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Caddy J.F.

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AVAILABILITY OF FAO STOCK ASSESSMENT SOFTWARE AND DATABASES, AND POSSIBLE FUTURE DIRECTIONS

J.F.Caddy
Chief, Marine Resources Service
FAO, Rome

Current software packages available from FAO

A review of the packages currently available, or soon to be available, from FAO, (see attachment), illustrate the recent evolution of the stock assessment software program in FAO and of work carried out with its collaborators, notably ICLARM. The FAO program originated with the first compilation of FORTRAN mainframe programs provided in the Abramson package issued in 1971, and updated in 1871 (Caddy 1981). To some extent also, the search for methods more adapted to data-poor developing fisheries in tropical waters led to the proliferation of, rule-of-thumb or empirical approaches; side-by-side with the mathematically more sophisticated size frequency analysis techniques such as those included in the Abramson package which was designed for main line computers.

Perhaps the first of these 'rule of thumb' approaches was Gulland's now famous equation: MSY = 0.5MB0. Later, these approaches were extended to the estimation of analytic population parameters, and following a landmark meeting in 1981 (see Pauly and Murphy 1982), a wide range of size-based methods were compiled into packages that attempt to analyse population structure and parameters, and a suite of length-based methods began to parallel the age-based methods already established for cold-temperate northern stocks. With the availability of programmable calculators (Pauly 1984), these short-cut methods of rapid assessment began to be assembled into packages, and in the mid to late 1980's were rapidly transferred to programmable microcomputers.

Clearly, as developments in use of microcomputers and their software have proceeded, earlier packages tend to be superceded by later, supposedly more comprehensive, packages, although in may cases the earlier packages remain more suitable, or may be particularly well adapted to specific applications. Examples here are the way that the ELEFAN package of ICLARM, and the LFSA package of FAO have been merged and streamlined in the joint FAO-ICLARM FiSAT package. This last package also covers methods included earlier in ANALEN and ANACO, which are nonetheless, still useful for certain purposes given the specific features they include. This trend is also true to some extent for the BEAM 1 to BEAM 4 packages, where there has been a progressive broadening of the scope of application in the chronological development of the series, but the earlier packages had specific applications in shrimp assessment, that they may still be best adapted to address.

This tendancy to merge a lot of smaller routines or options into a larger package may lead to improved generality, and seems to have originated partly from the search for

universal' solutions, and partially from the desire to support more easily training courses in stock assessment. It should not however discourage the user from picking the better or more easily applied aspects of any one of the smaller, more specifically adapted packages that aim to solve specific problems, such as for example, BEAM 1 and 2 for shrimp stocks, or the CAST package for growth and tag-recapture analysis. Some of the earlier packages (e.g. ANACO, which has a sensitivity analysis routine for VPA/Cohort Analysis); and ANALEN which has routines for fecundity/recruit calculation and multi-gear applications, among others, are still worth examination for serious stock assessment purposes.

A brief comment on the Mediterranean context

The complexity in terms of species and gears, and the local nature of many Mediterranean fisheries has been widely commented on, and these and other features, such as the high price of fish (which discourages port sampling), have been discussed in GFCM meetings and elsewhere, and widely used (for example) as a justification for not applying quota management control methods to most Mediterranean resources.

Without attempting to digress too widely on Mediterranean-specific issues, it may be worth repeating the opinion expressed in Caddy (1993a) that the early age and size at first capture of Mediterranean demersal resources encourages an assessment approach based on prerecruit or recruit surveys, in which yield models are based on vectors of numbers caught by categories of weight at size and age (rather than on fits of von Bertallanffy growth functions used with constant natural death rates, which do not well represent early life history growth and death rates). Such data sets, once available, would be well suited to a Thompson-Bell modelling approach, and would support the optimal closure periods used successfully in several parts of the Mediterranean to be used for protecting new demersal fish prerecruits-of-the-year which have just settled to near-shore shelf areas.

In synthesis, the Mediterranean fishery scientists must take account both of assessment approaches adopted by their EC colleagues in areas such as the North Sea, and adopt (and adapt) those that can be supported by existing data. At the same time, the data-poor nature, and high diversity of resources of the Mediterranean Sea suggests that the simpler methods developed for the tropics can be usefully used here where more complex and data-hungry approaches are not available. This process has already been underway for some time, as evidenced by the reports of the subregional Technical Consultations on Stock Assessment held by the GFCM over the last 14 years or so. Combining the 'North and South technologies' in a satisfactory way in order to arrive at an appropriate mix of methodologies seems to be the main challenge now facing Mediterranean resource assessment workers.

Possible future FAO Software and Database initiatives

At present, the FIRM programme for software development in support of stock assessment is undergoing a pause for reflection, and will perhaps in future experience a change of emphasis. The emphasis to date has been on providing 'Off the shelf' tools for carrying out routine analyses using the various techniques developed during the 1970's and 80's, which by now are available in programmed form, and are now being widely used

even outside the tropics. In the developed fisheries of the northern hemisphere, the new emphasis in practical assessment terms seems to involve large 'combinatorial' models or groups of interlinked models, such as the ADAPT framework, which 'reconcile' a variety of relevant data such as port samples for size/age, catch and effort data and biomass survey data to obtain best estimates of stock parameters, and more explicit evaluation of the risk of the management options resulting from the assessments.

These large combinatorial approaches, and the growing use of 'one-off' simulations of a given fishery, do not seem to be well adapted at this time to an 'off-the-shelf' software series. Certain new developments (especially risk assessment, and combined assessment and management options incorporating them- see e.g. Smith et.al. 1993), will need watching carefully to see if any new syntheses emerge which can be usefully distributed more widely, and here FAO in future will not be placing emphasis on developing packages 'in house' but highlighting new developments originating elsewhere.

We will probably see also the wider use of large models incorporating different aspects of the fishery assessment and management process; perhaps used first of all for training purposes, and several of our current software packages, e.g. SPATIAL and CLIMPROD can be regarded as operating in a training or even as fishery 'games' that illustrate the consequences of different choices of the user.

It may not be too far in the future also that as fishermen take over a bigger role in participatory management, that we will eventually see games programmes incorporating large models of the fishery which can be played by fishermen and processors, (perhaps even over INTERNET?), in order to test out best strategies of management. The extension of database systems linked with GIS technologies, such as the integrated system being developed for West Africa by the University of Warwick, offer possibilities as part of a possible future package aimed at supporting management of EEZ's, which may in part be generalizeable. Such systems may also incorporate monitoring and control of catches and effort, linked to registries of licensed fishing vessels whose individual fishing power may be continually updated through an integrated software?

We may also see 'off the shelf' special purpose packages designed to support, for example, an ITQ management system with reporting, accounting and paperwork/procedural flow charts incorporated. Needless to say, these 'futuristic' (but currently realizeable) packages will not be confined to biological assessment options, but will have to be fully integrated with the flow of socio-economic data that typifies the ongoing operations of a managed fishery.

Given the above comments, the future for the FAO database/software program would appear to involve the following types of initiative:

1) An emphasis on database development (e.g. SPECIESDAB, FISHBASE, POPDYN) is aimed to provide the assessment worker with necessary basic data. It is intended, for example, that POPDYN be used and updated by stock assessment working groups as a record of past work and current management measures, and it is envisaged that institutions that agree to stock data in national or regional versions of these databases will be linked by network, in which data entry will be peripheral; transferred back to FAO at regular intervals to be verified, such that this verified component of the data is 'hard wired' in

read-only mode. More reliance on database approaches is already leading to better estimates (for demersals) of production per shelf area for Mediterranean basins. Hopefully in the future, if effort control becomes a reality in the Mediterranean area, standard effort per shelf area can also be calculated. Availability of such data would make 'Composite Production Models' a real option for dealing with single and multispecies resources.

2) Current initiatives in GFCM suggest that effort control will be the predominant model for management in the Mediterranean; using the initiative provided under the FAO 'Compliance Agreement'. This Agreement has now been adopted internationally, and provides for regularly updated vessel lists for any fishing boat exploiting 'High Seas' areas: (i.e. the Mediterranean beyond Territorial Seas). A more systematic approach to collecting effort and catch data seems fundamental to making much progress in the assessment and evaluation of optimal effort levels however, and the ARTFISH (Stamatopoulos in press) seems to provide an important tool here for evaluating the error or bias embedded in the basic data used later by all of the other methods. At present, ARTFISH handles data from sample-based surveys for artisanal fisheries only, but with little modification, it could become the basis for an effort-based monitoring system in which data by port of origin are 'raised' to stock level. Whatever system is used, it seems essential that the data-gathering and database compilation functions by unit stock not be considered separately from stock assessment methods as has been the case to present!

2) A move has begun in FIRM towards more geographically-based tools and databases, with a strong emphasis on GIS techniques. The SPATIAL package should perhaps also be seen as a parallel initiative in this same direction. This suite of 3 spatial and bioeconomic models incorporating different assumptions, is adapted to fishable stocks regarded as geographically separated and isolated (no migration term included). It illustrates in 'games' form the problems of analysing geographical information, and should be used to illustrate the need to take into account the effects of topography-specific and distance-related effects. It does however illustrate another feature that inevitably comes with an attempt to replace 'dynamic pool' approaches with more realistic models: a considerable proliferation of parameters and possible options that requires the modeller to quickly abandon general-purpose models for those adapted to specific circumstances.

3) Although static, and not adapted to size and age data, the ECOPATH model of ICLARM at the moment appears the only model that can be used to address the multispecies problem in the Mediterranean, given that the MSVPA approach is data-intensive. If in the future, the data problem is solved, (which I doubt will be soon in this region, except perhaps for certain limited areas such as the Gulf of Lions), then assistance from ICES experts can be arranged.

3) Spreadsheets are being more widely used to perform almost any type of assessment, even the most complicated. (A simple SUPERCALC programme for calculating biomass/recruit for different periods of rotation was used in Caddy 1993b). Especially on the West coast of North America, a move appears underway, to extensively use the ever-more powerful tools available through commercially-available spreadsheet programs (e.g. the SOLVER routine in EXCEL, and similar routines which use non-linear search procedures in the latest versions of LOTUS and QUATTROPRO1 - see e.g. Quinn and Szarzi (1994). The draft manual by Hilborn and Punt on fitting (dynamic) production

models is the first example in the FAO Software Series of a spreadsheet-based (EXCEL) program of this type, which should be available shortly also on LOTUS.

4) There has been criticism levelled in the European context at the use of production models for assessment of marine resources: most notably the negative reaction to the simple equilibrium version of the logistic model used to fit to multispecies catches in the Gulf of Lions (FAO 1988). Without defending the above model, (which with all its deficiencies served the purpose of illustrating that effort was excessive and that fleet fishing power needed to be carefully calibrated), the question must be asked if the generality and low data requirements of production models should be abandoned so rapidly at a time when the prospects are for an increased interest in effort control, and when a realistic assessment of the application of age or size-based analytical multispecies models does not encourage the idea that they will be readily extended to all Mediterranean fisheries.

In connection with the remarks made under 4) we may note that many models currently used make explicit or implicit use of the concept of fishery equilibrium; either explicitly in the analysis, or when translating their results into advice to management. We may question whether these models are totally appropriate to the Mediterranean where decadal scale fluctuations in production have been noted, and note that the Hilborn and Punt package, soon to be issued by FAO, does not make this assumption. In fact, (as with Hilborn and Waters 1992), it strongly recommends against use of equilibrium versions of production models.

5) Models that integrate management and assessment, and provide an evaluation of risk of the different options may emerge in a suitable form to provide a standard package, and will probably need to be reformulated in bioeconomic terms. Risk-averse approaches have been referred to as 'Precautionary' (see Garcia 1994), and precautionary management' approaches seem likely to be strongly recommended by the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks now underway in New York. One other approach to assuring conservative management approaches is to use reference points that correspond to fishing rates below those giving MSY, and to set upper limits to exploitation rate or lower limits to spawning biomass, using the so-called 'Limit Reference Point' approach (FAO 1994).

6) Special purpose statistical and mathematical packages (e.g. STATISTICA, MAPLE, MATHEMATICA) can now be used for a versatile range of problem-solving, fitting and simple modelling purposes, and are becoming widely used as such, (and of course don't require FAO distribution). The statistical packages incorporate versatile fitting and time series analysis routines which have the advantage that they offer a flexible approach to assessment which (unlike some off the shelf packages) requires the user to follow the standard scientific approach of creating hypotheses for testing, with a requirement to master and justify the theoretical basis of the analysis. Perhaps more importantly, the worker is required to state explicitly the hypotheses tested, and the assumptions that underlie it, which in itself provides a useful training process.

An example of the use of the SOLVER routine is incorporated into the Hilborn and Punt package: a simpler version is provided with the attached EXCEL spreadsheet which

shows how this routine can be applied and used to optimise (in this case) the fishing mortality rate which results in the maximum yield per recruit with a Thompson-Bell yield per recruit calculation.

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THOMBEL1.XLS

Thompson-Bell Yield per recruit:

(Using the SOLVER routine, maximize the value of cell g16 by changing cell C5)

	M=	0.3					
	F=	0.631261					
Interval-yr	Duration	Mean wt.	Survivors	No. death	Catch No.	Yield wt	
			100000				
0-0.5	0.50	2.4	62773.91	37226.09	25233.94	60561.46	
0.5-1.0	0.50	4	39405.63	23368.27	15840.33	63361.33	
1.0-1.5	0.50	5.7	24736.45	14669.18	9943.595	56678.49	
1.5-2.0	0.50	8.4	15528.04	9208.416	6241.983	52432.65	
2.0-3.0	1.00	9.5	6118.922	9409.117	6378.029	60591.28	
3.0-4.0	1.00	12.4	2411.2	3707.722	2513.303	31164.95	
4.0-5.0	1.00	14.3	950.1486	1461.051	990.3828	14162.47	
			TOTAL YIELD PER RECRUIT:			338952.6