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CHALLENGES FOR CROAIAN MARICULTURE IN THE 21ST CENTURY

HRVATSKA MARIKULTURA – IZAZOVI U 21. STOLJEĆU

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Abstract

Croatia's published mariculture goal for the first decade of the 21st Century calls for increasing annual production of fish from ca. 2.700 MT to 10.000 MT; and of shellfish from ca 4.500 MT to 20.000 MT. Implementing this first phase of development will require up to:

- *44 million 2- to 5-g fingerlings/yr*
- *95 million oyster spat/yr*
- *28.000 MT/yr of formulated fish feed*
- *1.600 trained full-time equivalent employees for fish and shellfish culture*
- *500 ha of commercial concessions in territorial waters for fish culture*
- *DEM 34 million/yr of production incentives, at current rates*
- *DEM 90 million in total investment for fish grow-out*

Gross annual revenue from this level of production could reach DEM 75 million for fish and DEM 62 million for shellfish.

The proposed production increases must be accompanied by parallel development of conventional seafood marketing channels, especially at the wholesale level. As in other countries, this will create significant employment and value in upstream and downstream service sectors, particularly in communities along Croatia's coast and on her islands.

Planning at both the enterprise and governmental levels must take into account the price softening that will accompany projected increases in seafood production throughout the Mediterranean. This, along with Croatia's accession to the World Trade Organization, will challenge Croatian mariculture firms to operate as efficiently as the most efficient of their international competitors.

Mariculture has the ability — perhaps even a responsibility — to enhance tourists' holiday experiences and contribute to creating a positive image of Croatia by providing a dependable supply of high-quality, reasonably priced seafood. Of utmost importance, this must be accomplished in a way that inflicts no damage on the environmental assets that are the foundation of Croatia's tourism industry — a rapidly growing sector that now accounts for over 12% of the GNP and employs about 180.000. Promoting constructive communication between professional tourism, aquaculture, and environmental organizations will encourage the sort of development that benefits all interests, and the nation as a whole.

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Challenges facing Croatia are homologous to those confronting other Eastern Adriatic transition economies. Regional cooperation in at least the fields of technical training and environmental protection will benefit all participants.

A National Mariculture Task Force, composed of expertise drawn from a variety of disciplines, can contribute the coordination and comprehensive analyses needed to chart a rational course for Croatian mariculture. Its recurring duties would include regularly reviewing the industry's progress and updating national mariculture policy, as the need may arise.

To avoid wasting time and limited resources repeating mistakes already made — and corrected — by others, the initial report of the Task Force should identify a successful European aquaculture development model on which essential parts of Croatian development might be based. Of several likely candidates, Ireland, for a number of reasons, represents an excellent choice.

Keywords: aquaculture, mariculture, economic development

Apstrakt

Cilj hrvatske marikulture u prvom desetljeću 21. stoljeća je porast godišnje proizvodnje ribe s cca. 2 700 t na cca. 10 000 t, a školjkaša s 4500 t na 20 000 t.

Ostvarivanje prvog razdoblja razvoja zahtijevat će do:

- *44 milijuna riblje mlađi (2-5 g)*
- *95 milijuna mlađi kamenica godišnje*
- *28 000 t riblje hrane godišnje*
- *1 600 zaposlenika izobraženih za uzgoj ribe i školjkaša*
- *500 ha koncesija za uzgoj ribe u teritorijalnim vodama*
- *34 milijuna DM za poticaje godišnje*
- *ukupno 95 milijuna DM za rast proizvodnje.*

Ovolika proizvodnja može dostići ukupni godišnji bruto prihod od 75 milijuna DM za ribu i 62 milijuna DM za školjkaše. Predloženi rast proizvodnje mora slijediti i razvoj tržišta morske hrane, osobito sustav prodaje na veliko. Kao i u drugim državama, takav rast će omogućiti značajno zapošljavanje i korist uslužnim djelatnostima, posebice u mjestima duž hrvatskog primorja i na otocima.

Planiranje porasta proizvodnje, kako u tvrtkama koje se time bave, tako i na razini Vlade, mora uzeti u obzir pad cijena koji će pratiti predviđeni porast proizvodnje morske hrane na cijelom Sredozemlju. To će, kao i pridruživanje Republike Hrvatske Svjetskoj trgovačkoj organizaciji predstavljati veliki izazov hrvatskim tvrtkama koje se bave marikulturom.

Marikultura ima mogućnost, pa čak i odgovornost u proširivanju iskustava turista, kao u poboljšavanju imidža Hrvatske osiguravanjem pouzdanog izvora visokokvalitetne hrane povoljne cijene.

Od najvećeg je značaja da pri porastu proizvodnje ne dođe do narušavanja prirodne ravnoteže okoliša koji predstavlja temelj hrvatskog turističkog proizvoda koji sudjeluje s preko 12% u bruto nacionalnom proizvodu i zapošljava oko 180 000 ljudi. Razvijanjem konstruktivne komunikacije između turističkih djelatnika, uzgajivača i organizacija za zaštitu okoliša, potaknut će se razvoj koji bi zadovoljio sve interese.

Izazovi s kojima se suočava Hrvatska odgovaraju izazovima ostalih istočnojadranskih tranzicijskih gospodarstava. Regionalna suradnja na području tehničke izobrazbe i zaštite okoliša nužna je za zadovoljavanje svih sudionika.

Osnivanje Nacionalnog vijeća za marikulturu koje bi bilo sastavljeno od stručnjaka iz različitih područja, moglo bi pridonijeti koordinaciji i opsežnoj analizi potrebnoj za razumno usmjeravanje razvoja hrvatske marikulture, a pridonijelo bi i redovitom ocjenjivanju napretka i u skladu s tim korekcije marikulturne politike ovisno o potrebama.

Kako bi se izbjegao gubitak vremena i ograničavanje izvora ponavljanjem pogrešaka koje su već napravili i ispravili drugi, uvodno izvješće Vijeća trebalo bi prepoznati uspješne modele razvoja akvakulture u Europi na čijim bi se primjerima mogao temeljiti razvoj hrvatske akvakulture.

Od nekoliko međusobno sličnih kandidata, primjer Irske predstavlja izvrstan izbor iz više razloga.

Ključne riječi: akvakultura, marikultura, gospodarski razvoj

Introduction

Uvod

Croatian entrepreneurs were among the first in Europe to undertake commercial culture of marine fish in the Mediterranean. During the early 1980s two large production sites for seabass and sea bream, each with hatchery and grow-out facilities, were established: Cenmar started operations near Zadar, along the Central Adriatic coast; and Marimirna began in Rovinj, on the Istrian Peninsula (Filić, 1984).

The research community actively supported commercial development by addressing improvements in production techniques for these species (*e.g.*, Katavić, 1984, 1986; Katavić *et al.*, 1989) and by evaluating promising candidate species, including *Dentex dentex* (Glamuzina *et al.*, 1989) and several species of bream (Jug Dujaković and Glamuzina, 1988). Another important body of research focused on developing the potential of salmon culture (*e.g.*, Teskeredžić, 1981; Teskeredžić and Teskeredžić, 1990).

Despite this head-start laying the foundation for a strong commercial sector, twenty years later finds

the Republic of Croatia with a small, stagnant industry that contributes only about 3% to total Mediterranean cultured fish production.

The history of shellfish culture in the area is much older (Benović, 1997, 2000). Nevertheless, while present commercial operations produce oysters and mussels of excellent quality, Croatian companies have yet to advance beyond artisanal cultivation techniques.

The inchoate state of Croatian aquaculture is even more dramatically revealed when viewed against the backdrop of world aquaculture: The global industry was valued at more than DEM 100.000 million in 1997 and since has been growing at a rate of nearly 15% per year (Pedini and Shehadeh 1997; FAO 1999). Such rapid growth is owed to the combined effects of increasing world population, decreasing catch from traditional fisheries (Caddy and Griffiths, 1995), and evolving consumer preferences in developed countries (Tacon, 1997; Lem and Shehadeh, 1997). These factors are expected to continue to drive growth in the years ahead.

As part of its bid to participate in this economic success, the Croatian government has promulgated production goals for its mariculture sector for the first decade of the 21st Century (Katavić, 1999; Katavić *et al.*, 2001). The objectives are to increase annual production of cultured fish from *ca.* 2.700 MT to 10.000 MT; and of cultured shellfish from *ca* 4.500 MT to 20.000 MT. The former target is similar to current fish production in Spain; the latter would position Croatia near the level of current Greek shellfish production.

Though this still would place the country far below the Mediterranean leaders — Greece produced over 55.000 MT of marine fish in 2000, and both France and Spain produce over 200.000 MT of shellfish annually — attaining these goals would mark a significant step in the revitalization of Croatian mariculture.

To steer the country on a course that leads to a profitable mariculture industry, Croatian entrepreneurial, research, and governmental communities will have to join forces to overcome a diverse array of challenges. Understanding the course that must be followed begins with a brief summary of the present state of mariculture in Croatia.

Present national context

Sadašnja situacija

The following summary is drawn principally from the reviews Katavić (1999), Benović (1997, 2000), Kučić (2000), and Katavić and Vodopija (2001), and from the especially comprehensive treatment of Dujmušić (2000).

The species

Seabass (*Dicentrarchus labrax*) and sea bream (*Sparus aurata*)—as throughout the Mediterranean—are the dominant cultured fish species in Croatia. Owing to Croatia's marine ecological setting, seabass is deemed the more suitable of the two (Katavić and Vodopija, 2001). Additionally, Bluefin tuna (*Thunnus thynnus*) captured in the wild are reared in the Central Adriatic; and there is a very small production of several fish species with future commercial promise.

The two shellfish species cultivated in Croatia are the European Flat Oyster, *Ostrea edulis*, and the Black Mussel *Mytilus galloprovincialis*. About sixteen other mollusk species are harvested from natural shellfish beds, but none of these yet is under cultivation (Benović, 1997).

The grow-out sector

Thirty-one companies culture seabass and/or sea bream along the Croatian Adriatic and seven raise wild-caught tuna. (Harvest of the latter is exported exclusively to Japan.)

Those who know Croatian seafood data best admonish that official production statistics are inaccurate, owing both to inadequate resources to implement a proper collection program and intentional under-reporting by the industry. Dujmušić (2000), for example, suggests that reported fisheries data may be as much as 20% - 30% too low. The same situation likely applies to most official mariculture data.

With this in mind, Katavić and Vodopija (2001) used records of domestic and imported fingerlings purchased in 1999 to derive what may be a more reliable production estimate for the 2000 – 2001 growing season. Their value, 2.700 MT of seabass and sea bream, is 40% - 50% higher than those reported for each of the two previous years.

Based on their analysis, five firms comprise over 60% of production; the largest of these operates two sites and accounts for an estimated 800 MT/yr. Much smaller 'family' farms with yields generally from 30 - 50 MT/yr make up the remainder.

Tuna production, according to export data, has increased dramatically from 39 MT in 1996 to 1.100 MT in 2000.

Only three large companies are involved in shellfish production, but at least 100 small family operations, situated mainly around the Bay of Mali Ston, also are active in the sector. Official statistics again are unreliable, but mussel production is on the order of 3.000 MT/yr, and oyster production is perhaps one-half of this (Benović, 1997). Total shellfish production thus is approximately 4.500 MT/yr.

Seed & feed

There currently is insufficient hatchery capacity in Croatia to support the demands of the fish grow-out sector. No more than 3,5 million fingerlings were produced for the 2000 stocking season. The shortfall, approximately 8 million fingerlings, was

made up by imports, mainly from two hatcheries in Sicily.

Regarding feed, a plant was built near Zadar in the 1980s with the intention of producing marine fish feed, but this plan never was realized. There is, however, an operating feed mill located inland, in Hrvatski Leskovac (near Zagreb), that produces formulated feed for freshwater trout and carp (Dujmušić, 2000). Production of marine fish feed has been planned, but not yet implemented.

As a result — as is the case with fingerlings — feed also is imported from neighboring EU countries, mainly Italy, France, Denmark, and Germany (Katavić and Vodopija, 2001). Croatian fish farmers use well-known European brands such as BIOMAR, DIBAQ, and UNIFISH.

All shellfish seedstock now derives exclusively from naturally-occurring spat collected at the appropriate time of the year. Also, owing to the nature of the production techniques employed, formulated feed is not an issue in shellfish grow-out.

Direct labor

In lieu of reliable data, direct labor for the fish-culture sector may be estimated by dividing estimated production, 2.700 MT, by a labor production efficiency. Anagnopoulos and Karagiannakos (2000) report that the Greek industry evolved from 10 MT/man in 1990 to an average of 27 MT/man in 1999. Typical values for salmon farms in Ireland range from 30 – 40 MT/man; the more efficient farms achieve 60 MT/man (Liam O'Shea, Deenish Island Salmon Farm, *pers. comm.*); and some highly automated operations in Norway greatly exceed this value, reaching over 100 MT/man.

Using a moderate value of 20 and a low value of 12 MT/man, the current cage-culture labor force for seabass and sea bream in Croatia would be between 135 and 235. For the tuna sector, the range would be 55 - 92.

Regarding shellfish, Benović (1997) reports that Croatia's three commercial firms have only 60 employees; but the more than 100 family shellfish farms—composed of a mixture of full-time, part-time, and casual workers—make it difficult to estimate accurately the combined equivalent full-time work force.

The average labor ratio for the Irish shellfish-culture industry is about 27 MT/man (data from Anonymous, 2001 and J. Clarke, *pers. comm.*). This figure — encompassing culture activities ranging from bottom mussels (67 MT/man) through labor-intensive scallops (1,2 MT/man)—is calculated in terms of 'full-time equivalent' employees: Part-time employees are figured as one-half, and casual employees as one-sixth, of a full-time employee.

Owing to the predominance of traditional family farms in Croatia, the average efficiency cannot be applied confidently. In the absence of other data, however, a useful range may be constructed using the Irish rope-mussel culture ratio, 30 employees/MT, and the *Crassostrea gigas* oyster value, about 18 MT/man. Current Croatian production of 4.500 MT/yr thus would require a labor force of 150 – 250 full-time equivalent employees.

Summary

Key results developed above are summarized in the following table. For comparison, data from two successful European countries — one smaller than Croatia (Ireland) and the Mediterranean leader in cultured fish production (Greece) — are included.

This lays the groundwork for evaluating the resources that must be marshaled to meet Croatia's production targets.

EI Quick-o Country Comparison	CROATIA (2000)		IRELAND (1999)		GREECE (2000)
Population (millions)	**4,5**		**3,6**		**11,6**
Main Species	**seabass & sea bream**	**mussels & *O. edulis***	**salmon**	**mussels & *C. gigas***	**seabass & sea bream**
Number of Farms	**31**	***ca.* 100**	**63**	**489**	**247**
Production (MT/yr)	**2.700**	**4.500**	**18.076**	**23.210**	**56.000**
Value (million DEM)	**??**		**132**		**517**
Direct Labor	**190 - 330**	**150 – 250**	**659**	**876**	***ca.* 2.100**
source(s):	*see* references herein		B.I.M., F.E.A.P.		F.E.A.P.

Estimated requirements

Pretpostavke

Several key requirements that are directly related to achieving Croatia's production goals may be estimated readily. These are tabulated below, with separate columns for fish and shellfish. Investment and revenue projections also are included. Other important issues not as amenable to quantification are considered in the accompanying discussion.

PROJECTED IMPLICATIONS OF CROATIA'S TEN-YEAR MARICULTURE GOALS		
	Fish (10.000 MT/yr)	Shellfish (20.000 MT/yr)
Seed Stock	34 - 44 million/yr (2- to 5-g) *or* 27 - 35 million/yr (30-g)	75 - 95 million/yr (oyster) *and* 175 - 215 million/yr (other)
Feed	22.000 - 28.000 MT/yr	*N/A*
Direct Labor	500 to 800	800
Seabed Area	350 to 500 ha	150 to 250 ha
Government Incentives	DEM 13 - 18 million/yr	DEM 13 - 16 million/yr
Total Investment	DEM 80 – 90 million	DEM ?? million
Gross Revenue	DEM 75 million/yr	DEM 52 to 62 million/yr

Direct production needs

Izravne potrebe proizvodnje

Seed

Fingerlings. Calculating the number of fingerlings required to support production of 10.000 MT of fish is straight-forward. If the target market size is 350-g, about 29 million fish will have to be harvested annually. Reasonable upper and lower survival rates, respectively, of 85% - 65% imply an annual need of 34 - 44 million fingerlings.

Existing Croatian producers stock smaller (2-g to 5-g) fingerlings. The more mature Spanish industry is moving toward larger, nursed fingerlings of up to 30-g each. (Stocking larger juveniles has been a common trend in the evolution of other successful aquaculture sectors, such as the prawn- and salmon-farming industries.) Producers using this head-started seedstock enjoy a competitive advantage: The cage grow-out period is reduced by several months, thereby yielding up to a 25% increase in the use of capital equipment (R. Barrera, Valenciana de Acuicultura, *pers. comm.*).

As suggested by Katavić and Vodopija (2001), fingerling requirements could be met by 3 or 4 modern hatcheries, each of which produced 12 – 15 million fingerlings annually. Advancing these smaller animals to 30-g juveniles would require an extra 70 – 90 days in nursery facilities, part of the infrastructure of which could be shared with the parent hatchery.

Spat. A very rough estimate of the amount of shellfish seed needed to reach the target may be made using the figure of approximately 15.000 spat/MT. Assuming only oyster spat will be produced initially, neglecting collection of natural spat, and further assuming that oysters (65 – 80 g/each) will make up 30% of production, an annual total of 75 to 95 million spat would be required to meet the oyster target.

Extending the same reasoning to the remaining fraction of the 20.000 MT/yr target, an additional 175 to 215 million spat of other species—mainly mussels—would be required annually.

Regardless of the species mix and the accuracy of these order-of-magnitude calculations, continued dependence on the vagaries in timing and abundance of natural spat will not permit the industry to attain efficiently—and to advance beyond—the national goal. Instead, a sufficient number of modern shellfish hatcheries will have to be established to insure the reliable supply of high-quality seed needed to fuel this level of development. At least one major facility should be sited in close proximity to the Bay of Mali Ston shellfish fields, Croatia's premier oyster and mussel culture area.

Feed

Because feed expense usually is the largest line-item in the production budget of a fish farm, implementing efficient feed management is the surest means of reducing the cost of production. It also is central to practicing sustainable aquaculture: Apart from therapeutic agents, feed is the ultimate source of the dissolved and particulate pollutants associated with cage-culture operations.

Feed requirements are estimated simply by multiplying the target production, 10.000 MT, by 2,2 and 2,8, the range of Feed Conversion Ratios (FCRs) typical of many un-automated commercial farms currently operating in the Mediterranean. The less desirable higher value was the average for the Greek industry in the early 1990s; their industry average presently is about 2,1 (Anagnopoulos and Karagiannakos, 2000).

The projected range of feed needed to meet Croatia's fish production goal thus runs from 22.000 to 28.000 MT/yr.

(As noted earlier, formulated feed is not an issue in shellfish grow-out.)

Direct labor

Direct labor required to support target fish production is estimated according to the approach outlined earlier. Using a reasonable range of labor efficiencies, culture of 10.000 MT/yr will require 500 – 800 full-time equivalent employees.

Again using values introduced above, and assuming that the target production mix will include 70% mussels and 30% oysters, 20.000 MT of shellfish per year would require a work force on the order of 800 full-time equivalents.

Indirect support needs

Neizravne potrebe proizvodnje

Concession area

The area of seabed needed to implement a given level of production depends strongly on a number of site-specific engineering and operational parameters. Wave climate, water depth, cage design, and mooring geometry are prominent engineering concerns; of the latter, the variety of routine procedures that determines production efficiency, one important metric of which is biomass density. Broadly, well-managed installations located in relatively shallow, protected sites occupy less seabed than those moored offshore in deep water and exposed, at least periodically, to the full brunt of a storm sea.

Regarding mooring design, conventional moorings are deployed in geometric patterns with a scope (the ratio of the lateral extension of a mooring leg to water depth) usually from 4 to 5. For a constant scope, the area enclosed by a mooring increases as a quadratic function of the water depth. Thus, the seabed area needed to secure a cage system may exceed greatly the combined surface area exposed by the individual cages.

This point is illustrated by a simple example: A single 20-m diameter cage has a surface area of 314 m^2. In 15 m of water and with a modest scope of 3,5, its mooring system would occupy about 0,8 ha of seabed—about twenty times greater than the surface area of the cage itself. The same cage installed at a 25-m-deep site would require 1,9 ha. If the mean production of this cage were 24 MT/crop, the production density in the first case would be 30 MT/ha, and only about 12,5 MT/ha at the deeper location. Combining multiple cages in an array enhances these values, but they still are on the order of only one-tenth of the capacity realized with the much larger Bridgestone octagonal cages common in salmon culture.

(Tension-leg systems (Lisac, 2000), on the other hand, feature vertical moorings—*i.e.*, the scope theoretically is zero. Thus, the area of seabed occupied by the system effectively is equal to the cage surface area. Such systems are in production in the Mediterranean, but as yet are not common.)

Estimates made herein are based on practical examples of conventional moorings suggested by knowledgeable industry sources cited in the ***Acknowledgments***. Without describing all of the details involved, the lower limit derives from the assumption of a site with a rectangular array of twelve 25-m-diameter cages, an average of seven of which is harvested every year, that produces 400 MT/yr. Water depth is 25 m and the scope is 4. This arrangement requires about 13 ha of seabed which, when scaled linearly to 10.000 MT, implies a requirement for about 350 seabed hectares.

The upper limit was arrived at by assuming conditions more typical of an open-ocean site: A rectangular array of four 19-diameter cages producing 120 MT/yr and moored in 30 m of water with a scope of 4. Such a facility requires 11 ha of seabed, which scales to about 910 ha to produce 10.000 MT of fish.

With nearshore installations likely to predominate over the next decade, a range of 350 – 500 ha to meet target fish production may be reasonable for initial planning purposes.

Shellfish grow-out—unlike fish culture—must rely exclusively on a site's natural productivity to supply the nutritional requirements that support good growth. Carrying capacity of a site thus depends partly on the rate at which it is exposed to suspended labile organic matter of suitable nutritional value; this is a function of the rates of net planktonic production, current speed, and the configuration of the culture structures. Very generally, for a given design, less area will be required for an installation at an inshore site with good circulation than at a less-productive offshore site.

Data needed to perform an accurate calculation for the present case are not available. However, informal analysis by Croatian researchers with practical experience in the field suggests that a total of 150 – 250 ha would suffice to reach the 20.000 MT/yr national target. The Bay of Mali Ston alone comprises 7.500 ha. By comparison, open-ocean mussel culture off the coast of Languedoc-Roussillon is practiced in 4.200 ha and yields 8.000 to 10.000 MT/yr (Danioux *et al.*, 2000).

Government incentives

Državni poticaji

Government production incentives currently granted to fish farmers are Kn 5/kg (DEM 1,3/kg) for producers operating from bases on the Croatian mainland; and Kn 7/kg (DEM 1,8/kg) for those based on the islands (Anonymous, 1999). A per-fingerling

incentive of Kn 0,35 (DEM 0,09) is provided for hatchery operators.

Shellfish incentives are 1 Kn/kg (DEM 0,26/kg) for mussels and 0,5 Kn per oyster (DEM 0,13/piece).

These rates have been applied to the national production targets, and the results translated into Deutschmarks at an exchange rate of DEM 0,26 per Kuna, to project a separate range of potential government production incentives for both fish and shellfish.

For fish, the broadest range is constructed by assuming complete mainland-based development for the lower end, and complete island-based development for the upper limit. This simple approach yields DEM 13 - 18 million/yr.

For shellfish, a production mix of 70% mussels and 30% oysters is assumed. The resulting oyster harvest—6.000 MT/yr—is converted to lower and upper limits of pieces/yr using mean mass values of 80 g/ind and 65 g/ind, respectively. The range of potential incentives that results is nearly identical to that of the fish sector: DEM 13 – 16 million/yr.

To put these figures in context, in 1999 the Croatian government paid out Kn 11.750.000 (*ca.* DEM 3,0 million) in incentives for marine aquaculture. (This was, by the way, little more than 1% of the total incentives and subsidies transferred to all agricultural sectors in 1999 (USDA, 2000)).

Incentives actually paid to culturists are lower than the amount that would be expected based on reasonable estimates of production made by those with first-hand knowledge of the sector. The implication is that a significant portion of both fish and shellfish production is sold ex-farm without being officially reported.

The profitability of a number of companies, nevertheless, appears to depend critically on receiving incentive payments. The impact that Croatia's membership in the World Trade Organization will have on these firms is mentioned below.

Will that be cash or charge?

Prihod ili opterećenje?

Accurately estimating the total investment needed to produce 10.000 MT of fish is made difficult by the sensitivity of this calculation on such key factors as the location of the cultivation sites (especially whether placed inshore or offshore), the production technology employed, and the details of the financing plan, to name but three.

A rough estimate nevertheless can be made by drawing on the experiences of other Mediterranean producers. For example, the average capital investment for a farm in Turkey's cage-culture sector typically is from about DEM 4.700 to DEM 5.500 per MT (Gözçözoglu, *pers. comm.*). This may be considered a reasonable range for nearshore development.

Deeper, exposed sites, on the other hand, demand more robust equipment and mooring gear, as well as larger and more durable work boats. Lisac and Muir's (2000) analysis of several actual installations suggests a typical capital investment for working offshore projects on the order of DEM 12.500 per MT.

Assuming that 2.700 MT/yr of fish will continue to be produced with existing equipment, an additional 7.300 MT/yr will be needed to achieve the Croatian target. If this were realized through inshore development exclusively, a capital investment of DEM 35 million to DEM 40 million would be required. If, on the other hand, this were realized exclusively through open-ocean installations, capital investment would be on the order of DEM 92 million.

Despite advantages promised by the more expensive open-ocean alternative—lower production expenses, enhanced fish health, and especially elimination of potential conflicts with principal tourism venues (*e.g.*, Muir and Basurco, 2000)—most development in the next decade likely will be confined to relatively protected sites closer to Croatia's coast. Thus, with 90% nearshore and 10% offshore development, the estimated range of capital investment is DEM 40 million – DEM 45 million.

In addition to the capital investment, working capital—the funds needed to support operations through the point at which revenues at least cover expenses—must be raised. This is a substantial part of the total investment, owing partly to the relatively long production cycle involved—on the order of 18 months for 300- to 350-g fish under Croatian conditions, compared with, say, tropical penaeid shrimp, a crop of which may take only six months. Working capital requirements, in fact, will be at least as large as the capital investment.

Thus, without factoring in inflation, this simple analysis suggests that the total investment needed to finance the grow-out sector required to achieve Croatia's fish-culture target is on the order of DEM 80 million – DEM 90 million.

This estimate takes into account neither other core sector components, such as hatcheries and feed mills; nor investment in essential support services, such as processing, distribution, monitoring, and training. (Of note, the hatchery capacity needed to support the grow-out target would require an investment of at least another DEM 15 million – DEM 20 million.)

It is particularly difficult to provide an accurate estimate of the investment required to achieve the shellfish target, as a significant fraction of current production derives from small family operations that employ artisanal cultivation techniques. A more thorough analysis than can be performed here is called for to determine whether the national goal can be reached simply by expanding use of this sort of production; or whether more modern procedures must be introduced.

Gross revenue

Bruto prihod

Annual gross revenue naturally depends on prevailing market prices for the products in question. Prices vary with product quality, size, season, and market segment. Responsible long-term planning also must incorporate the impact of changes in product supply and demand on price. This issue is of particular importance in the present case, but available information does not permit confident analysis of this effect. Thus, representative prices drawn from contemporary markets have been used to arrive at rough estimates of the revenue that would result from achieving the production targets.

Spring 2001 prices for cultured seabass (fresh, whole) between 300 – 450 g were DEM 8,27/kg and DEM 8,70/kg, respectively, in Italy and Germany—two likely markets for Croatian products. Seabream of the same classification and in the same markets sold for DEM 7,83/kg and DEM 8,25/kg, respectively.

For the same markets, seabass prices for the 200- to 300-g size class were DEM 7,64/kg and DEM 8,20/kg; and seabream prices were DEM 7,44/kg and DEM 7,92/kg, respectively.

The smaller cultured seabass (150- to 200-g) and sea bream (120- to 200-g) offered in the Croatian domestic market typically have fetched relatively higher prices, averaging about 33 Kn/kg (DEM 8,60/kg) throughout 2000.

Increases in supply have driven down both foreign and domestic prices significantly over the past decade. Domestic prices may be expected to fall further when import barriers are removed, most likely within the next ten years. The lower Italian prices listed above thus would seem more appropriate in making revenue projections, especially after applying a rather arbitrary 8% discount. Assuming, then, that the 10.000 MT/yr target is composed of 70% seabass and 30% sea bream, each averaging about 350 g each at harvest, annual gross revenue would be on the order of DEM 75 million.

The same general market parameters must be considered when projecting revenue generated from proposed shellfish production. First considering oysters, prices are much higher in the Croatian market than internationally, but, as is the case with fish, these may be expected to decrease as import barriers are eliminated. Assuming oysters comprise 30% (6.000 MT/yr) of the target; that individuals range in size from 65 g to 80 g each; and using an ex-farm sales price of DEM 0,52 each, annual revenue from oyster production may fall in the range of DEM 39 million to DEM 48 million.

If the remaining fraction is made up of mussels, and if these are sold at DEM 925/MT to DEM 1.000/MT, gross annual revenue will be on the order of DEM 13 million to DEM 14 million.

The total estimated revenue from shellfish culture thus lies in the range DEM 52 million/yr to DEM 62 million/yr.

Related issues

A number of other issues enters into designing a rational plan to meet Croatia's goals. Their comprehensive analysis is not attempted here; but, for the sake of encouraging their discussion, three are mentioned next.

Upstream & downstream services

Popratne usluge

Seafood producers may be visualized as occupying the center of a market chain. Upstream businesses support core production activities by supplying feed, providing and maintaining production equipment, and performing essential technical and administrative services on a contract basis. The downstream sector includes firms involved in storage, processing, packaging, and distribution of fish and shellfish. The role of the government is to provide certain technical, educational, and promotional services, as well to formulate and implement policies that support industry development.

A key downstream component in all modern seafood markets is the wholesale level. Wholesalers provide the main interface between producers and consumers, whether these are true end-users or retailers. Italy's well-developed market has over 50 seafood wholesalers; Croatia currently has none. Yet, if the production sector meets the national goals, and if their product is to be marketed in an efficient, profitable fashion, a modern wholesale sector must emerge in Croatia.

How many upstream and downstream jobs might be created in a developed Croatian seafood industry? Again, the experiences of other industries provide suggestions. In Texas, support businesses account for almost two-thirds of employment in the entire industry (Haby *et al.*, 1993). In the fully-integrated Norwegian aquaculture industry in 1995, the 3.734-strong production labor force supported over 17.500 jobs in related non-production businesses, or over 80% of all employment. The Irish aquaculture industry creates about 1.26 upstream service jobs for each production job (Anonymous, 2001); further, industry-wide, there are about two processing jobs for each production job. Thus, about 75% of all jobs are in non-production activities.

With these figures as rough guides, and using the lower total direct employment (1.300) from projections made earlier, Croatia might expect 3.200 positions to be created in support of its targeted fish and shellfish production.

Deeper analysis would be required to assess the value injected into the Croatian economy by these support activities. It may be more significant than suggested by the modest employment figures,

however, as its impact would be concentrated mainly in communities along the Adriatic coastal strip and on Croatia's inhabited islands. Indeed, in the cases cited above, the seafood industry often is the largest employer and greatest source of taxes in many coastal counties.

Technical training
Tehnička izobrazba

Commercial mariculture is not a hobby; it is an industrial activity that, when practiced successfully, is supported by a cadre of professionals. Not only will a farm operated by casual, untrained labor likely fail, especially in an increasingly competitive environment; but the inherently dangerous nature of the daily routine at exposed cage-culture sites has led to serious injuries even within seasoned crews of cage-hands.

This does not mean that a production site should be populated only by people with advanced degrees and seaman's cards; it does mean that a certain amount of certified training in a well-defined set of applicable skills will promote employee safety, product quality, and a firm's profitability. A recent report from the Irish government on training and employment in their successful seafood industry (Anonymous, 2001)—of which mariculture is a very important component—would be an excellent blueprint from which a country such as Croatia might devise its own training plan.

Applied research
Primijenjena istraživanja

Attaining and protecting the competitive edge depends, in part, on developing—and quickly applying—advances in all aspects of the culture process, including nutrition and feeding, disease prevention and treatment, evaluation of new species and new processing techniques, and engineering design. Activities of this sort clearly are the responsibility of the country's marine science community.

To accomplish this task requires that available scientific expertise be encouraged to undertake top-notch applied research—likely in collaboration with investigators in countries with strong aquaculture sectors—on problems identified as critical to the success of the national industry. Further, to insure a supply of the highly-trained researchers that will be needed in the future, a rigorous curriculum leading to an advanced degree in applied aquaculture should be instituted.

Transferring technical advances to the commercial sector is the province of trained field agents in a government-operated mariculture extension service, perhaps modeled on that found in the United States.

The competitive challenge
Izazov tržišnog natjecanja

The most pressing challenge confronting Croatia's mariculture sector is the need to compete against top producers in countries with mature industries. This competition is unavoidable: It will be forced both by the decrease in market price that must follow projected increases in seafood production and by Croatia's accession to the World Trade Organization (WTO).

Price trends

The consistent increase of cultured fish production in the Mediterranean over the past decade has been accompanied by an inevitable decrease in the sales prices of sea bass and seabream. For example, the mean per-kg price in the Italian market (without adjusting for inflation) fell 60% from about L 25.000 in 1990 to under L 10.000 in 1998 (Dujmušić, 2000). In the Croatian domestic market, prices for both seabass and sea bream have fallen an average of 25% and 30%, respectively, from 1998 to 2000. Price decreases of this magnitude inexorably force inefficient producers out of the market.

Further price softening may be expected as fish supply increases; and supply certainly will increase: Croatia is not the only country planning to augment its seafood production. For example...

- Cyprus' 10-year target is 10.000 MT/yr of marine fish (D. Stephanou, 2001)

- Algeria's plan calls for 30.000 MT/yr of aquaculture products (B. Basurco, CHIEAM, Zaragoza *pers. comm.*)

- Greece, far-and-away the leader in the Mediterranean, plans a 120% increase in the period between 2000-2006 (P. Anastasiadis, Institute of Marine Biology, Iraklio, Crete, *pers. comm.*)

- Turkey's 10-year plan calls for 200,000 (*sic*) MT/yr of aquaculture products (E. Gözçözoglu, Ministry of Agriculture and Rural Affairs, Department of Aquaculture, Ankara, *pers. comm.*)

- Some observers predict Mediterranean seabass & sea bream production will increase fivefold, to 500.000 MT

The extent to which these goals will be realized is uncertain, but rational planning dictates that Croatian enterprises incorporate this effect in their business decisions—or face the very unpleasant consequences.

The WTO

Croatia acceded to the World Trade Organization in November, 2000. This insures its products a position in the global marketplace on par with those of other members. In exchange, Croatia has agreed to adhere to WTO trade policies.

The WTO framework will present challenges to Croatian mariculture that must be considered in strategic planning at both the enterprise and national levels. For example, the WTO stipulates that government production- and export-based incentives be decreased or, in some cases, completely eliminated. (Incentives still may be authorized for environmental protection measures and crop insurance.) The intent is to eliminate the ability of richer countries to subsidize their industries on a larger scale, thereby conferring them with a competitive advantage unavailable to less-developed members. Thus, government incentives now available for mariculture in Croatia likely will have to be phased out, and companies that depend on such subsidies for profitability must plan accordingly to insure their survival.

Croatia also is obligated to lower its import duties, a move designed to open its markets to other WTO members. This will lower the price of imported fish, which will benefit Croatian consumers and should stimulate domestic demand. The other side of the coin: Croatian seafood producers will be in direct competition with producers from around the world for a share of their own domestic market.

Of special importance, this policy is to be implemented over a 5- to 10-year period, thus providing a window of opportunity that will give alert firms the chance to adapt their practices to the new trade environment.

Product quality & EU standards

International standards have been instituted to address increasing consumer concern over the quality of a variety of products, including those derived from aquaculture. These fall under the rubric of Hazard Analysis/Critical Control Point (HACCP) and encapsulate internationally recognized requirements for assuring food safety.

Other countries have developed comprehensive HACCP plans for selected aquaculture products. The USA, for example, has such plans for shellfish and catfish. In other countries, individual producers have undertaken voluntary certification for control as well as marketing purposes. Indeed, in many markets it has become essential to demonstrate some sort of safety certification. Croatian companies must satisfy the minimum requirements of these protocols to be competitive internationally, and the policy of companies that aspire to excellence should be to exceed them.

How to Compete

Competing successfully within the world market will require Croatian firms to capture the economies of scale that characterize their product. Simply stated: Production costs will have to be lowered to levels that are comparable to those of their most efficient international competitors.

Larger firms usually enjoy this competitive edge, as they better are able to take advantage of certain internal economies. These include:

- commercial economies (*e.g.*, deeper discounts afforded when buying supplies in bulk)
- financial economies (*e.g.*, the ability to borrow money at lower rates)
- marketing economies (*e.g.*, absorbing higher promotional costs to penetrate new markets)
- managerial economies (*e.g.*, affording specialists, such as accountants and sales managers)
- technical economies (*e.g.*, implementing new processes, such as open-ocean culture)
- R & D economies (*e.g.*, testing and developing new products)

Croatian fish and shellfish culturists, however, currently are comprised mainly of small, privately-held family farms. Traditional family enterprises often operate with lower labor expenses, but this may not be sufficient to insure a strong competitive position in the new marketplace. Smaller companies surely will have to find innovative ways to lower other components of production expenses, perhaps cooperating with companies in the same situation to reduce certain supply, harvest, promotional, and technical expenses.

In the domestic market, Croatian-based producers should have at least one clear advantage over their international competition: Evidence gathered informally from Dubrovnik seafood restaurants indicates a very strong consumer preference for fresh white fish, whereas imported white fish—as attested by customs records (Dujmušić, 2000)—surely will be frozen.

In the larger internal market that includes household purchases, however, Croatian products can expect to be in head-to-head competition with these same frozen imports. This will require, among other things, a marketing strategy that positively differentiates the Croatian product in the minds of domestic consumers.

Internationally, WTO membership will permit Croatian companies to take advantage more easily of larger seafood markets abroad and not be unduly dependent on domestic demand generated by seasonal tourism. For example, China—where consumers spend almost 50% of their income on food—has concluded negotiations that will lead to its accession to the WTO, thereby requiring it to lower its trade barriers. Further, China's recent Fisheries Law, enacted in December, 2000, codifies a policy of zero-growth in domestic fisheries production. As a direct result, China's seafood imports have increased, recently doubling to 2,5 million MT/yr. This creates opportunities for aggressive, forward-

thinking Croatian seafood firms interested in finding profitable niches in this very large market.

A longer-term competitive strategy is to diversify Croatia's seafood products, both in terms of introduction of new fish and invertebrate species (*e.g.*, Katavić, 1999; Skaramuca *et al.*, 2000) and innovative, value-added processing and packaging. Indeed, both avenues of research are actively pursued in countries with well-developed industries, as each offers the promise of forging new markets for mariculture products.

Finally, Croatian firms share a potentially valuable external economy: the relatively unspoiled marine environment in which they work. This should be exploited responsibly to earn a reputation for producing premium seafood of the highest international quality. The goal would be to have the phrase "Croatian seafood" evoke the same strong, positive impression in the minds of world consumers as, say, the phrase "Belgian chocolate"; that is, a product of unquestionably high quality.

The tourism challenge

Izazov turizma

Part of the motivation for promoting mariculture is to satisfy the country's anticipated demand for high-quality seafood. Meat traditionally makes up a much greater part of the Croatian diet than fish, but the average annual per capita consumption of seafood—not only fish—reportedly has increased over the past several years from about 3,6 kg in 1994 to 9,2 kg in 2000 (Kolega and Božić, 2001). These same authors report marine fish consumption of about 6,6 kg/person annually. (As these data depend partly on official catch statistics, the shortcomings of which have been noted by Dujmušić (2000), they need to be accepted with due caution.)

According to these figures, Croatian seafood consumption yet is only about half of the EU annual average (*ca.* 20 kg/person); and that of the EU is much less than those typical of Asian countries—the Japanese, for example, consume on the order of 70 kg/person. (Annual consumption in Iceland is about 90 kg/person.)

Resurgence of tourism to the Croatian Adriatic and its many islands—it now accounts for over 12% of the GNP and employs, directly and indirectly, about 180.000—bodes well for the Croatian economy. This is very good news for the seafood sector, too: Tourists must eat; and fresh seafood is an important part of a Mediterranean holiday.

Mariculture has the ability—perhaps even a duty—to provide a dependable supply of fresh seafood for tourists during their visit to Croatia. With tourism projected to reach at least 9 million visitors representing about 60 million over-night stays by 2005, accurate prediction of the impact of tourism on seafood demand becomes a very important part of designing a rational mariculture development plan (Stephanou, 1998, 2001).

The ready availability of high-quality, reasonably priced seafood that efficient culture practices are able to offer only can enhance a tourist's holiday experience and contribute to creating a positive image of the country. Of utmost importance, this must be accomplished in a way that inflicts no damage on the environmental assets that are the foundation of Croatia's tourism industry. Promoting constructive communication between professional tourism, aquaculture, and environmental organizations will encourage the sort of development that benefits all interested parties, and the nation as a whole.

Regional co-operation

Regionalna suradnja

The challenges facing Croatia are homologous to those confronting other so-called transition economies bordering the Eastern Adriatic. This begs the question: *How can effective regional cooperation be nurtured within an economic system in which these countries will interact principally as competitors for seafood market share?* Two areas of mutually beneficial cooperation quickly come to mind: environmental protection and technical training.

The advantages of cooperating on environmental protection issues are obvious: With one country being geographically downstream of another, and with the anticipated free trade of feed, fingerlings, and fish across national boundaries, the absolute need to control any disease or pollution incidents clearly must be a matter of high regional concern.

Regarding training, technical expertise drawn from participating countries could be tapped to provide academic content for a regionally-available Adriatic Aquaculture Online University. This website would provide distance learning in the form of interactive lessons on topics such as aquaculture-related chemistry, biology, engineering, production economics, and marketing. If sufficiently rigorous, the curriculum might be accredited by a consortium of regional institutions and earn cyber-students partial credit toward an *Aquaculture Associates* degree.

The website could, as well, offer an array of software tools to assist registered users in performing the sometimes onerous calculations associated with routine water-quality analyses, length-mass conversions, therapeutic dosage determinations, and recurring design problems. As an added benefit, the analytical uniformity that would result from general use of these tools would promote more reliable comparison of national data sets.

Another dimension of shared training would combine scarce national resources to establish a

pilot-scale production site where student-employees from participating nations would receive essential hands-on job experience before entering the workforce in their respective countries. Qualified students would learn a variety of practical skills, including professional small-boat handling, mariculture-related diving ops, water-quality analyses, disease identification and treatment, small engine repair and maintenance, sustainable management techniques, harvest procedures, and safe, efficient net changing. The training site also would serve as a regional field station for conducting commercial-scale applied research.

Conclusion
Zaključak

The challenges outlined above—by no means an exhaustive list—are daunting. They should not be approached casually, but rather attacked head-on to build a successful, modern mariculture industry in Croatia.

Within the free-market system, the burden of achieving this success will be borne mainly on the shoulders of determined entrepreneurs willing to undertake the risks and do the hard work of establishing mariculture firms in exchange for sharing in the expected profits. Important supporting roles, however, must be played by other sectors with a stake in development.

One way to foster the efforts of these disparate interests would be to establish a National Mariculture Task Force composed of highly-motivated, unbureacratic representatives from the production, financial, tourism, environmental, legislative, and academic communities. Its principal charge would be to provide the coordination and comprehensive analyses needed to chart a rational course for Croatian mariculture. This would entail regularly reviewing the industry's progress and updating national mariculture policy, as the need may present itself.

The Task Force's first assignment would be to produce and distribute, in no more than nine months, a comprehensive report that, among other things, includes:

- identification of *the best* seafood production, processing, and marketing practices available internationally
- thorough examination of the costs and benefits of implementing these practices in Croatia
- objective analysis of the efficiency level Croatian firms must meet to be competitive in the global marketplace
- detailed definition of the steps that must be taken to comply with—or surpass—EU seafood standards
- concrete suggestions of how financial institutions can support new—and expansion of existing—enterprises
- consideration of mariculture as a development engine for revitalizing rural island communities
- an outline of a standardized system for collection of national mariculture production and economic data
- a proposal for establishing mariculture investment promotion offices in each of the coastal *Županije*
- serious evaluation of research priorities, with emphasis on implementing an aggressive New Species Initiative
- initial analysis of the potential of open-ocean mariculture in the Croatian Adriatic & of closed-system production

Finally, a key part of the Task Force's brief should be to identify a successful national development model from which Croatia has the most to learn. This approach will avoid wasting time and limited resources 're-inventing the wheel'. Important lessons may be learned from the experiences of, for example, Norway, Greece, Turkey, and Spain. Despite obvious differences in climate and species under cultivation, one excellent choice, owing to its commercial success, similar size, and—in the opinion of the senior author—the nature of her people: Ireland.

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