THEORY AND PRACTICE OF OVERFISHING:
A SOUTHEAST ASIAN PERSPECTIVE\textsuperscript{a)}

by

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ABSTRACT

A brief review is given of the demersal and pelagic fisheries of Southeast Asia, with emphasis on biological and socioeconomic factors (such as, for example, the presence of inshore shrimp stocks and mass unemployment, respectively) and which tend to promote over-exploitation of marine fish resources.

It is shown that several models routinely used by fishery biologists to assess Southeast Asian fish stocks tend to lead to management advice that is less conservative than warranted. Straightforward remedies exist for the latter set of problems. On the other hand, non-traditional approaches will have to be identified to deal with problems related to resource over-exploitation.

Introduction

This contribution is an attempt to discuss overfishing, with emphasis on those aspects of the phenomenon that are relevant to Southeast Asia. The following forms of overfishing will be discussed:

i) growth overfishing,
ii) recruitment overfishing,
iii) ecosystem overfishing,
iv) economic overfishing.

(Conceptual and operational definitions of these four forms of overfishing will be given below).

Southeast Asia is extremely diverse, both in terms of its peoples, cultures and natural resources and has therefore frequently been labelled as the "Europe of Asia". This comparison, in the context of the present contribution begs the question as to whether Southeast Asian fisheries are in a state of overfishing similar to that of Northern Europe, whose fisheries have been stated to dissipate a potential rent of about $10^9$ US$ annually (Gulland 1982).

The central core of Southeast Asia is formed by the countries forming the Association of Southeast Asian Nations, or ASEAN (i.e., Brunei, Indonesia, Malaysia, Philippines, Singapore and Thailand). Closely related to these through cultural, historic and economic ties are Burma to the west, Vietnam, Kampuchea and the southern China coast (including Hong Kong and Taiwan) to the east and Papua New Guinea to the south.

As can be seen from Table 1 (column E), the economies of these countries differ widely, with GNP per capita ranging from values well above US$6,000 per year for Singapore and Brunei to values of the below US$200 per year.

Overall marine landings from the countries listed in Table 1 are of about 6.7 million tonnes annually, of which about 64% consist of demersal resources (i.e., animal caught near the sea bottom using gears such as otter trawl), which themselves consist of 11.4% penaeid shrimp.

Table 1. Selected statistics relevant to the fisheries of the countries mentioned in this contribution.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<td>Brunei</td>
<td>5.80</td>
<td>163</td>
<td>0.2</td>
<td>12,000</td>
<td>3</td>
<td>3</td>
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<td>677</td>
<td>2,800</td>
<td>37</td>
<td>200</td>
<td>443</td>
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<td>1,919</td>
<td>36,800</td>
<td>169</td>
<td>500</td>
<td>1,600</td>
<td>900</td>
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<td>Kampuchea</td>
<td>181</td>
<td>435</td>
<td>6.2</td>
<td>95</td>
<td>51</td>
<td>27</td>
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<td>16</td>
<td>1,800</td>
<td>726</td>
<td>523</td>
<td>76.5</td>
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<td>462</td>
<td>10,000</td>
<td>3.3</td>
<td>800</td>
<td>13</td>
<td>11.2</td>
<td>1.0</td>
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<tr>
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<td>300</td>
<td>17,500</td>
<td>57</td>
<td>800</td>
<td>127</td>
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<td>2,580</td>
<td>53</td>
<td>700</td>
<td>2,100</td>
<td>1,770</td>
<td>174</td>
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<tr>
<td>Vietnam</td>
<td>330</td>
<td>2,310</td>
<td>61</td>
<td>170</td>
<td>505</td>
<td>250</td>
<td>49.1</td>
</tr>
</tbody>
</table>

A. Country. ASEAN countries are in italics; China is not included, because only its South China Sea coast belongs to Southeast Asia.
B. Area in km² × 10³, from Anon. (1985, p. 6-7).
C. Coastline length in km, from Marr (1976) except for Burma (from Anon. 1982), and PNG (from Frielink 1983).
E. Annual per capita income (US$), from Hinton (1985); note large per capita income for Brunei, due to relatively large oil revenues.
F. Annual marine landings in metric tons × 10³, from FAD Statistics for 1983, except for PNG which is from P. Dalzell and A. Wright (PNG Dept. of Primary Industry, pers. comm.); figure excludes tuna and baitfish, whose fishery essentially stopped in 1981, as well as beche-de-mer and pearl shells.
G. Demersal component of marine landings in metric tons × 10³, from FAO Statistics for 1983, except for PNG which is based on data in Wright and Richards (1985) and which consists mainly of reef fishes, for Kampuchea whose value of 27 (from Aoyama 1973) refers to pre-war (1971) trawler catches and for Burma and Vietnam whose demersal component was set at approximately 90% and 50% of their total marine catch, respectively.
H. Penaeid shrimp production in metric tons × 10³, from FAO Statistics for 1983 (and including aquaculture production), except for Burma (Price and Kyaw Htin 1984), Brunei (Currie 1982), Kampuchea (Aoyama 1973) and PNG (Anon. 1979). Note that the latter fishery conducted in the Gulf of Papua also catches about 7,000 tons of fish per year, all of which is discarded. The figure for Kampuchea (trawler catch of shrimp in 1971) is dated and is given here to serve as minimum estimate of potential yield.

The latter as will be shown below are extremely important both in terms of their higher value (usually about 10 times the value of the demersal fish with which they are caught), and in terms of their nearshore distribution, about which more will be said later. Figure 1 presents a map of the distribution of major shrimping grounds in Southeast Asia, along with averaged annual catches in thousand tonnes.

Forms of overfishing occurring in Southeast Asia

Growth overfishing is that aspect of overfishing that is conceptually easiest to grasp, and which is easiest to theoretically account for. It is in layman’s terms what occurs when fish are caught before they had “a chance to grow” (note that growth overfishing has nothing to do with fish reproduction which is dealt with under “recruitment overfishing” - see below). The converse of growth overfishing is growth underfishing which is what occurs when fish are caught at such an advanced age that their death rate (as due to natural causes) exceeds the rate at which they grow. The methods most commonly used to identify the level of fishing and associated mesh size which maximize the yield from a given number of young fish (i.e., “recruits”) have been developed by Beverton and Holt (1957). Massive growth overfishing occurs in Southeast Asian stocks, as will be discussed further below.

Recruitment overfishing is what occurs when so few adult fish are left in a given exploited stock that the production and/or survival of eggs (and larvae) is reduced to the extent that recruitment to a fishery is impaired. Many of the concepts related to recruitment overfishing have been first formulated by Ricker (1954).
Fig. 1. Major shrimping grounds of Southeast Asia (shaded), with average annual catch (1976-1978) for each area in thousands of metric tons (from SCSP 1981, with figures for Brunei, Burma, Kampuchea and Vietnam added from Table 1).
Recruitment overfishing is usually harder to detect than growth overfishing, and one of the few (or the only?) ‘stock recruitment’ curves so far derived for a Southeast fish stock is shown here as Figure 2.

Fig. 2. Stock-recruitment data of false trevally (Lactarius lactarius) in the Gulf of Thailand, fitted with Ricker curves (GM and AM) (from Pauly 1984a).

Ecosystem overfishing has been defined elsewhere as what takes place in a [ multispecies ] stock when the decline (through fishing) of the originally abundant stocks is not fully compensated for by the contemporary or subsequent increase of the biomass of other exploitable animals” (Pauly 1979). A now exemplary case of ecosystem overfishing is the Gulf of Thailand, where species (e.g., slipmouths, Fam: Leiognathidae) that were extremely abundant when the fishery began were partially replaced (e.g., by squids, Loligo spp.) but where this and other species replacement failed by far to compensate for the enormous drop in overall catch per effort (Table 2).

Economic overfishing occurs when less than maximum economic yield is obtained from a fishery, i.e., when fishing effort exceeds that needed to maximize the economic rent (or pure profits) from a fishery. It will be shown below that concepts such as this, far from being irrelevant to fishery biologists, are in fact highly compatible with biologically sound management, particularly in Southeast Asian waters.

A partial list of overfishing effects on single and multispecies stocks is given in Table 3.
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<td>71.50</td>
<td>20.02</td>
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<td>14.37</td>
<td>10.59</td>
<td>10.25</td>
<td>2.98</td>
<td>4.86</td>
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<td>11.78</td>
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<td>7.40</td>
<td>2.95</td>
<td>3.89</td>
<td>3.83</td>
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<td>15.31</td>
<td>11.78</td>
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<td>6.81</td>
<td>7.31</td>
<td>4.73</td>
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<td>1.46</td>
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<td>6.14</td>
<td>3.77</td>
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<td>6.59</td>
<td>6.64</td>
<td>3.07</td>
<td>3.32</td>
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<td>3.91</td>
<td>2.62</td>
<td>1.91</td>
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<td>5.60</td>
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<td>7.45</td>
<td>7.38</td>
<td>5.21</td>
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<td>0.74</td>
<td>1.14</td>
<td>1.43</td>
<td>0.35</td>
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<td>2.00</td>
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<td>0.35</td>
<td>0.29</td>
<td>0.19</td>
<td>0.13</td>
<td>0.11</td>
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<td>4.02</td>
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<td>2.25</td>
<td>0.99</td>
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<td>1.09</td>
<td>0.63</td>
<td>0.23</td>
<td>0.14</td>
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<td>1.01</td>
<td>1.24</td>
<td>1.46</td>
<td>0.74</td>
<td>0.94</td>
<td>0.69</td>
<td>0.85</td>
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<td>1.37</td>
<td>1.05</td>
<td>0.95</td>
<td>0.86</td>
<td>0.51</td>
<td>0.33</td>
</tr>
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<td>Rastrelliger neglectus</td>
<td>(0.96)</td>
<td>0.80</td>
<td>0.19</td>
<td>0.37</td>
<td>0.52</td>
<td>1.03</td>
<td>1.54</td>
<td>0.40</td>
<td>0.16</td>
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<td>Crabs</td>
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<td>0.70</td>
<td>0.92</td>
<td>0.61</td>
<td>0.70</td>
<td>0.86</td>
<td>1.32</td>
<td>1.15</td>
<td>1.61</td>
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<td>0.02</td>
<td>0.03</td>
<td>0.01</td>
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<tr>
<td>Shrimps</td>
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<td>0.12</td>
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<td>0.11</td>
<td>0.15</td>
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<td>0.17</td>
<td>0.16</td>
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<td>0.09</td>
<td>0.05</td>
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<td>0.09</td>
<td>0.05</td>
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<td>0.40</td>
<td>0.99</td>
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<td>0.71</td>
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<td>0.23</td>
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<td>0.21</td>
<td>0.22</td>
<td>0.09</td>
<td>0.13</td>
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<td>0.86</td>
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<td>0.28</td>
<td>0.23</td>
<td>0.11</td>
<td>0.16</td>
</tr>
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<td>0.29</td>
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<td>(12.86)</td>
<td>(6.76)</td>
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<td>Rastrelliger konaguri</td>
<td>(0.96)</td>
<td>(0.80)</td>
<td>0.42</td>
<td>0.66</td>
<td>0.63</td>
<td>0.96</td>
<td>0.86</td>
<td>0.47</td>
<td>0.36</td>
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<td>Bothidae</td>
<td>(14.44)</td>
<td>(14.44)</td>
<td>0.63</td>
<td>0.28</td>
<td>0.38</td>
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<td>0.32</td>
<td>0.12</td>
<td>0.28</td>
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<td>(0.28)</td>
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<td>0.06</td>
<td>0.04</td>
<td>0.14</td>
<td>0.07</td>
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<td>0.31</td>
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<td>Sepia spp.</td>
<td>[1.86]</td>
<td>(5.32)</td>
<td>2.80</td>
<td>1.87</td>
<td>2.10</td>
<td>2.33</td>
<td>2.62</td>
<td>2.28</td>
<td>2.97</td>
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</table>

| Total catch (including misc. fish) | 297.80| 248.93| 130.98| 114.84| 105.54| 102.37| 97.24| 66.31| 63.12|
| No. of hauls       | 133   | 200   | 713   | 713   | 713   | 713   | 717   | 718   | 718   |


*bBased on Tiews (1963), with values in round brackets extrapolated using % in 1963 catch; values in square brackets originally referred to "sharks and rays" and "cephalopods" and were assigned to lower taxa in relation to their values in 1963.*
Table 3. Some Effects of Biological and Economic Overfishing in (Multispecies) Stocks

**Single Species Fisheries**

i) reduction of size (length and weight) of the animals caught, hence:
   --- usually a reduction in value per unit weight
   --- usually higher handling, sorting and processing costs per unit weight

ii) reduction of biomass on the ground, hence
   --- reduction of catch per unit effort (and hence returns) of individual vessels

iii) reduction of total catch (at high levels of effort), hence
   --- lowered overall food supply
   --- increased prices
   --- need to import substitutes
   and hence, increased nutritional deficiency among poorer segments of the population.

iv) increased fluctuation of stock due to reduced number of age groups in stock and to reduced “buffering” of recruitment fluctuations, hence
   --- more frequent occurrence of periods with extremely low catches
   --- increasing risk of occasional recruitment failure, inclusive of total collapse of stock fishery

v) lowered income among fishermen; hence
   --- a multitude of social ills such as violent conflicts between pauperized small-scale fishermen and their “industrial” competitors

**Multispecies Fisheries**

i) same as (i) to (v) above, plus:

ii) massive changes in species composition of catch, i.e.
   --- disappearance of previously important species,
   --- increase of unmarketable species (“trash fish”) and/or squids (see Larkin and Gasey 1982, Pauly 1985)
   --- reduction in average value of species mix.

**Examples of stock assessment practices that promote overfishing**

It is common “knowledge” - at least among fishery biologists - that fishermen, or “politicians” are at fault when overfishing occurs, since all that fishery biologists do is give conservative advice which goes unheeded.

However, I shall show in the following paragraphs that a number of models routinely used by fishery biologists to formulate management advice have the common feature of suggesting management goals that induce overfishing.

**Example I. Using erroneous techniques for fitting surplus yield models to time series of catch-and-effort data.**

The most commonly used models for fishing management are various surplus production models, such as those proposed by Schaefer (1957) or Fox (1970). Notwithstanding their original assumptions (which strictly apply only to single species stocks), these models are routinely applied to multispecies situations, and “MSY” estimates and their associated level of effort (“f_{msy}”) proposed as management goals. (Gulland 1983).

Numerous authors (notably in contributions to the Can. J. Fish. Aquat. Sci.) have shown that these models tend to overestimate both MSY and f_{msy} when marked annual variations of recruitment occur.

No instance of this point being considered has come to my attention for Southeast Asia, but this is easy to explain given that the mathematical reasoning presented by these authors is, too obscure to most practitioners.
On the other hand, no real excuse is available for not heeding Gulland’s (1969) straightforward advice of explicitly accounting for lags in the response of the catch to the change in effort, e.g., by averaging effort over a period corresponding to the lifespan of the fish in single or multispecies stocks. As can be seen on Fig. 3, this simple adjustment has the effect of reducing estimates of MSY and $f_{msy}$, i.e., of providing both biologically more correct and also more conservative advice.

![Fig. 3. Schematic representation of the impact of regression type (AM or predictive vs GM or functional) and "lagged" effort (i.e., mean of contemporary effort + effort of preceding year) on a high scatter data set as typically obtained from tropical fisheries (adapted from Fig. 10.3 in Pauly 1984a). Note decline from (1) to (4) of "MSY" and "$f_{msy}$" estimates (see text).]

In a similar vein, it can only be wondered why authors keep using arithmetic mean (AM) or predictive regression for their $c/f$ vs. effort plots, given that this regression type assumes the data on the abscissa scale, i.e., effort to be measured without error (Ricker 1973) which is clearly unrealistic.

Rather, one should use a geometric mean (GM) or functional regression, i.e., use instead of

$$
c/f = a + b f
$$

a plot of

$$
c/f = a' + b' f
$$

where

$$
b' = b/|r|
$$

where $|r|$ is the absolute value of the correlation between $c/f$ and $f$ values and where

$$
a' = (c f' - f') / b'
$$

As may be seen in figure 3, this simple, statistically appropriate, modification automatically accounts for uncertainty in the data by “translating” a low value of $r$ into lower estimates of MSY and $f_{msy}$.
Example II. Estimating optimum mesh sizes from length-per-recruit analyses based on the assumption of knife-edge selection.

For reasons such as the lack of computers, programmable calculators and the like at the time they developed their theory, Beverton and Holt (1957) incorporated in their otherwise rather realistic model the assumption that mesh size selection by a gear such as trawl is "knife-edged", i.e., all fish below a certain length ("Lc") are assumed to be able to escape through the mesh of the net, while all fish above that length are assumed to be caught. These authors were also able to show, with reference to more extensive computations involving realistic selection ogives that the assumption of knife-edge selection had little or no impact on their yield per recruit analyses and estimates of optimum mesh size in relatively large fish such as plaice and other North Sea fishes.

Figure 4 shows the results of incorporating realistic selection ogives into yield per recruit analysis (i.e., in the method used to estimate optimum mesh sizes), in the small fish typical of Southeast Asian demersal stocks, as compared to results based on the knife-edge assumption. As might be seen the differences are profound. All one needs to add here is that to date all estimates of optimum mesh sizes performed in Southeast Asia and in neighboring areas (e.g., Sainsbury 1984 and Table 3) assumed knife-edge selection, and that most textbooks of stock assessment continue to advocate the knife-edge assumption, even for gillnet selection curve (e.g., Gulland 1983).

Example III. Continuing the use of Gulland's equation for potential yield estimates.

Gulland (1970) proposed, as a rule of thumb, that the fishing mortality generating MSY (F_{msy}) should be approximately equal to M, the rate of natural mortality in a stock, and used an equation based on this assumption, i.e.,

\[
MSY = \frac{1}{2} \times M \times \text{unexploited biomass}
\]

to estimate (potential) MSY in a variety of tropical stocks, including multispecies stocks (for which a mean value of M is extremely hard to define). The equation continues to be used widely although it has been shown to be grossly misleading by a number of authors, notably Francis (1976) and particularly Beddington and Cooke (1983) who showed that \(F_{msy} = M\), applies only in fishes with low values of M, such as, for example, North Sea plaice, and that \(F_{msy}\) is much smaller than M when the latter is high - as occurs in the small, short-lived species characteristic of tropical waters (Pauly 1980).

Although more could be put forward, these three examples should suffice to illustrate the contention that fishery biologists far from being innocent observers of the overfishing scene have contributed to it and continue to do so - through over optimistic estimation of potential yields (or of sustained yields in exploited fisheries), as well as through overoptimistic advice as to appropriate levels of fishing effort and mesh size.

[ Lest this last paragraph be misunderstood, I hasten to add here that I do belong to the group of fishery biologists that is being criticized here. Also, I suspect that fisheries economists commit similar mistakes, e.g., by not considering all factors, including hidden subsidies when they estimate fishing costs. ]

Particular features of Southeast Asian fisheries that make them particularly susceptible to overfishing (adapted in part from Pauly and Neal 1985)

Item I: The co-occurrence of penaeid shrimp and the bulk of the demersal fish stocks.

In 1980, the price per kg (live weight) of medium quality penaeid shrimp in the Philippines was about 56 pesos (8 Philippine P = 1 US$ in 1980). During the same period, the price of medium quality demersal fish was about 7 pesos/kg (Anon. 1981). The 8:1 ratio between these two prices, which is typical of the situation prevailing in Southeast Asia is one of the root causes of a number of biological, technological and social problems besetting the demersal fisheries of this region. These problems, although they form a continuum may be split into 3 sets, as follows:
Assuming knife-edge selection

Using a realistic selection ogive

Fig. 4. Effect of the “knife-edge assumption” on yield-per-recruit estimates in a single species stock of small fish or shrimp. Note that overoptimistic estimates are generated when the unrealistic knife-edge assumption is made (Adapted from Pauly and Soriano 1986).

Table 4. Optimum mesh size for the cod-end of Southeast Asian trawlers as estimated using various methods (present mesh size is usually 2 cm or less).

<table>
<thead>
<tr>
<th>Area/country</th>
<th>No. of species (groups) included in analysis</th>
<th>Optimum cod-end mesh size (cm)</th>
<th>Sources and remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern South China Sea</td>
<td>44</td>
<td>4.5 - 5.5</td>
<td>Sinoda et al. (1979) based on original method derived from considerations in Jones (1976).</td>
</tr>
<tr>
<td>Malacca Strait</td>
<td>38</td>
<td>4.5 - 5.5</td>
<td>Meemeskul (1979) based on method of Sinoda et al. (1979).</td>
</tr>
<tr>
<td>Inner Gulf of Thailand</td>
<td>51</td>
<td>4.5 - 5.5</td>
<td>Meemeskul (1979) based on method of Sinoda et al. (1979).</td>
</tr>
<tr>
<td>Brunei</td>
<td>numerous, but emphasis on 4 spp. of Leiognathidae</td>
<td>4</td>
<td>Lindley (1982), based on an approach suggested by Jones (1976).</td>
</tr>
<tr>
<td>San Miguel Bay, Philippines</td>
<td>16</td>
<td>5.4</td>
<td>Based on landed weight, Smith et al. (1983), using method of Sinoda et al. (1979).</td>
</tr>
<tr>
<td>San Miguel Bay, Philippines</td>
<td>16</td>
<td>5.3</td>
<td>Based on landed value, Smith et al. (1983), using method of Sinoda et al. (1979).</td>
</tr>
<tr>
<td>Southern Samar Sea, Philippines</td>
<td>10</td>
<td>3.5</td>
<td>Silvestre (1986), based on an original model which assumed knife-edge recruitment and/or selection.</td>
</tr>
</tbody>
</table>

*One of the 16 groups was "penaeid shrimp"; their inclusion, and their high price had surprisingly little impact on overall mesh size estimate.
problems in assessing the shrimp and associated fish stocks, inclusive of the problems associated with accounting for the biological interaction between fish and shrimp (Larkin and Gasey 1982, Pauly 1982, 1984b);

- technological problems arising from the attempts to catch only one part of the exploited shrimp/fish complex (e.g., catching shrimp but no fish or vice versa);

- social problems arising from fishing on inshore fishing grounds by trawlers aiming at shrimp concentrations.

As will be noticed, these problems do not include the “bycatch” problem *per se*, due to the fact that most fish caught in Southeast Asia are landed even when taken incidentally with shrimp. Exceptions are the demersal fisheries of Malaysia, the shrimp fisheries in the Arafura Sea (Naamin 1984) and in the Gulf of Papua (see Table 1). The relatively short duration of fishing trips which is interrelated with the lack of ice usage or the use of too little ice (Baasch *et al.* 1976) enables shrimp fishermen to land fish more easily than, e.g., in most shrimp fisheries in the western hemisphere. Perhaps more important is the fact that there is typically a ready market for all bycatch in Southeast Asia for use as human food, fish meal, animal or fish feed or fish sauce. Other than for human food, the bycatch need not be in good condition to be marketed.

All of the above problems occur because shrimp occur in commercially exploitable quantities in Southeast Asia only in habitats which are also the habitats of a large number of fish, and often in which the fish occur predominantly as juveniles.

In fact, the co-occurrence of certain species of shrimp with certain species of fish led to some fish species being referred to as “shrimp indicators”; such species are, for example, Bombay duck (*Harpodon neheros*), croakers (*Fam: Sciaenidae*) and hairtail (*Fam: Trichiuridae*) (Unar and Naamin 1984). Other indicator species are *Leiognathus equulus* and *Leiognathus splendens* (Rapson and McIntosh 1972).

This implies that in Southeast Asia, at least, attempts to “disentangle” the small-scale inshore fisheries from the trawl fisheries by classical legislative or administrative means (exclusive zones, bans on inshore fishing for trawlers, and others) will generally not work because the offshore stocks, defined roughly as those occurring at depths greater than 50 m, simply cannot support commercial trawl fisheries. Figure 5 shows the reason why.

The development of gear capable of selectively catching shrimp or at least increasing the proportion of shrimp in catches was at its onset driven by two considerations, neither of them necessarily related to attempts to reduce fish mortality *per se*. They were:

- to reduce the turtle bycatch,

- to reduce the time spent sorting the shrimp from the overall catch.

The first of these considerations affected mainly the USA segment of the Gulf of Mexico shrimp fishery (Watson and Seidel 1980), and is related to concerns that are external to the fishery itself (i.e., to conserve turtles). The second consideration is often due to economic considerations within the fishery itself and may in the long term be more successful, especially when the reduction of the fish bycatch can be demonstrated to benefit the finfish fisheries. Figure 6 illustrates schematically some technological approaches to reducing shrimp bycatch (see also Sternin and Allsopp 1982).

Within Southeast Asia, research on fish-excluding devices on shrimp trawlers has been conducted mainly in Indonesia, notably in the Arafura Sea. Reports of these experiments have been presented by Sujastani (1984 and Figure 6). Some conclusions from these experiments are:

"The application of [a bycatch excluding device] for shrimping is very useful for fishery management. It conserves fishery resources, saves operational time for sorting and reduces waste. The simultaneous implementation of (a bycatch excluding device and mesh-size regulation for (the) shrimping industry in the Arafura Sea (...) has been an ideal management measure."

The effectiveness of the bycatch excluding device (BED) is reported to stem from the feature that, while reducing the shrimp catch to an insignificant extent, it reduces the fish catch to a large extent, thus markedly
Fig. 5. Depth distribution of some Southeast Asian demersal stocks, as established from trawling surveys using similar gears, or through appropriate conversion factors. Note similarity of the two little-exploited stocks, and the absence of the shallow water "bulge" in the exploited stocks, suggestive of a concentration of trawl effort in shallow waters (graphs based on data in Warfel and Manacop 1950, Pauly et al. 1984, Saeger 1983, Saeger et al. 1976 and Sujastani et al. 1976, respectively).
Fig. 6. Schematic representation of various methods to reduce bycatch of turtles and fish in shrimp trawling.
- reverse barrier prevents turtles from entering the mouth of the net,
- turtle excluder device allows escape of turtles (caught when reverse barrier is not used),
- bycatch excluder device (BED) reduces bycatch of large vertebrates (large fish and turtles caught when reverse barrier is not used).

Adapted from figures in Watson and Seidel (1980, Fig. 2) and Sujastani (1984, Fig. 1).

increasing the shrimp/fish ratio in the catch and hence reducing catch sorting time and hence fishing (Sujastani 1984) and hence costs.

A discussion such as this can deal only superficially with the social, political, economic and related problems caused by or associated with the co-occurrence of shrimp and fish on the richest demersal fishing grounds of Southeast Asia (Fig. 1). However, it should be mentioned here that selectively exploiting shrimp stocks without markedly reducing the associated fish biomass could increase the predator-prey ratio, and hence endanger shrimp fisheries, as suggested in Pauly (1982, 1984) and Pauly and Mathews (1986).

Item II: Socioeconomic disparities as a cause of overfishing.

In most ASEAN countries, fish catches, shrimp catches and shrimp exports have all increased steadily over the last 20 years. Development funding has been used widely for adding new, larger boats, engines and gear to the trawl fishery.

While resources were under-exploited this expansion of effort was beneficial; however, many Southeast Asian trawl fisheries are today over-exploiting the resources. Nevertheless, a lack of alternative employment opportunities has resulted in continuing entry of more fishermen and more gear. Unfortunately, in recent years harvests have
been increasing relatively slowly compared to earlier years and have not kept pace with demand. Kent (1983) has noted that in Thailand, Malaysia and the Philippines, seafood exports have expanded sharply while per capita consumption of seafood has declined. In Malaysia for example, per capita availability of fish declined 30% between 1967 and 1975. An increasing amount of the fish bycatch consists of small fish, often the juveniles of important commercial species (Sinoda et al. 1978), which are used for animal feed (e.g., for cultured catfish in Thailand). The importance of the fish catch in relation to shrimp fisheries will be examined further below.

Although shrimp fisheries utilizing a variety of gears have existed probably for centuries, the introduction to Southeast Asia of other trawls and the larger vessels used to fish them brought about a major transition. To fully understand the impact of this transition it must be kept in mind that numbers of small-scale fishermen utilizing other small gears for fish and shrimp were increasing simultaneously. Trawling has created a "trashfish" industry; as trawling has increased, landings and usage of bycatch have also increased (Sinoda et al. 1978). Boonyubol and Pramokchutima (1984) observed that total catch of food fish has increased only slightly since 1963 in Thailand; however, the "trashfish" catch has increased dramatically as is demonstrated by the increased number of fish meal factories from 6 in 1967 to 95 in 1980. The high value of the shrimp taken by trawlers "subsidizes" the harvesting of fish populations at densities lower than would be economical if only the fish were taken.

The net effect of the situation is the conflict between trawl fishermen and small-scale fishermen using traditional gears (Fig. 7). It is not surprising that there are fewer fish as a result of shrimp trawling, or that small-scale fishermen catch less than previously, or that the small-scale fishermen recognize the trawlers as one of the causes of their problems: Outside of total bans as in Indonesia, efforts to restrict trawling on traditional small-scale fishing ground near shore are largely ineffective because these grounds yield the best shrimp catches. The small-scale fishermen have no tenure rights to the resources or the areas fished and thus tension mounts between the many poor fishermen and small number of well-equipped trawl owners and operators. Traditional fishing and management systems have eroded and few viable alternative systems are in sight, short of radical measures such as the trawling ban implemented in Indonesia (Sardjono 1980).

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*Fig. 7. Schematic representation of the basic cause for conflicts between two types of gears exploiting a common (multispecies) stock with a flat-topped surplus-production curve. Note that environmental and/or economic fluctuations may trigger off outside intervention ("management"), without being the actual reason why one group is "squeezed" by the other—which is actually due to gear(s) 2 being economically more efficient—or more heavily subsidized—than the other. (see Larkin et al. 1984 for a detailed discussion of this model).*
Discussion

The shrimp trawling problem discussed above is an example of the broader, general problem of conflicts between large-scale, expansive gear users and the small-scale, poor fishermen. Management agencies have generally been unable to formulate rational non-contradictory sets of management goals under these circumstances (Lawson 1978 and see contributions in Pauly and Murphy 1982). In fact, they are serving two masters and political expediency dictates that stated management goals appear to serve both the interests of the large-scale commercial fishermen and the poor small-scale fishermen. Thus, management goals often simultaneously include increasing total sustained harvest, increasing exports, increasing employment, improving distribution of benefits among the fishermen and improving the economic efficiency of the industry.

Among the various pressure groups striving to influence management decisions, the group most likely to prevail is that of the wealthy boat owners and exporters of high-priced fishery products (particularly shrimp) especially if the country concerned is “hungry for foreign exchange”. Poor fishermen in Southeast Asia face extreme difficulties in organizing themselves and thus have less opportunity to state their case.

Fishery management schemes which do not address these issues, and especially the crushing poverty experienced by most fishermen and their families in Southeast Asia (as well as in other parts of the developing world), are bound to fail.

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