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# FISHING CAPACITY OF THE SMALL-PELAGIC FISHERY AT BANDA SEA, MOLUCCAS

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## ABSTRACT

*Excessive fishing capacity is a core issue in marine capture fisheries. In relation with the capacity issue, this study was conducted to determine annual changes of fishing capacity of the small-pelagic fishery at FMA-714 Banda Sea using time-series data of 1985 until 2006 which was analyzed using data envelopment analysis (DEA) approach. The small-pelagic fishery was found to be excess capacity in 17 out of 22 DMU. And there was indication of overcapacity in the period of 1989 until 1998. The fishery had a tendency to be not efficient with the highest score of 23.7% at DMU-1998. Consequently, alternative fishery management policies are needed to reduce fishing inputs of the fishery at the FMA-714 Banda Sea.*

**Key words**: Small-pelagic fishery; fishing capacity; data envelopment analysis; Banda sea

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## INTRODUCTION

Fisheries Management Area (FMA)-Banda Sea, so-called “the FMA-714 Banda Sea” (Nurhakim, *et al.*, 2007) is one of the important region in Moluccas which contains abundant small-pelagic fish resources (DKP RI, 2006). Most of the resources are exploited by fishers that inhabit in coastal region of Central Moluccas and its surrounding area.

Exploitation of the small-pelagic fish at the FMA-714 Banda Sea has grown rapidly since early 1980’s. In 2005 the exploitation attained 146,470 tonnes (DKP RI, 2006), while the resource’s potential was estimated approximately 132,000 tonnes per year (BRKP and LIPI, 2001). On the other side, based on the last two-year observation on the small-pelagic fishing activities in Central Moluccas and Ambon City there was indication of declining catch per unit effort (CPUE) of the purse-seine and lift-net gears.

Control of the exploitation can be performed on the basis of fishing capacity which is useful information for policy’s consideration. Fishing capacity is a maximum capital stock of fisheries that can be fully utilized at a maximum technical efficiency at a certain time and a market condition (Kirkley and Squires, 1998). The excessive capacity has become crucial and global issue in world’s fisheries. FAO, for instance, has already given a great attention to the crucial issue since 1999 through its suggestion to manage the world’s fisheries including Indonesia on the basis of fishing capacity; that is efficient, equatable, and transparant (Fauzi, 2005).

Dimension of fishing capacity is an important measurement of the capacity that provides strategic information for the direction of policy’s implementation when there is an indication of declining catches. The dimension can be measured by data envelopment analysis (DEA) approach. The technique of measurement of performance can be applied to evaluate a relative efficiency of decision making unit (DMU) at any acitivity and a certain periode of time. This technique is an input and output orientation developed by Charnes, Cooper, and Rhodes or CCR and then continued by Färe, *et al., 2000.* (Fauzi and Anna, 2005). Using the technique in fisheries

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was introduced by Kirkley and Squires, 1998. The technique is able to determine whether a fishery activity at certain waters is efficient in term of economic overfishing when production decreases because of imbalance of fishing inputs and fish stocks.

The DEA technique is a non-parametric method that uses mathematical programming to determine optimal solution that is subject to existing constraints (Kirkley, *et al.,* 2004). Efficiency measure from DEA analysis is a free value because it is based on data available without taking consideration from decision making (Korhumen, *et al.*, *vide* Fauzi and Anna, 2005).

Differences in measure unit of inputs and/or outputs of capture fishery can be analyzed by the technique (van Hoof and de Wide, 2005). Results from DEA measurement is a relative technical efficiency on the optimal frontier technology in terms of “best practice” of fishing fleets. The frontier technology of output orientation is the combination of optimal input i.e. tonnage, engine power, and fish catch.

General strengths of the DEA approach are: (i) able to estimate fishing capacity under constrains of policy’s implementation such as total allowable catch or TAC, vessel size, tax, and socio-economic constrains (Kirkley and Squires, 1998); (ii) able to accommodate a non-discrete input and output, and to determine a level of maximum potential from input variables and their optimal rates; (iii) possible to make a combination of input variable, output variable, fixed input, and fishing enterprise characteristics in terms of maximum outputs and minimum inputs. Therefore, the technique is useful for estimating capacity and evaluating efficiency of fisheries policy at any fishery’s region.

Fishery studies using the DEA approach have just been developed for the last two decades. In Indonesia, study of using the technique in fisheries is extremely lacking, and recent studies are as follows. A research conducted by Effendi (2007) used the DEA technique to measure fishing capacity in terms of inefficiency and/or overcapacity of the purse-seine fishery of Pekalongan. An application of the DEA was also carried out by (Desniarti, 2007) to determine fishing capacity of the small-pelagic fishery at the West Sumatera waters. In addition, Hiariey (2009) applied the DEA to analyze the status of pelagic fish at Moluccas waters. Results of the studies imply that fishing efficiency is declining, and the exploitation of fish resource at each area of the study tends to be overcapacity.

Kirkley and Squires (1998) stated that fishing capacity can be measured in the basis of the resource stocks available and/or unavailable. With regards to the term of available resource stock, fishing capacity is the output maximum potential that can be produced at a given resource rate. Capacity measure based on the unavailable resource stock can be assumed as potential output that is produced without resource constraints. The latter concept of the measurement was utilized in this paper; hence, rate of available resource is not treated as input. The purpose of this paper is to study annual changes of fishing capacity of small-pelagic fishery at the FMA-714 Banda Sea, Moluccas.

# MATERIAL AND METHODS

## Data Collection

Data of the small-pelagic were derived from annually published data by the Provincial Fisheries Offices located in Ambon as well as by the Department of Marine Affairs and Fisheries in Jakarta. The data were also derived from all Regencies Fisheries Offices and Ambon City of the Province Moluccas except for Regency of Aru Islands. This is because the Banda Sea covers most area of the regencies and/or the city of Moluccas. In addition, data from the fishing industries in Moluccas and the Scientific Research Reports of the small-pelagic fisheries in the Banda Sea were combined with the province and regencies data so as to obtain appropriate data by small-pelagic species, fishing gears, and fishing efforts. The data collected cover 22 time-series data from 1985 until 2006, and were considerably reviewed and computed. The fishing gears and fishing effort were then treated as variable inputs, while catch as a variable output. Each annual time-series data is treated as a DMU that is used as a basis of evaluation for development of capacity’s performance.

In this paper, efficiency is typically represented by the fish production to fishing input ratio. A “maximum” efficiency, in terms of comparison across DMU, is then

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characterized by notion of the highest ratio of fish production and fishing inputs that has been reached. Thus, a relative efficiency of fishing input utilization that is attained in the small-pelagic fishery is not more than 100%.

**Data Analysis**

Assumed that input and output transformation on fishery production function is variable return to scale or VRS, DEA model used in this paper was designed and modified following the model developed by Banker, Charnes, and Cooper or BCC (Fauzi and Anna, 2005). The specification of model is able to analyze the efficiency of economic activity that is VRS. The DEA model of input minimization with VRS assumption is formulated as follows,

TE = Min $\theta$

Subject to the following restrictions,

$$\theta u_j \leq \sum_{j=1}^{J} z_j u_j$$

$$\sum_{j=1}^{J} z_j x_{jn} \leq x_{jn}, \quad n \in \alpha$$

$$\sum_{j=1}^{J} z_j = 1$$

$$\sum_{j=1}^{J} z_j x_{jn} = \lambda_j x_{jn}, \quad n \in \hat{a}$$

$z_j \geq 0, \quad \lambda_{jn} \geq$, j=1, 2… J, n=1, 2, …, N

Where j=1, 2,..., J is total year observation, or 22 DMU's. Fishing gears and fishing trips are treated as variable inputs, hence n=1, 2, and

TE = technical efficiency of the-j$^{th}$ year;

$\theta$ = value of measurement for each observation (≥1)

$u_j$ = output of the-j$^{th}$ year, that is one output (catch fish)

$x_{jn}$ = the-n input used, consist of 2 inputs (total fishing effort and total fishing gear)

$\lambda_j$ = utilization rate of the-n variable input

$z_j$ = utilization rate of variables.

The modified DEA model is used to find out outputs produced by fishing effort without reducing inputs, and to compute how many fishing gears that must be reduced without any changes of outputs. Therefore, the analysis of technical efficiency with the VRS and input orientation is used to determine input utilization rates in producing outputs, in addition to describe technical efficiency of each DMU. The use of the specific model is based on the assumptions that (i) there is still budget constraint faced by fishing units in capture small-pelagic fish at the FMA-714 Banda Sea; (ii) not all fishing units are operating in optimum scale. Consequently, the BCC model of DEA can be utilized to analyze technical efficiency.

According to Cooper *at al.*, (2000) *vide* (Lindebo, 2004), degrees of freedom for DEA analysis will increase if the DMU increases. On the contrary, the degrees of freedom will decrease if variable input and output increase. A rule of thumb of the significant level at the minimum total observation is: $n \geq \max\{m*s, 3(m+s)\}$; where: $n$ = number of minimum observation; $m$ = total inputs used; and $s$ = number of output.

# Results And Discussion

## A Short Description of Small-Pelagic Fisheries

The dominant fishing gears used by fishers in catching small-pelagic fishes at coastal waters of the FMA-714 Banda Sea are of purse seine, gill net, lift net, and beach seine. The purse seine, locally named "*jaring bobo*" among them, is the most productive fishing gear in that area. The season for small-pelagic fish comes about in March until October or the east season (Merta, *et al.,* 1998) very related to the upwelling process occured in the Banda Sea in the season.

The development of the small-pelagic fishery started in mid-1970's by introducing of a mini-purse seine powered by outboard engine *"ketinting"*. In mid-1980's the purse seine was continouesly developed by local fishers with gear size of 250m long and 75 m wide and boat size of 22 m long, 3 m wide, and 1.5 m high. The boat is powered by outboard engine of Yamaha 120 HP (horsepower).

The average production of the small pelagic per DMU amounted to 27,145.87 tonnes, with the average fishing effort of 582,214 trips and fishing gear of 6,005 units.

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**Table 1.** Descriptive statistics of the small-pelagic fishery per DMU

| Variables | N | Average | Std. deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Production | 22 | 27145.87 | 10636.5947 | 14225.72 | 62314.70 |
| Effort | 22 | 582214 | 191293.0643 | 176901 | 771741 |
| Fishing gear | 22 | 6005 | 2703.17 | 3051 | 11658 |

Changes of production for the small-pelagic fishery as shown at **Fig. 1** are fluctuated and tended to increase from 2001 until 2006. The lowest production was found in 1985, and the highest in 2006. Allocation of actual fishing trips represented in **Fig. 2** varied and tended to increase from 1985 to 1998, then declined from 1999 to 2006. Allocation of fishing unit relatively increased from 1985 to 1998, and then sharply increased from 1999 to 2006 (**Fig. 3**). Trends of declining fishing effort in the period 1999 to 2006 were due possibly to decreasing efforts as impact of the social conflict in Moluccas in the 1999.

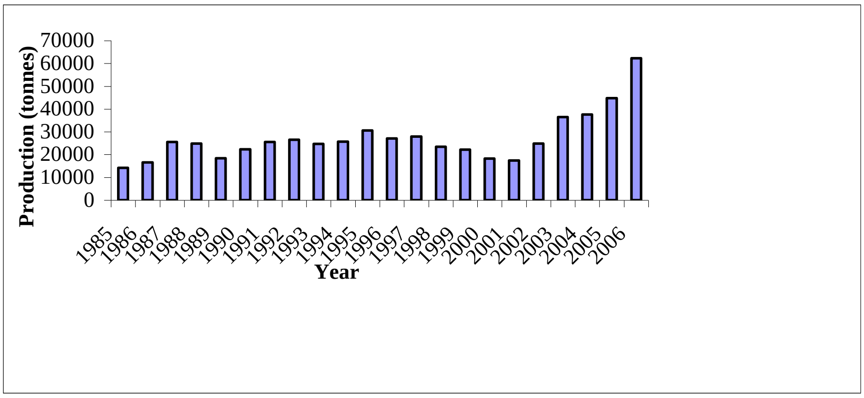


**Fig. 1** Production of the small pelagic fish of 1985-2006.

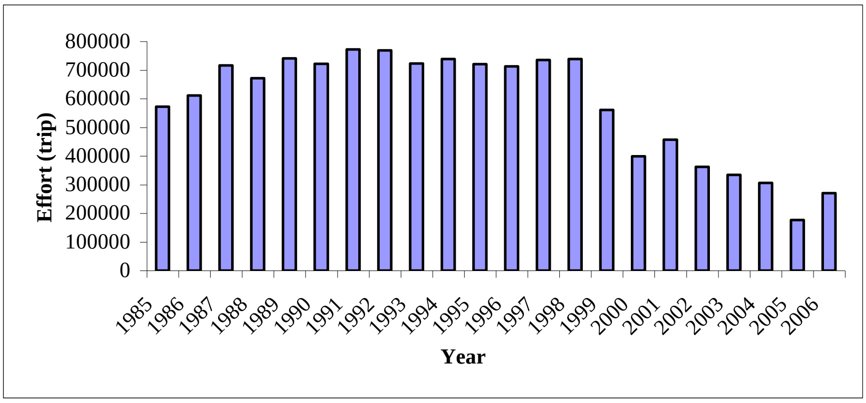


**Fig. 2** Allocation of fishing effort of the small pelagic fishery of 1985-2006.

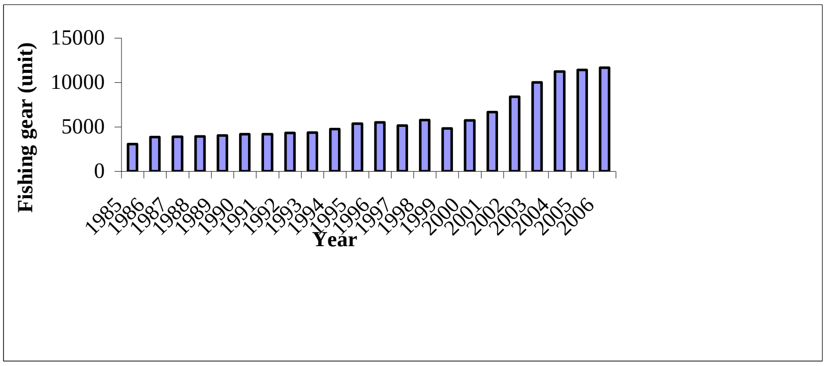


**Fig. 3** Fishing gears of the small pelagic fish of 1985-2006.

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## Fishing Efficiency of Small-Pelagic Fishery

Results of the DEA analysis provide the efficiency of input utilization in terms of increasing, constant, and decreasing to scale. Annual efficiency is fluctuated in accordance with the fishing efficiency scale, and the most efficiency changes are categorized as increasing rate to scale. These characteristics describe proportion of the rate of input utilization that is lower than the rate of output increases. Fluctuation of the input utilization efficiency was due to declining of fishing effort in period 1985 to 2006, but fishing fleet and production tended to increase.

The results of DEA in **Table 2** provide a dimension of relative efficiency for the small-pelagic fishery. There are six out of twenty-two DMU which have efficiency score equaled to 1 and this score is used as a base value in determining relative efficiency. The score 1 with constant scale was found at DMU-1987, DMU-2005, and DMU-2006. Therefore, those DMU were fully efficient. Efficiency score of input utilization in the period of 1985 to 2006 ranged from 0.763 to 1. These values imply that efficiency of all the fishing inputs are greater than 70 percent. Färe, *et al.*, (2000), suggests that if the efficiency of input is less than 1, the input used is not efficient. The inefficiency score can be calculated by 1 minus the efficiency score. Efficiency value in 1989 diminished to 83% compared to 1987. The increase in efficiency was found in period 1989 to 1992 because proportion of increasing production was larger than that of fishing unit, but proportion of fishing trip got smaller. Relative efficiency in period 2000-2004 was less than that of period 2005–2006. The lower rate of efficiency in the period of 2000- 2004 was due to increasing in production, fishing unit, and declining in trip.

**Table 2**. Efficiency of the small pelagic fishery at the FMA-714 Banda Sea

| No. | DMU (year) | BCC-Score (VRS) | Scale |
|---|---|---|---|
| 1. | 1985 | 1.000 | Increasing |
| 2. | 1986 | 0.909 | Increasing |
| 3. | 1987 | 1.000 | Constant |
| 4. | 1988 | 1.000 | Increasing |
| 5. | 1989 | 0.838 | Increasing |
| 6. | 1990 | 0.897 | Increasing |
| 7. | 1991 | 0.931 | Increasing |
| 8. | 1992 | 0.951 | decreasing |
| 9. | 1993 | 0.915 | increasing |
| 10. | 1994 | 0.882 | increasing |
| 11. | 1995 | 0.925 | decreasing |
| 12. | 1996 | 0.849 | increasing |
| 13. | 1997 | 0.881 | increasing |
| 14. | 1998 | 0.763 | increasing |
| 15. | 1999 | 0.931 | increasing |
| 16. | 2000 | 1.000 | increasing |
| 17. | 2001 | 0.869 | increasing |
| 18. | 2002 | 0.903 | increasing |
| 19. | 2003 | 0.890 | increasing |
| 20. | 2004 | 0.849 | increasing |
| 21. | 2005 | 1.000 | constant |
| 22. | 2006 | 1.000 | constant |

*Computed by the DEAP Version 2.1*

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The lowest score of efficiency of 76.3% was found in 1998 because of increased fishing unit of 11.9%, and decreased production of 16%. With an assumption that condition of decreasing return to scale occurred at the lowest efficiency, the management of small-pelagic fishery indicated overcapacity at fishing industry level. The indication of overcapacity was also shown by the most technical efficiency scores that are less than 1. In addition, the potential of increasing inputs of DMU based on the DEA analysis has a negative sign that points to overcapacity on the small-scale fishery at the FMA-714 Banda Sea. This implies that management of the small-pelagic fishery is not efficient.

The optimal use of input with efficiency scale of "constant" that was found in the DMU-1987, DMU-2005, and DMU-2006 denoted that all inputs were fully utilized; hence there was no potential to allocate more inputs in the fishery. In this regard the management is fully efficient. In DMU-1995 there was the inefficiency of 0.925 under decreasing return to scale. To use inputs optimally, fishing trip should be decreased by 9.13% and fishing unit by 7.45% as well. In 2001 inefficiency valued at 0.869. To reach input utilization optimally, each input of the fishing unit and fishing effort should be decreased by13.08%, and production should be increased by 5.79%.

## Managing Fishing Capacity

Most DMU show excess capacity, except for the DMU-1985, DMU-1987, DMU-1988, DMU-2000, DMU-2005 and DMU-2006.The excess capacity is the difference between target input and actual input. The highest value of the excess capacity occurred at DMU-1998 of 23.71%, and followed by DMU-1989 (16.21%), DMU-1996 (15.21%), and DMU-2004 (15.04%). The excess capacity indicated that input allocation is relatively high in the small-pelagic fishery. Kirkley *et al.*, (2004) stated that efficiency score of DMU less than 1 can be classified as excess capacity, and in the long-term it will cause overcapacity. Indication of excess capacity of the small-pelagic fishery at the FMA-714 Banda Sea is an important factor to explore for future management of sustainable fisheries.

The excess capacity that continuously existed at the FMA-714 Banda Sea from 1989 to 1998 indicated that overcapacity has occurred in the management of the small-pelagic fishery. This indication was also relevant to a tendency of declining CPUE in the period of time. The overcapacity was due to the increasing of demand for fishery production which imposed fishing fleets to heavily exploit fish stocks. This was in turn to gradually deplete fish resources, and input utilization in the small-pelagic fishery tended to become inefficient. This finding is consistent with the work of Salayo *et al.*, (2008) on the management of fishing capacity in small-scale fisheries in three Southeast Asian countries, i.e. Cambodia, Philippines, and Thailand. They concluded that excess capacity leads to a number of negative impacts such as overfishing, environmental degradation, economic wastage, and resource use conflicts.

Although the actual production was inclined to be increased from 1985 to 2006, the fishing effort tended to be declined. These changes showed that the fishers reduced their fishing activities to increase efficiency of the production as well as economic rent. However, the reducing of fishing activities was slightly inconsistent with an effort of the fishers in increasing a number of fishing gears in the same period. The strategy conducted by the fishers aimed to improve the productivity individually because they often belong to the poorest segment of the coastal communities. They are not likely to accept the prospect of being prevented from engaging in fishing activities (Salayo, *et al.*, 2008).

Status of fishing capacity and policy of input utilization from 1985 to 2006 is presented in **Table 4.** The status can be grouped as the following; (i) fishing level of 1985 was fully utilized and it was needed policies to maintain that status; (ii) fishing level of 1986 indicated excess capacity and it was needed to reduce fishing gears and fishing effort by 349 unit and 55,800 trips respectively to reach fully utilized status; (iii) fishing levels in 1987 and 1988 were fully utilized, and needed a strategy to maintain the status; (iv) fishing level from 1989 to 1999 was excess capacity and in the long-term period has indicated overcapacity.

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**Table 3.** Excess capacity, actual input, and target input of the small-pelagic fishery

| DMU/ Year | Actual inputs[b] | | Target inputs[a] | | Excess capacity[c] | | | |
|---|---|---|---|---|---|---|---|---|
| | Effort | Fishing gears | Effort | Fishing gears | Effort | | Fishing Gears | |
| | (trip) | (unit) | (trip) | (unit) | (trip) | % | (unit) | % |
| 1985 | 571 554 | 3 051 | 571 554 | 3 051 | 0 | 0.00 | 0 | 0.00 |
| 1986 | 611 709 | 3 831 | 555 909 | 3 482 | -55 800 | -9.12 | -349 | -9.12 |
| 1987 | 716 172 | 3 898 | 716 172 | 3 898 | 0 | 0.00 | 0 | 0.00 |
| 1988 | 671 393 | 3 935 | 671 393 | 3 935 | 0 | 0.00 | 0 | 0.00 |
| 1989 | 741 059 | 4 014 | 620 935 | 3 363 | -120 124 | -16.21 | -651 | -16.21 |
| 1990 | 722 333 | 4 158 | 647 865 | 3 729 | -74 468 | -10.31 | -429 | -10.31 |
| 1991 | 771 741 | 4 182 | 715 240 | 3 893 | -56 501 | -7.32 | -289 | -6.92 |
| 1992 | 768 626 | 4 299 | 705 114 | 4 090 | -63 512 | -8.26 | -209 | -4.85 |
| 1993 | 722 712 | 4 338 | 661 204 | 3 969 | -61 508 | -8.51 | -369 | -8.51 |
| 1994 | 738 624 | 4 741 | 651 232 | 4 180 | -87 392 | -11.83 | -561 | -11.83 |
| 1995 | 720 247 | 5 371 | 654 486 | 4 971 | -65 761 | -9.13 | -400 | -7.45 |
| 1996 | 712 503 | 5 488 | 605 217 | 4 662 | -107 286 | -15.06 | -826 | -15.06 |
| 1997 | 735 705 | 5 159 | 647 836 | 4 543 | -87 869 | -11.94 | -616 | -11.94 |
| 1998 | 738 011 | 5 773 | 563 007 | 4 404 | -175 004 | -23.71 | -1369 | -23.71 |
| 1999 | 561 427 | 4 809 | 522 461 | 4 475 | -38 966 | -6.94 | -334 | -6.94 |
| 2000 | 399 399 | 5 734 | 399 399 | 5 734 | 0 | 0.00 | 0 | 0.00 |
| 2001 | 457 296 | 6 654 | 397 460 | 5 783 | -59 836 | -13.08 | -871 | -13.08 |
| 2002 | 361 767 | 8 393 | 326 780 | 7 581 | -34 987 | -9.67 | -812 | -9.67 |
| 2003 | 333 791 | 9 994 | 297 106 | 8 896 | -36 685 | -10.99 | -1098 | -10.99 |
| 2004 | 305 815 | 11 231 | 259 788 | 9 541 | -46 027 | -15.05 | -1690 | -15.05 |
| 2005 | 176 901 | 11 394 | 176 901 | 11 394 | 0 | 0.00 | 0 | 0.00 |
| 2006 | 269 917 | 11 658 | 269 917 | 11 658 | 0 | 0.00 | 0 | 0.00 |

[a]*Computed by the DEAP Version 2.1*
[b]*From the raw data*
[c]*Target input minus actual input*

It was needed a strategy of reducing the fishing gears by 550 unit and the fishing effort by 85,308 trips as well; (v) fishing level in 2000 showed fully utilized status and needed to be maintained; (vi) fishing level of 2001-2004 was excess capacity and needed to reduce the capacity; and (vii) fishing level of 2005 and 2006 showed fully utilized and needed to be maintained. The status of fishing capacity and the implementation of the above policies which is based on the technical measures aimed at balancing of fishing inputs and production. The type of managing fishing capacity is relevant with the one which was recommended by FAO (2008).

Approaches to managing excess fishing capacity in the small-scale fisheries can be grouped into effort reduction, gears/fishing area/temporal restrictions, and alternative and supplemental livelihoods generating for fishermen (Salayo, *et al.,* 2008). These approaches are considered as an appropriate solution to manage the excess fishing capacity in the small-pelagic fishery at FMA-714 Banda Sea.

Annual change of the fishing capacity needed a temporal management of the small-pelagic fishery. This means the annual allocation of inputs in fishing should be managed efficiently to reduce capital waste in the fishery. To attain a higher efficiency of fishing, it was needed a strategy for reducing fishing capacity through a control mechanism such as reduction of investment, adjustment of fishing gears, setting of fishing period and fishing ground (Kirkley, *et al.,* 2004; FAO (2008).

Indications of excess capacity and overcapacity at the small-pelagic fishery require policy strategies of the optimal allocation of inputs based on the fishing capacity. The strategies aim to balance the level of fishing gears and trips with the sustainability of the small-pelagic resource. That is, the use of inputs in fishing should consider fish stocks to improve economic rent and to reduce degradation of the stocks as well. FAO (2008) suggested that at the open-access fishery such as fishery at the FMA-714 Banda Sea, it is required to limit gears into the fishing industry to decrease fishing capacity.

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**Table 4.** Status of the fishing capacity and strategy of input use for the small-pelagic fishery

| Period/ Year | Excess capacity | | Status of the capacity | Strategy of input utilization |
|---|---|---|---|---|
| | Effort (trip) | Fishing gear (unit) | | |
| 1985 | 0 | 0 | Fully utilized | Maintained |
| 1986 | -55 800 | -349 | Excess capacity | Reduced |
| 1987 | 0 | 0 | Fully utilized | Maintained |
| 1988 | 0 | 0 | Fully utilized | Maintained |
| 1989 | -120 124 | -651 | Overcapacity | Reduced |
| 1990 | -74 468 | -429 | Overcapacity | Reduced |
| 1991 | -56 501 | -289 | Overcapacity | Reduced |
| 1992 | -63 512 | -209 | Overcapacity | Reduced |
| 1993 | -61 508 | -369 | Overcapacity | Reduced |
| 1994 | -87 392 | -561 | Overcapacity | Reduced |
| 1995 | -65 761 | -400 | Overcapacity | Reduced |
| 1996 | -107 286 | -826 | Overcapacity | Reduced |
| 1997 | -87 869 | -616 | Overcapacity | Reduced |
| 1998 | -175 004 | -1369 | Overcapacity | Reduced |
| 1999 | -38 966 | -334 | Overcapacity | Reduced |
| 2000 | 0 | -0 | Fully utilized | Maintained |
| 2001 | -59 836 | -871 | Excess capacity | Reduced |
| 2002 | -34 987 | -812 | Excess capacity | Reduced |
| 2003 | -36 685 | -1098 | Excess capacity | Reduced |
| 2004 | -46 027 | -1690 | Excess capacity | Reduced |
| 2005 | 0 | 0 | Fully utilized | Maintained |
| 2006 | 0 | 0 | Fully utilized | Maintained |

in addition, other mechanism in managing capacity would be gear and vessel restrictions. Such gear restriction of minimum mesh size should be particularly implemented to lift-net fishery to lessen fishing mortality of the small-pelagic fish in the coastal waters.

In the context of managing excess capacity of the small-pelagic fishery at the FMA-714 Banda Sea, an alternative and supplemental livelihood as suggested by Salayo, *et al.*, (2008) would provide supplemental income to the fishers and their households. The alternative livelihood may be related to the fisheries sector such as seaweeds farming, and/or outside the sector such as livestock raising and vegetable gardening. The new alternative and supplemental livelihood, which provides an income that is at least equal to what they are obtaining from fishing, is considered as a key pre-condition to moving out of fishing. The strategy for exit from the fisheries should take into account the technical, social, economic, and political feasibility in addition to management supports and integrated approach (Salayo, *et al.*, 2008).

## CONCLUSION

Fishing capacity of the small pelagic in the period of 1985 until 2006 can be analyzed using the DEA approach. The results contribute some findings on how to temporarily manage the open-access fishery that is indicative of excess capacity, and overcapacity at fishing industry level. The findings include annually estimated technical efficiency and its scale, the optimal allocation of fishing inputs, status of fishing capacity, and strategy of input utilization. Annual changes in fishing capacity of the fishery at the FMA-714 Banda Sea should be managed wisely to improve economic rent and to reduce resource degradation for sustainable fisheries management in future. That is, fishing inputs should be allocated optimally in terms of fishing capacity. This optimal allocation can be done through a Fishery Management Plan as a policy's strategy established by stakeholders with the province government as an initiator. Implementation of the strategy will create a condition for balancing input utilization with the existing resource stocks towards sustainable fisheries development.

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