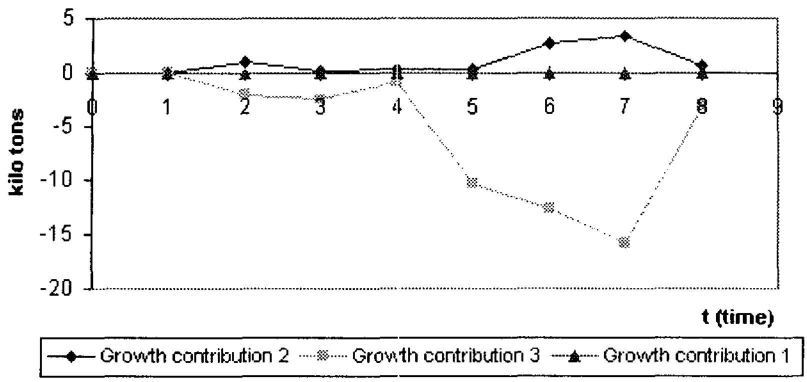
cumulative stock increase is fully compensated according to the stock size increase by the individual.

(3) VPU3

VPU 3 also changes harvest levels over time, but in a way that severely depletes its VP. In time period 1, it increases actual harvest by 10 (95 thousand mt). Therefore, the suggested harvest for the next time periods 2 and 3 (75 and 73 thousand mt) dropped by more than it decreased at the time period 1. At the time period 3, VPU 3 decreases harvest by 10 (75 thousand mt) which is the same as the increase in time period 1. Even though VPU 3' s average actual catch during the three time periods 1, 2 and 3, is the same as that of VPU 1, its suggested harvest for the next time period 4, is 80.5 (thousand mt) which is lower than that of VPU 1 (85 thousand mt). At time period 4, VPU 3 does not follow the suggested harvest amount and increases catch significantly. This behavior drops own VP for the next time period significantly. Now VPU 3 harvests as much as VPU 1 does during time periods 5 and 6, but still its harvests are much higher than the suggested harvest amounts. Own virtual population for time periods 6 and 7 keeps decreasing. At time period 7, VPU 3 realizes the seriousness of the problem and chooses the suggested harvest amount, 16.7 (thousand mt). The difference between the initial suggested harvest level (85 thousand mt) and 16.7 (thousand mt) is significantly greater than the difference between the initial suggested harvest amount and the actual harvest amount (125 thousand mt) at the time period 4. At the time period 8 VPU 3 follows the suggested harvest again. We can see how the safe minimum standard on VPs work here. Since suggested harvests are based on steady state condition, a binding safe minimum standard returns the current VP to the initial VP size.

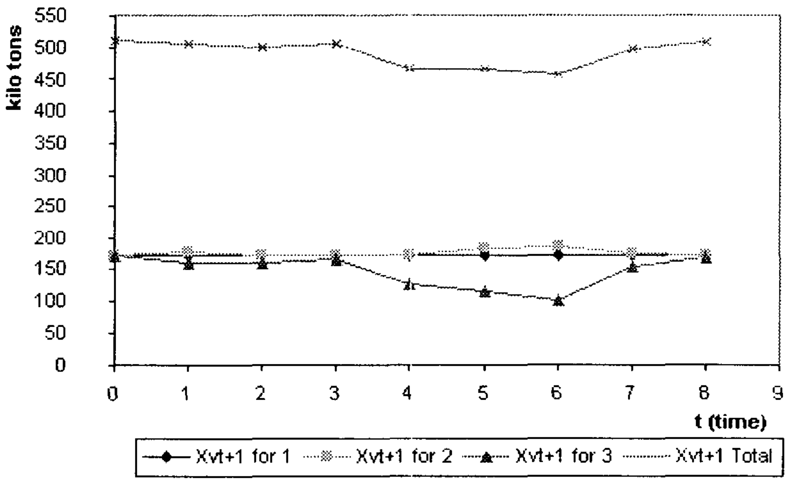
The sum of actual harvests for VPU 3 over all time periods is 720.9 (thousand mt) which is much less than the total harvests by VPU 1. Even though actual total harvests are much less than the total harvests by VPU 1, VPU 3 at the final time period, 166.7 (thousand mt), is still less than VPU 1, 170 (thousand mt).

Figure 1 shows the growth rate change for individual VPUs over time according the individual contribution to the total growth rate change. This is the



Time periods are the same as numbers on the horizontal axis (t)

Figure 1. Growth contribution over time ($\Delta G_t(\Delta Xv_t^i/\Delta Xv_t^T)$)

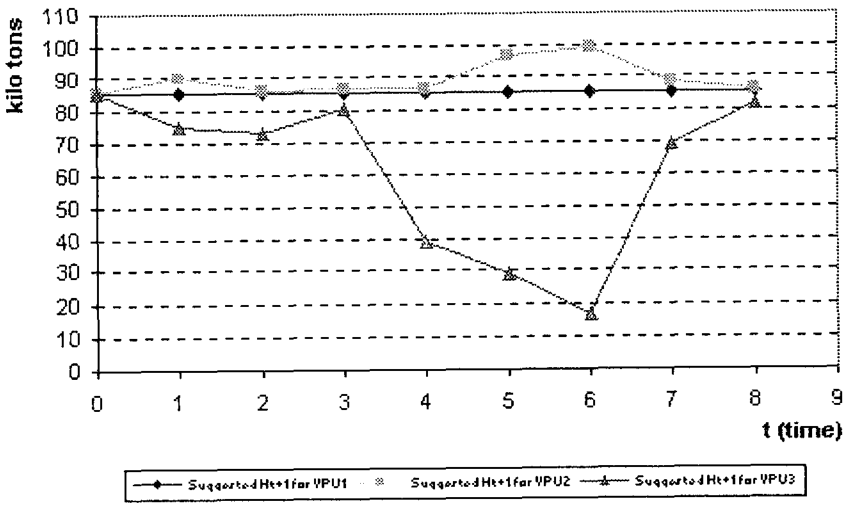


Time periods are the same as numbers on the horizontal axis plus one (t + 1)

Figure 2. Virtual population size over time

last part of the equation (6). Individual contribution to the aggregate growth rate change is confined to the individual contributors.

The following two figures (2 and 3) show the individual virtual population changes and suggested harvest amounts. During time periods 4 to 7 (horizontal axis), total virtual population is much smaller than the aggregate initial virtual population due to the significant increase in actual harvests by VPU 3. Even though the aggregate virtual population is smaller than the aggregate initial



Time periods are the same as numbers on the horizontal axis plus one (t + 1)

Figure 3. Suggested harvests over time

virtual population, VPU 2's virtual population is greater than its initial virtual population in figure 2. This explains why suggested harvests for VPU 2 are greater than average 85 (thousand mt) over time in figure 3.

In any institutional structure there is a learning process; individuals do make mistakes. In a decentralized context, mistakes can be self-correcting if the incentive structure rewards correct decisions and if sustainability is maintained. We envision this discretion as bounded by "Safe Minimum Standards" on each VP (Ciriacy-Wantrup, 1968). If VPUs increase the stock size by individual harvest reduction, this increases the individual growth rate. The increased stock size and growth rate compensate for the harvest reduction for the individual without sharing the conservation effect with other resource users. Under VP management, the growth benefit is confined to the conservation contributors. Therefore fishers can have the feedback from their individual action and this provides strong incentive for conservation. This conservation becomes self-interest for individual VPUs.

IV. Area-based Management and VPUs

If virtual populations are assigned to separate areas and VPUs are the legal entities of managing those areas, VPUs can work as a TURF system. A VPU system has flexibility in harvesting own stock. With this greater flexibility, a VPU system can be applied to various forms of area-based managements. We address the basic suggestion of applying VPU system to a various situation of area-based management in the following.

1. Suggested Harvests for All Areas

The Atlantic herring fishery management plan (FMP) is an example of a FMP that establishes a procedure for allocating the annual overall TAC to different management areas. The total allowable catch is distributed to Management Areas 1A, 1B, 2, and 3 on an annual (January through December fishing year) basis.

In this case VPUs represent each management area. As TACs are assigned to each area, each VPUs should follow the suggested harvest level which is calculated by the central government in order to keep the target stock (=VP). The suggested harvests here simply become TACs.

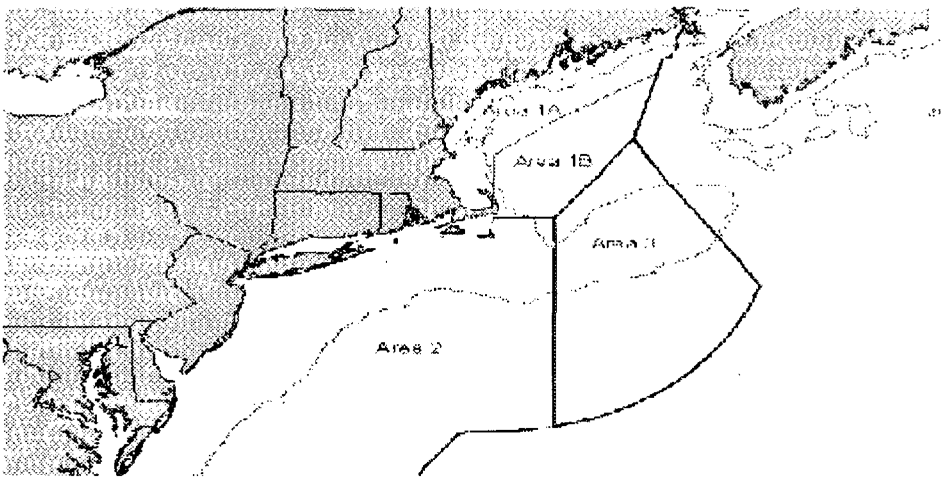


Figure 4. Management areas for Atlantic herring

2. Suggested Harvests for a Certain Area and Flexible Harvests for the Rest

If there is a specific area to be protected more than other areas, this scenario can be applied. If the specific area is the spawning ground, then the suggested harvest should be applied to protect the area to a desirable stock level. This mixture of harvest plans can support eco-system based management.

The largest portion of the landing comes from the inshore area of Management Area 1 (Figure 4). A TAC is established in Area 1 to limit harvest to acceptable limits since some Gulf of Maine herring migrate into Management Area 2 in the winter months and the TAC set for Area 1 must consider the impact of the winter fishery in the northern part of Management Area 2. In the Management Area 2 and 3 spawning closures were not established when the FMP was implemented because of the robust condition of the herring resource and interest in developing the offshore fishery (NEFMC, Original FMP). In this case, Area 1 receives suggested harvests and the remaining areas can have flexible harvests.

3. Flexible Harvests for All Area

1) Non-separable stock

Most stocks are physically non-separable since fish are mobile. If there is no specific area to be protected more than others, flexible harvests by a VPU system can be applied to all areas. The VPU system is an accounting concept and individual growth change is calculated using a VP stock equation.

2) Separable stock

If stock is separable into small stocks physically or because the species is sedentary, flexible harvests by a VPU system have features of soleownership such as aquaculture. Each VPU has own separate stock and there is little or no production interdependency between areas. In this case, an individual VPU has its own growth function as in aquaculture and does not have to use our modified VPU growth equation(eq(6)). However, sedentary species such as sea urchin disperse larvae over all areas and the aggregate population is decided by the aggregate growth rate, not by the sum of individual growth rate from each area. Even though stock disposition looks like they are separable, larvae dispersion and intermixing can affect all VPs. Thus VPU stock equation can be applied in this case (eq(7)) .

V. Concluding Remarks and Discussion

The concept of VPU is addressed and suggested according to different situations. The VP/VPU approach can be viewed as an alternative pathway to decentralization. The devolution/decentralization of rule-making authority is very important for fisheries. The experience with regional, (but still highly centralized rule-making), is often one of stalemate. Decisions require near unanimity among heterogeneous groups. Little is resolved until everything is resolved, which is to say, never.

A virtual population provides better-defined use rights than traditional fishery management systems. VPs are similar to flexible Individual Quotas on a portion of a stock. Virtual populations may provide the following benefits:

- End of period carryovers are handled easily because each VPU decides how to handle it. There is no necessary quota per se but harvesting too much this year means a smaller VP next year; less this year means more next. This flexibility allows VPUs to exploit fluctuation in market conditions by delaying or accelerating harvest.
- In connection with the expected influence of substitutes and complements to target fish, VPUs can make their own harvest decisions in order to get the best price for their harvests.
- As with Community Development Quotas, distributional issues may be lessened by leaving to each VPU, the decision how to allocate harvests among its membership.
- Supplementary management measures can better reflect regional or individual knowledge of fishers.
- Progress does not require a uniform set of management measures.
- Issues of spatial and temporal distribution of real stocks may be diminished.
- Punitive measures, such as temporary shutdowns for violation of safe minimum standards are focused on the VPU which commits the violation.

Since there is no carry over under a management such as IQs or ITQs, fishermen have an incentive to sell or lease when the quota is greater than their fishing capacity or when fishermen have personal reasons not to catch the quota amount for that fishing year. However, own carryover is automatic under VPU management and a VPU' s investment in conservation will increase own VP size at later time periods. This flexibility is advantageous in a world of uncertainties with respect to markets and personal issues. Management using virtual population is decentralized and the harvest decisions are handled largely at a local level. A VPU can plan and adjust own harvests as long as its decision does not seriously deplete own VPU.

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가상자원단위를 이용한 지역 및 구역별 어업관리에 대한 연구

이정삼 · J. M. Gates

요 약

지역별 또는 구역별 어업관리(Area-based management of fisheries)는 해당 지역 또는 구역에 특수한 생태환경 및 지역관련 정보를 고려할 수 있는 순응적(adaptive) 관리제도로써 이에 대한 연구와 관심이 고조되고 있다. 각 지역 및 구역에 대한 총허용가능어획량(TAC)의 전통적인 할당은 각 지역 및 구역별 양륙양의 역사적 자료에 의존해왔다. 이러한 총허용가능어획량의 할당은 중앙집권적이고 해당 지역에서의 어획에 대한 어떠한 유연성을 제공하지 못하고 있다. 하지만 특정 지역 및 구역을 관리하는 법적 실체(legal entity)인 가상자원단위(Virtual Population Units: VPU)를 이용한 어업관리 하에서는 어획에 대한 유연성과 할당된 자원에 대해 상당한 자율성을 가지고 있다. 본 논문은 가상자원단위가 어떻게 지역 및 구역별 어업관리에 적용될 수 있는지를 보여준다.

Key words : Virtual Populations, Virtual Population Units, Area-based Management

수산경영론집 편집방침

수산경영론집은 수산업분야의 종합 사회과학적 접근방법을 채택하고 있는 학술지로서 연구범위가 단순한 수산업 경영문제에 국한되는 것이 아니라 수산자원관리, 어장관리 등 수산경제분야와 수산금융, 유통 등 수산정책, 어촌관광과 개발, 수산법규 및 제도 등 수산업 전반의 광범위한 영역을 연구주제로 삼고 있다. 또한 게재논문의 성격도 순수한 학술논문에만 국한되는 것이 아니라 현장의 시사성 있고 경험적인 실증연구, 국내외 저명 학자의 특별기고, 대학원생의 연구노트, 서평 등을 포함한다.

(1) 투고자는 원칙적으로 본회의 회원에 한한다. 단 회원과의 공동연구자 및 초청된 기고자는 예외로 한다.

(2) 연구 논문은 다른 간행물에서 발표되지 않은 것이어야 한다.

(3) 논문의 내용에 대한 책임은 집필자가 진다.

(4) 투고된 논문은 반환하지 아니하며 본 학회지에 게재된 논문의 판권은 본 학회가 갖는다.

(5) 논문 투고와 편집에 관련된 제 과정은 전자우편으로 진행함을 적극 권장한다.

(6) 논문의 심사과정

① 논문이 접수되면 편집 위원장은 논문 접수일자를 투고자에게 즉시 통지하여야 하며, 해당분야 편집위원과 협의하여 2인의 심사위원을 선정한다.

② 심사위원은 심사를 의뢰 받은 날로부터 2주일 이내에 다음의 4가지 의견 중 하나를 내어 그 결과를 편집위원장에게 통지하여야 한다.

- 무수정 게재가 : 무수정 혹은 사소한 문제만 있어 연구 결론에 영향을 미치지 않는 경우
- 수정후 게재 : 게재가능성은 높은 논문이나 일부 내용에 문제가 있어 이를 수정, 보완하지 않으면 연구 결론에 동의하기 어려운 경우
- 수정후 재심사 : 게재가능성이 불투명한 논문으로서 논리구성이나 분석방법에 대폭적인 수정이 필요한 경우
- 게재 불가 : 논문이 전혀 공헌도가 없거나 본 학회지의 성격에 적합하지 않은 경우

③ 편집위원장은 심사결과를 투고자에게 통지하여야 하며, 수정요구를 받은 투고자는 한 달 내에 수정 논문을 편집위원장에게 제출하여야 한다. 투고자가 사유를 통보하지 않고 기일 내에 논문이 제출되지 않을 경우 투고 철회로 간주한다.

④ 투고자로부터 수정 논문을 받은 편집위원장은 동일한 심사위원에게 다시 심사를 의뢰함을 원칙으로 한다.

(7) 심사결과 처리기준

심사결과는 4단계(1. 무수정 게재가 2. 수정후 게재 3. 수정후 재심사 4. 게재불가) 이며 2명의 심사위원의 심사결과에 따라 다음과 같이 처리한다.

① 1/1 : 수정 없이 게재(게재예정증명서 발부 가능)

② 1/2, 2/2 : 수정 후 게재(게재예정증명서 발부 가능)

③ 1/3, 2/3, 3/3 : 수정 후 재심사

④ 1/4, 2/4, 3/4, 4/4 : 게재 않음(투고자의 반론 제기시는 제3의 심사자 선정 가능)

(8) 심사위원 간의 의견이 대립되거나 투고자가 반론을 제기할 때는 편집위원장이 해당 분야 편집위원과 상의하여 제 3의 심사자에게 심사를 의뢰할 수 있다.

(9) 특별기고의 경우도 위와 같은 심사과정을 거쳐 게재하나 연구노트, 서평 등의 경우는 별도의 심사과정을 거치지 않고 편집위원회의 의결에 따라 결정한다.

(10) 논문의 게재 순서는 논문 게재확정순서를 따름을 원칙으로 하나 편집위원장이 학회지의 편집구성을 고려하여 조정할 수 있다.

(11) 학회지는 연 2회(6월, 12월) 발간하며 필요하면 특별호를 발간할 수 있다.

수산경영론집 투고요령

(1) 투고자는 심사용 원고 3부(디스켓포함)를 등기우편으로 편집위원장에게 제출해도 좋으나, 업무상 편의를 위해 전자우편으로 파일을 송부하는 것을 적극 권장한다.

(2) 투고자는 심사의뢰비 5만원을 소액환 또는 지정 은행구좌로 편집위원장에게 송부한다.

(3) 원고는 국문, 국한문 또는 영문으로 쓰여져야 한다.

(4) 원고는 한글(97판 이상)로 A4용지에 작성하되 아래와 같이 편집용지를 설정한다.

<table>
<tr><th colspan="3">편집용지 A4</th><th colspan="2">글 꼴</th></tr>
<tr><td rowspan="3">용지
여백</td><td colspan="2" rowspan="3">위쪽 36, 아래쪽 38
왼쪽34.5, 오른쪽34.5
머리말 10, 꼬리말8</td><td>장 - I</td><td>12 신명 태고딕</td></tr>
<tr><td>절 - I</td><td>11 신명 중고딕</td></tr>
<tr><td>기타 - 1), (1), ①</td><td>10 신명조 진하게</td></tr>
<tr><td rowspan="4">문단
모양</td><td>여백주기</td><td>왼쪽0, 오른쪽0</td><td>본문</td><td>10 휴먼명조(한글)
10 신명조(영문)</td></tr>
<tr><td>들여쓰기</td><td>2</td><td>각주</td><td>8.5 신명조</td></tr>
<tr><td rowspan="2">줄간격</td><td rowspan="2">160</td><td>표, 그림제목</td><td>10 신명 중고딕</td></tr>
<tr><td>표그림내용</td><td>9 신명조 줄간격 160</td></tr>
</table>

(5) 원고 제1면에는 논문제목, 투고자의 성명, 소속과 직위, 연락처(주소, 전화번호, e-mail), 연구비지원등을 명기한다. 단, 논문제목과 투고자의 성명은 국문과 영문으로 병기한다.

(6) Abstract(초록)은 영문(국문)으로 작성하며 1매가 넘지 않도록 하여 독립된 마지막 페이지에 첨부한다. Key words를 5개 이내로 선택하여 초록뒤에 기술한다.

(7) 모든 표 및 그림은 수정없이 사진판으로 인쇄 가능하도록 선명하게 작성되어야 한다. 해당번호(예 : 〈표 1〉, 〈표그림 3〉)와 제목을 표의 경우는 상단 중앙에, 그림의 경우는 하단 중앙에 붙여야 한다.

(8) 각주는 될 수 있는 한 줄이고, 꼭 필요한 경우는 어구의 오른편 상단에 일련 번호를 붙여 아라비아 숫자로 표시하고 각 면 하단에 작성한다.

(9) 본문 중에 인용되는 참고문헌은 아래와 같이 (　　) 안의 저자와 별표/출판연도를 명시하고, 그 원문은 본문끝의 참고문헌 난에 일괄기입한다.

예 : 홍길동(1990), Adams(1990)

(10) 참고문헌은 본문이 끝난 다음에 면을 달리하여 기재하되 기재순서는 서적과 논문의 구별없이 국문문헌, 일본어문헌, 영어문헌, 기타국어 문헌의 순으로 한다. 문헌의 기재는 저자를 기준으로 하되 국문문헌은 가나다순, 일본문헌은 히라가나 순, 영문문헌은 알파벳 순, 기타문헌은 해당어법의 순으로 표시한다. 동일한 저자의 문헌이 2개 이상인 경우에는 연도순으로 한다.

(11) 참고문헌은 아래의 예와 같이 논문인 경우 저자명, 논문제목, 학술지명(국내문헌의 경우 고딕체로, 외국문헌의 경우 이탤릭체로 표시), 권, 호, 발행년도, 페이지 순으로 기입하고, 서적인 경우는 저자명, 도서명(국내문헌의 경우 고딕체로, 외국문헌의 경우 이탤릭체로 표시), 출판회수(2판 이상), 출팔사명, 출판연도순으로 기입한다.

예 :

홍길동, "우리나라 어업 구조조정 전략" **수산경영론집**, 제20권 제1호, 1990. 6, pp. 27-33

홍길동, **수산경영학** 3판, 대한출판사 1990.

Gordon, H. S., "The Economic Theory of A Common Property Resource; The Fishery", *Journal of Political Economy*, Vol. 62, No.4, 1954, pp.124-142

Adams, H. D., *Production Srtategy*, 3nd. ed., John Willy & Sons, 1990. pp.129-239

(11) 장, 절의 표시는 다음과 같이 표시한다.

Ⅰ

1

1)

(1)

①

(12) 수학식은 일련번호를(　)에 넣어 식의 오른쪽에 표기한다.

예 : Y = X + aZ (3.1)

(13) 논문게재자는 특별한 요청을 하지 않는 한 10부의 별쇄본을 받는다.

학 회 소 식

1. 2004년도 추계학술발표대회 및 심포지움 개최

1) 일　　시 : 2004년 11월 26일(금) 10:00~

2) 장　　소 : 부산시 남구 대연3동 부경대학교 경영대학 최고경영자 강의실

3) 개인발표 : 6발표

4) 심포지움 : 수산물 수출입 무엇이 문제인가? 5발표

본 심포지움을 공동으로 개최하게 된 부경대학교 수산기업연구소와 (사)한국수산회에게 지면을 빌어 감사의 말씀을 전합니다.

2. 회장 및 임원진 변경

정기학회 총회에서 본 학회의 회장으로 부경대 김태용 교수, 신임이사로 부경대 정형찬 교수, 장영수 교수, 신임감사로 경상대 김우수 교수, 부경대 김기수 교수가 선출되었습니다.

3. 학회 홈페이지 이용안내(http://www.fima.or.kr)

학회 홈페이지가 공식적으로 만들어졌습니다. 학회연혁, 공지사항, 학회지 D/B 서비스, 수산관련 사이트 등 저의 학회의 전반적인 내용을 담고 있으며, 체계적인 학회운영을 하도록 노력하겠습니다. 회원 여러분들의 많은 관심과 동참을 기대합니다.

4. 학회지 구성 및 논문투고 규정 변경

새로운 편집위원회의 구성과 함께 저의 학회지가 새로운 모습으로 변모하였습니다. 회원 여러분들의 많은 투고와 참여를 기다립니다. 또한 2002년도 제33권 1호부터 새롭게 바뀐 편집방침 및 투고요령을 적용할 예정입니다. 부록에 첨부된 편집방침 및 투고요령을 숙지하시어 논문투고에 차질 없으시길 바랍니다.

5. 한국과학재단의 공지사항

앞으로 한국과학재단의 과학기술연구인력 DB에 등록해야만 연구비 지원의 혜택 및 연구 평가자 활동이 가능하다고 합니다. 과학기술연구인력 DB 등록 및 수정은 과학재단 홈페이지 "연구인력관리시스템"에 접속하여야 합니다. 자세한 내용은 http://mars.kosef.re.kr/rmapp를 참고하시길 바랍니다.

6. 2005년도 춘계학술발표대회 공지

2005년도 춘계학술발표대회는 서울에서 개최할 예정입니다. 자세한 일정은 추후에 공지하겠습니다.

7. 2005년도부터 개인회비가 20,000원으로 인상되었습니다.

회장(100,000원) 및 이사(50,000원)의 회비는 이전과 변경이 없습니다.

8. 일본지역어업학회와 소규모 세미나 개최하였습니다.

1) 일정 및 장소 : 9월 25일 2박 3일 , 대마도
2) 세미나 주제 : 한일수산물 무역의 향후 전개방향, 유어와 어촌진흥
3) 주 제 발 표 : 한국 2명, 일본 2명
4) 참 가 인 원 : 한국측 20명, 일본측 50명

차기 세미나는 한국(부산, 통영, 제주도)에서 개최할 계획입니다.

9. 우수 논문상 수상

우수논문상에 김도훈의 "복수어업에 있어서 어업관리수단 평가를 위한 생물경제학적 연구 구"가 선정되었습니다.