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## INLAND CAPTURE FISHERIES AND ENHANCEMENT: STATUS, CONSTRAINTS AND PROSPECTS FOR FOOD SECURITY

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# INLAND CAPTURE FISHERIES AND ENHANCEMENT: STATUS, CONSTRAINTS AND PROSPECTS FOR FOOD SECURITY

## EXECUTIVE SUMMARY

Reported inland capture fisheries production increased steadily from 1984, to peak in 1990, and thereafter stabilised at about 6.5 million mt. However, catches from informal activities, particularly subsistence fisheries, are seriously under-reported. Actual catches may be at least twice the reported figure. There are, therefore, dangers with assessments based solely on reported catches. The production is almost entirely fin-fish, with negligible amounts of crustaceans or molluscs, except in localised areas.

Freshwater fish is mainly consumed in its entirety, with practically no discards and minimal wastage. Produce is rarely exported, but consumed domestically, usually by local communities, but it can be transported over large distances. Whilst the reported inland catch represents a modest 7% of capture fishery production, in a significant number of countries there are no marine fisheries at all and current and potential production arises entirely from freshwaters.

Inland capture fisheries are complex in nature involving a wide variety of activities undertaken by people from the widest spectrum of socio-economic backgrounds. Main fishing areas are rivers in major basins, often associated with extensive areas of floodplain in the tropics, lakes, reservoirs and an array of smaller rivers, irrigation and drainage canals and a variety of seasonal or permanent small water bodies.

In general, African freshwater resources are dominated by major rivers and floodplains and the Great Lakes. In South America, lakes are less important but the region has the largest of the world's river basins. Asia has a number of impressive river systems but artificial impoundments, especially large reservoirs, are more prominent than in Africa or South America. In Europe, North America and other developed regions freshwater resources are varied but many rivers have regulated flows and fisheries management systems are becoming increasingly governed by recreational considerations.

Catching methods, on the whole, are dominated by labour intensive gears used on an individual basis, or by small groups; high efficiency commercial gears are rare. This, coupled with the high level of artisanal and informal activity, leads to a high degree of participation, including a significant number of women and children in some regions. It is this level of participation, particularly amongst low income and/or resource poor groups, that is the most important aspect of inland fisheries in relation to food security. The significance of freshwater catches to food security far exceeds what production figures alone might suggest. The overriding tendency for local consumption of the product, with negligible discards and limited wastage, is testament to the value of the product amongst local communities. In some regions inland waters produce a relatively high value product and the relevance of the catch to food security stems from its commodity value. In many other regions, however, freshwater fish represent an essential, and often irreplaceable source of high quality, and cheap, animal protein crucial to the balance of diets in marginally food secure communities.

Notwithstanding the importance of informal aspects of inland fisheries, there are also a significant number of important commercial/artisanal fisheries in many regions. Fisheries in some of the larger open water regions, for example, resemble marine industrial fisheries and the problems and management requirements are similar. A significant number of fisheries in other areas are equally as important as these in generating income and employment.

Environmental impacts arising from other sectors are the major constraint to sustaining, or increasing, production. These effects can be reduced by improved integrated resource management, incorporating a basin-wide approach to multiple use considerations for freshwater resources. At most risk from these impacts are those communities in areas of high population density presently living on relatively unregulated floodplains, or near major lakes where catchment degradation is escalating. Where opportunities for participation in the development activities that fuel these environmental changes are limited, localised food insecurity will become a fact.

Regional differences exist as to how environmental changes are likely to arise. In the developed world, and in increasingly affluent industrialising economies, rehabilitation of freshwaters is driven by recreational demands in particular. In Eastern Europe (including the former States of the Soviet Union) and much of Asia, without improved mitigation, the effects of predicted rapid economic development will likely severely impact freshwaters, especially through industrial effluents entering rivers. In Africa, the main impacts are likely to arise through population pressures including increased land degradation, through agricultural intensification, especially near the Great Lakes. By comparison, environmental changes in rivers in South America, where lakes are less important, may be less dramatic than in Asia. Localised impacts arising from rapid industrialisation, including mining, can be anticipated. Agricultural intensification is leading to changes in vegetation cover which may inevitably result in shifts in the ecology of much of South America's flowing waters.

Decisions relating to the allocation of water resources need to incorporate multiple use considerations for aquatic resources. For this to occur on a fair and equitable basis, and on sound economic grounds, governments need to gather more information on the current value and utilisation of freshwater habitats. Fishers should, generally, have improved legal access rights to resources. Where projects will have major impacts on freshwater resources, governments need to make clear and unambiguous decisions on whether or not they wish to keep the resources in question.

Often, such issues must be considered in pragmatic terms. In many cases, political decision making processes need national infrastructures able to provide, sectorally impartial, technical advice regarding the various development options available. Most major fisheries have reached, or exceeded, their maximum sustainable yields, unless enhanced. Whilst there are possibilities for increased production from some areas, through improved gears and management, these may be offset by decreases in production from others brought about by over-exploitation, habitat destruction and/or water pollution. Hence, absolute world production may be sustained to the year 2010, but this scenario masks important localised anomalies that are likely to occur.

Considerable potential exists for increasing catches on a local scale by rehabilitating freshwater habitats and, hence, the fisheries they support. This has already led to improved fisheries in many countries, including developing or industrialising nations, and is being considered as a serious option in many others.

The greatest potential for increasing catches from inland waters is by applying and/or improving culture enhancement techniques. These stocking activities offer particular promise for small water bodies and reservoirs. Stocking is already contributing to a major proportion of the catch from inland waters in many regions, particularly in Asia. The divisions between capture fisheries and culture enhancement activities will rapidly fade and, in many regions, have already gone.

Estimates of biological potential for stocking suggest that, for most areas, this will not be the major constraint, whereas, socio-economic potential, and constraints, vary considerably between regions. Estimates of realistic increases in production that can be achieved through intensified stocking activities are in excess of *5 million mt* per annum from existing water-bodies. New reservoirs will present further opportunities for increased production. Where stocking activities are intensified and/or combined with the enhancement of primary production (through, for example, nutrient enrichment of water) increases in production may be well in excess of this.

Improving production through culture-enhanced fisheries has several other attractions including: existing water resources are used; low resource input systems are involved; using species low in the food chain can help maximise the biological efficiency of production; increased participation; beneficiaries are often low income, resource poor, communities; no pollution; and, limited management inputs into the rearing process. Increases in production do not require any major technological changes; management requirements are well known, and not technically complex. Most importantly, the management requirements for increased production through stocking are unlikely to result in conflicts of interest since the process involves enhancing existing activities. Therefore, the prospects for achieving this increased production are excellent.

Issues relating to the ownership of, or access rights to, the stock will constrain private sector involvement in increasing production through stocking. Many of the areas with major potential for stocking are open access (in itself not undesirable). In many cases, the *institutional or government sector* will be required to take the *major initiative.* This differs from more intensive aquaculture related activities which might be driven more by the private sector.

Hence, institutional or government funding might be directed at stocking activities in preference to more intensive aquaculture. In the longer-term, private sector management, including community-based approaches, should be encouraged, where necessary and appropriate, by resolving resource use or access rights and issues on a fair and equitable basis. Examples of how this can be achieved already exist.

# PECHES DE CAPTURE EN EAUX CONTINENTALES ET AMELIORATION: SITUATION PRESENTE, OBSTACLES ET PERSPECTIVES EN MATIERE DE SECURITE ALIMENTAIRE

## RESUME

La production déclarée des pêches de capture en eaux continentales, après avoir fortement augmenté à partir de 1984, a atteint un maximum en 1990 et s'est depuis stabilisée à environ 6,5 millions de tonnes. Toutefois, beaucoup de prises résultant d'activités non répertoriées, et notamment de pêches de subsistance, ne sont pas déclarées. En fait, les prises réelles pourraient atteindre au moins le double des prises déclarées. La production consiste pour l'essentiel en poissons à nageoires; les crustacés et les mollusques sont pêchés en quantités négligeables, sauf dans certaines zones bien délimitées.

Les poissons d'eau douce sont généralement consommés en entier. Il n'y a pratiquement pas de rejets et très peu de déchets. Ces produits, rarement exportés, sont habituellement consommés par les collectivités locales, bien qu'ils puissent être transportés sur de longues distances. Si les prises en eaux continentales déclarées ne représentent que 7 % de la production des pêches de capture, un nombre non négligeable de pays ne disposent pas de pêcheries maritimes et leur production halieutique actuelle et future repose entièrement sur la pêche en eau douce.

La pêche de capture en eaux continentales, de nature fondamentalement complexe, regroupe un grand nombre d'activités relevant de catégories socio-économiques fort diverses. Au nombre des principales zones de pêche figurent les cours d'eau des grands bassins hydrographiques, souvent associés à de vastes plaines d'inondation sous les tropiques, les lacs, les réservoirs et une multitude de cours d'eau de moindre importance, de canaux d'irrigation et de drainage et de petites masses d'eau permanentes ou saisonnières. En Afrique, les ressources en eau douce sont essentiellement constituées des fleuves et des vastes plaines d'inondation qui leur sont associées ainsi que des Grands Lacs. L'Amérique du Sud, où les lacs sont moins abondants, possède cependant le plus grand bassin hydrographique du monde. Si l'Asie compte un certain nombre d'imposants bassins hydrographiques, on y relève davantage de réservoirs de retenue artificiels qu'en Afrique ou en Amérique du Sud. En Europe, en Amérique du Nord et dans d'autres régions développées, si les ressources en eau douce sont abondantes, le débit de nombreux cours d'eau est régularisé et l'aménagement halieutique est de plus en plus subordonné à des impératifs récréatifs.

Dans l'ensemble, les méthodes de capture sont fondées sur l'utilisation, à titre individuel ou par de petits groupes, d'engins de pêche nécessitant une importante main-d'oeuvre; les engins commerciaux à haut rendement sont rares.

Ces circonstances, associées à la forte proportion d'activités artisanales et informelles, sont à l'origine du fort taux de participation généralement enregistré, et notamment du concours d'un nombre appréciable de femmes et d'enfants dans certaines régions. C'est ce taux de participation élevé, en particulier dans les groupes à faible revenu et/ou à ressources limitées, qui constitue l'aspect primordial de la pêche en eaux continentales pour ce qui est de la sécurité alimentaire.

Le rôle que jouent les prises de poissons d'eau douce dans la sécurité alimentaire dépasse de loin ce que les simples chiffres de la production peuvent suggérer. Le fait que la consommation locale du produit prévale et que cette forme de consommation occasionne très peu de rejets et de déchets est la preuve de la valeur accordée par les collectivités locales au produit.

Dans certaines régions, le produit tiré des eaux continentales a une valeur relativement élevée, et la contribution des prises à la sécurité alimentaire est subordonnée à leur valeur commerciale. Toutefois, dans bon nombre d'autres régions, les poissons d'eau douce constituent une source essentielle, et souvent irremplaçable, de protéines animales bon marché et de grande qualité et jouent un rôle capital dans l'équilibre des régimes alimentaires des communautés peu favorisées en ce domaine.

Malgré l'importance de la part prise par les activités non organisées dans la pêche en eaux continentales, il existe aussi un nombre appréciable d'importantes pêcheries à vocation commerciale ou artisanale dans beaucoup de régions. Ainsi, sur certains des plus grands plans d'eau, les activités de pêche s'apparentent à celles qui sont pratiquées en mer à l'échelle industrielle et suscitent d'ailleurs les mêmes problèmes et les mêmes exigences en matière de gestion. Dans d'autres régions, certaines formes de pêche en eau douce ont également un rôle comparable à celui de la pêche en mer sur le plan des revenus et de l'emploi.

L'impact préjudiciable des autres champs d'activité sur l'environnement est le principal facteur qui fait obstacle au maintien ou à l'accroissement de la production. Il est possible d'atténuer ces effets en pratiquant un aménagement intégré des ressources en eaux douces, et notamment en abordant à l'échelle du bassin dans son ensemble la question de leurs multiples usages. Cet impact menace particulièrement les communautés des secteurs à forte densité démographique qui sont implantées dans des plaines d'inondation relativement dépourvues de dispositifs de régulation ou à proximité de grands lacs dont le bassin d'alimentation est en voie de dégradation accélérée. Une insécurité alimentaire localisée ne devrait pas manquer de se manifester là où il n'existe guère de possibilités de participer aux activités de développement qui occasionnent ces modifications de l'environnement.

Les modifications de l'environnement devraient prendre des formes différentes selon les régions. Dans les pays développés, mais aussi dans les pays en voie d'industrialisation où cette activité industrielle engendre toujours plus d'abondance, la régénération des eaux douces obéit souvent à des motifs récréatifs.

En Europe de l'Est (notamment dans les ex-républiques de l'Union soviétique) et dans une grande partie de l'Asie, en l'absence de mesures palliatives efficaces, le rapide développement économique prévu devrait avoir un effet extrêmement dommageable sur les eaux douces, en particulier du fait des déversements d'effluents industriels dans les cours d'eau. En Afrique, et plus particulièrement près des Grands Lacs, les atteintes à l'environnement devraient essentiellement résulter de la pression démographique, qui donne notamment lieu à une dégradation accélérée des terres par suite de l'intensification de l'agriculture. En Amérique du Sud, où les lacs sont de moindre importance, les modifications écologiques des cours d'eau devraient avoir une plus faible ampleur qu'en Asie. On peut prévoir des effets localisés découlant d'une industrialisation rapide, notamment dans le secteur de l'extraction minière. L'intensification de l'agriculture engendre actuellement des modifications du couvert végétal qui devraient inévitablement se répercuter sur l'écologie de la plupart des cours d'eau d'Amérique du Sud.

Pour décider de l'affectation des ressources en eau, il est indispensable de tenir compte de la multiplicité de leurs usages. Afin de procéder de façon juste et équitable tout en respectant des principes économiques sains, les pouvoirs publics se doivent de rassembler davantage de renseignements sur la valeur et l'utilisation présentes des habitats d'eau douce. Il conviendrait généralement de faciliter, au plan juridique, l'accès des pêcheurs aux ressources. Lorsque certains projets font peser de lourdes menaces sur des ressources en eau douce, les gouvernements doivent faire clairement savoir s'ils sont décidés, ou non, à protéger les ressources en question. Il faut souvent faire preuve de pragmatisme en la matière. Dans de nombreux cas, le processus décisionnel qui intervient à l'échelon gouvernemental nécessite des infrastructures nationales susceptibles de fournir des avis techniques impartiaux sur les diverses options de développement possibles.

La plupart des grandes pêcheries ont atteint, ou dépassé, leur rendement viable maximal, à moins d'une mise en valeur ultérieure. Bien que, dans certaines zones, un accroissement de la production fondé sur une modernisation des engins de pêche et des méthodes de gestion puisse être envisagé, il pourrait être contrebalancé par le recul de la production provoqué, dans d'autres zones, par la surexploitation, la destruction des habitats ou la pollution des eaux. En conséquence, si la production mondiale totale devrait pouvoir se maintenir jusqu'en 2010, il est vraisemblable que cela n'ira pas sans de sérieuses anomalies au plan local.

A l'échelon local, il existe d'excellentes perspectives d'accroissement des prises par régénération des habitats d'eau douce et, par conséquent, des pêcheries qu'ils abritent. Cela a déjà permis d'améliorer les pêches dans de nombreux pays, dont un certain nombre de nations en développement ou en voie d'industrialisation, alors que beaucoup d'autres envisagent sérieusement de prendre des mesures de ce genre.

La meilleure possibilité d'amélioration des prises en eaux continentales consiste à appliquer des techniques piscicole améliorées ou à perfectionner celles qui sont déjà en usage. Ces méthodes d'empoissonnement s'avèrent particulièrement prometteuses dans le cas des petits plans d'eau et des réservoirs.

Dans de nombreuses régions, et notamment en Asie, l'empoissonnement procure déjà une bonne part des prises en eaux continentales. Les distinctions entre pêche de capture et pisciculture s'estomperont rapidement et ont d'ailleurs déjà disparu dans de nombreuses régions.

D'après les estimations, le potentiel biologique ne devrait pas constituer le principal obstacle à l'empoissonnement, alors que le potentiel socio-économique et les contraintes qu'il suscite varient considérablement d'une région à l'autre. Des prévisions réalistes semblent indiquer que, s'agissant des plans d'eau existants, l'intensification des opérations d'empoissonnement pourrait permettre d'augmenter la production de plus de *5 millions de tonnes* par an. L'aménagement de nouveaux réservoirs contribuera également à accroître la production. Cet accroissement de la production pourrait être d'ailleurs beaucoup plus marqué lorsque les opérations d'empoissonnement seront intensifiées et/ou combinées avec l'amélioration de la production primaire (par exemple grâce à l'enrichissement des eaux en éléments nutritifs).

Parmi les autres avantages que présente l'augmentation de la production par le biais de pêches améliorées par l'élevage, on peut mentionner l'utilisation des ressources en eau existantes; des apports limités de ressources; la possibilité d'optimiser le rendement biologique grâce à l'utilisation d'espèces situées en bas de la chaîne alimentaire; la participation accrue; le fait que les bénéficiaires consistent souvent en communautés à faibles revenus manquant de ressources; l'absence de pollution; la simplicité des méthodes de gestion que nécessite le processus d'élevage. L'accroissement de la production ne requiert aucune innovation technique importante; les besoins en matière d'aménagement sont bien connus et ne présentent aucune difficulté technique. Surtout, l'aménagement permettant d'augmenter la production par le biais de l'empoissonnement ne devrait pas engendrer de conflits d'intérêts, puisque le procédé consiste en une amélioration des techniques existantes. Les perspectives de succès sont par conséquent excellentes.

Les questions liées à la propriété du stock (ou aux droits d'accès) obligeront le secteur privé à participer à l'accroissement de la production par le biais de l'empoissonnement. Bon nombre de zones propices à l'empoissonnement sont d'accès libre (ce qui n'est pas une mauvaise chose en soi). Dans de nombreux cas, il incombera au *secteur institutionnel ou gouvernemental* de prendre l'*initiative première*. Cela diffère des opérations menées dans le cadre d'une aquiculture plus intensive, où le secteur privé peut jouer un rôle prédominant. En conséquence, il est préférable que les fonds d'origine institutionnelle ou gouvernementale soient consacrés aux activités d'empoissonnement plutôt qu'à une aquiculture plus intensive. A plus long terme, il convient d'encourager, le cas échéant, la participation du secteur privé à la gestion, notamment sur une base communautaire, en réglant les questions ayant trait à l'utilisation des ressources et aux droits d'accès de façon juste et équitable. Il existe déjà des exemples de réussites dans ce domaine.

# PESCA CONTINENTAL Y SU POTENCIACION MEDIANTE ACUICULTURA EXTENSIVA: SITUACION ACTUAL DIFICULTADES, Y PERSPECTIVAS PARA LA SEGURIDAD ALIMENTARIA

## RESUMEN OPERATIVO

La producción notificada de la pesca continental registró un aumento continuo a partir de 1984, alcanzando un volumen máximo en 1990 para luego estabilizarse aproximadamente en 6,5 millones de toneladas. Sin embargo, dado que la notificación de las actividades informales, especialmente la pesca de subsistencia, es sumamente incompleta, las capturas reales podrían elevarse por lo menos al doble de la cifra mencionada, por lo que es peligroso efectuar evaluaciones basadas exclusivamente en las capturas comunicadas. Salvo en zonas muy localizadas, casi toda la producción corresponde a peces propiamente dichos, a los que se suman cantidades insignificantes de crustáceos o moluscos.

Los peces de agua dulce se consumen generalmente en su totalidad, prácticamente sin descartes y con una producción mínima de desperdicios. El producto rara vez se exporta; se destina al consumo interno, generalmente de las comunidades locales, aunque también puede ser transportado a través de grandes distancias. Si bien las capturas notificadas de la pesca continental representan un modesto siete por ciento de la producción pesquera total, en un número considerable de países no existe actividad pesquera marina, por lo que toda la producción actual y potencial procede de los cuerpos de agua dulce.

La naturaleza de las pesquerías continentales es compleja; en efecto, éstas comprenden una gran diversidad de actividades, realizadas por personas pertenecientes a sectores socioeconómicos sumamente variados.

Las principales zonas donde se llevan a cabo son los ríos de las mayores cuencas hidrográficas, que en las zonas tropicales se asocian con frecuencia a amplias superficies de llanuras inundables, así como en los lagos, los embalses, una serie de ríos más pequeños y canales de riego y drenaje, y toda una gama de pequeños cuerpos de agua estacionales o permanentes. En términos generales, entre los recursos de aguas dulces de Africa predominan los principales ríos y llanuras inundables, así como los grandes lagos. En América del Sur los lagos tienen menos importancia, pero la región cuenta con la más grande de las cuencas hidrográficas del mundo. En Asia existen numerosos sistemas fluviales de magnitud imponente, pero los reservorios artificiales, y en particular los grandes embalses, son más importantes que en Africa o en América del Sur. En Europa, América del Norte y otras regiones desarrolladas, los recursos de agua dulce son variados, pero la corriente de muchos ríos se halla regulada y los sistemas de ordenación pesquera responden, cada vez más, a consideraciones de índole recreativa.

Entre los métodos de captura predominan, en el conjunto, los artes de pesca que requieren mucha mano de obra, que son utilizados por pescadores individuales o pequeños grupos de pescadores; son raros los equipos comerciales de alta eficiencia. Esta característica, sumada a la gran proporción de actividad artesanal e informal, se traduce en un alto grado de participación, que en algunas regiones incluye un número significativo de mujeres y niños. Y es justamente este nivel de participación, especialmente entre los grupos de bajos ingresos y/o pobres en recursos, el aspecto más importante de la pesca continental por lo que atañe a la seguridad alimentaria.

La importancia de las capturas de agua dulce para la seguridad alimentaria va mucho más allá de lo que parecen indicar las meras cifras de producción. La tendencia predominante al consumo local del pescado, con descartes insignificantes y poco desperdicio, atestigua el valor de este producto para las comunidades locales. En algunas regiones la pesca continental brinda un producto de valor relativamente alto, de modo que la importancia de sus capturas para la seguridad alimentaria deriva del valor comercial de las mismas. Pero en muchas otras zonas el pescado de agua dulce representa una fuente esencial, y a menudo insustituible, de proteínas animales de alta calidad y bajo costo, vitales para el equilibrio de la dieta de comunidades que alcanzan apenas el nivel de seguridad alimentaria.

A pesar de la importancia de los aspectos informales de la pesca continental, también existe en muchas regiones un número significativo de pesquerías artesanales/comerciales importantes. Por ejemplo, las pesquerías de algunas de las mayores regiones de aguas continentales abiertas se asemejan a las pesquerías marinas industriales en cuanto a los problemas que plantean y a sus necesidades de ordenación. En otras zonas existe un número considerable de pesquerías no menos importantes en cuanto a los ingresos y el empleo que generan.

Los efectos ambientales de actividades de otros sectores constituyen el mayor obstáculo para el mantenimiento o el aumento de la producción. Dichos efectos podrían reducirse mediante una ordenación mejor integrada de los recursos, en la que consideraran los múltiples usos de los recursos de agua dulce dentro de un enfoque global para toda la cuenca hidrográfica.

Las comunidades más expuestas a riesgo a causa de este tipo de impacto ambiental son las de las zonas de alta densidad demográfica que viven actualmente en llanuras inundables relativamente poco reguladas, o en proximidad de grandes lagos cuyas cuencas sufren una degradación cada vez más intensa. Si las oportunidades de participación en las actividades de desarrollo que alimentan estos cambios ambientales son escasas se producirán, de hecho, situaciones localizadas de inseguridad alimentaria.

Existen diferencias entre las regiones en cuanto a la forma que probablemente asumirán los cambios ambientales. En el mundo desarrollado, así como en las economías cada vez más prósperas de los países en vías de industrialización, la rehabilitación de las aguas continentales está dirigida sobre todo a satisfacer necesidades recreativas.

En Europa oriental (incluidos los estados de la ex Unión Soviética) y gran parte de Asia, si no se toman medidas compensatorias para atenuar los efectos del rápido desarrollo económico previsto, es probable que éste tenga graves repercusiones en las masas de agua dulce, especialmente por la descarga de aguas residuales de la industria en los ríos. En Africa el mayor impacto será consecuencia, seguramente, de la presion demográfica, que traduciéndose en una intensificación de la agricultura llevará a una mayor degradación de las tierras especialmente en las inmediaciones de los grandes lagos. En comparación con Asia, es posible que los cambios ambientales en los ríos de América del Sur, donde los lagos tienen menos importancia, sean menos espectaculares. Se pueden prever efectos locales como consecuencia de la rápida industrialización, y en particular de la actividad minera. Además, la intensificación de la agricultura está produciendo modificaciones de la cubierta vegetal que inevitablemente conllevarán cambios ecológicos en la mayor parte de las aguas que fluyen en América del Sur.

En las decisiones relacionadas con la asignación de los recursos hídricos deben tomarse en cuenta las consideraciones relativas al uso múltiple de dichos recursos. Para que esto se haga con imparcialidad y equidad y con un sólido fundamento económico, es necesario que los gobiernos reunan más información acerca del valor y de la utilización efectiva de los hábitat de agua dulce. En términos generales, los pescadores deberían contar con mayores derechos de acceso legal a los recursos. Cuando los proyectos vayan a tener un impacto importante sobre los recursos de agua dulce, los gobiernos deberán decidir, en forma clara y sin ambigüedades, si desean o no conservar el recurso en cuestión; estos problemas deben abordarse a menudo con criterios pragmáticos. En muchos casos los procesos políticos de adopción de decisiones requieren una infraestructura nacional que, sin favorecer los intereses específicos de uno u otro sector, pueda brindar orientación técnica sobre las distintas opciones de desarrollo disponibles.

La mayor parte de las pesquerías más importantes ha alcanzado o superado su rendimiento máximo sostenible, si no se han efectuado intervenciones de potenciación pesquera mediante acuicultura extensiva. Si bien existen posibilidades de que mejores equipos y una ordenación adecuada permitan un aumento de la producción en algunas zonas, éste podría ser en parte anulado por la reducción que ocasionarán en otras zonas la explotación excesiva, la destrucción del hábitat y/o la contaminación del agua. Por consiguiente, por más que en cifras absolutas la producción mundial pueda mantenerse hasta el año 2010, esta hipótesis encubre las importantes anomalías que probablemente han de producirse a nivel local.

Existe un potencial considerable para aumentar las capturas a nivel local rehabilitando los hábitat de agua dulce y, por consiguiente, la actividad pesquera que éstos sostienen. Por este medio ya se han logrado mejoras en las pesquerías de muchos países, incluidas naciones en desarrollo o en vías de industrialización, mientras que muchos otros están examinando seriamente esta opción.

El mayor potencial de aumento de las capturas de aguas continentales se halla en la aplicación y/o perfeccionamiento de técnicas de potenciación pesquera mediante la acuicultura extensiva.

Estas actividades de repoblación resultan particularmente promisorias para los cuerpos de agua y embalses de pequeñas dimensiones, y ya contribuyen a una parte importante de la captura continental en muchas regiones, especialmente de Asia. Las distinciones entre pesca y actividades de potenciación pesquera mediante la acuicultura extensiva están destinadas a desaparecer rápidamente, y en muchas regiones ya han dejado de existir.

Las estimaciones del potencial biológico para la siembra de peces llevan a pensar que en la mayor parte de las zonas no será ésta la dificultad principal, mientras que entre las distintas regiones existen variaciones considerables en cuanto al potencial y socio-económico y a otros impedimentos que sí pueden llegar a ser limitantes. Cálculos realistas de los aumentos de producción que se pueden lograr intensificando las actividades de repoblación indican un exceso de *5 millones de toneladas* anuales para las masas acuáticas existentes. Además, los nuevos embalses ofrecerán ulteriores oportunidades de aumento de la producción. En caso de que las actividades de repoblación de peces se intensifiquen y/o se combinen con intervanciones dirigidas a incrementar la producción primaria (por ejemplo, mediante el enriquecimiento en nutrientes del agua) el incremento productivo podría ser incluso mucho mayor.

La posibilidad de incrementar la producción potenciando las pesquerías mediante la acuicultura extensiva presenta además varios otros atractivos, a saber: se aprovechan los recursos hídricos existentes; los sistemas empleados requieren un insumo escaso de recursos; que se usan especies situadas en niveles bajos de la cadena trófica, lo que puede optimizar la eficiencia biológica de la producción; se logra una mayor participación; los beneficiarios son, en general, comunidades de bajos ingresos y pobres en recursos; no se produce contaminación; por último, el proceso de cría requiere limitados esfuerzos de gestión. No se precisan grandes cambios tecnológicos para hacer aumentar la producción; las necesidades de ordenación son claras, y sencillas desde el punto de vista técnico. Y, lo que es más importante, es improbable que las exigencias en materia de ordenación para el aumento de la producción se traduzcan en conflictos de intereses, ya que el proceso consiste en potenciar las actividades existentes. Por consiguiente, existen excelentes posibilidades de que se alcance el incremento productivo esperado.

Las cuestiones relacionadas con la propiedad de la población pesquera o los derechos de acceso a la misma limitarán la participación del sector privado en actividades destinadas a aumentar la producción mediante la siembra de peces. Muchas de las zonas con mayor potencial para la repoblación son zonas de acceso abierto (lo cual no es, en sí, indeseable). En muchos casos será el *sector institucional o público* el que deberá tomar la *iniciativa principal.* Esto marca una diferencia con las actividades de acuicultura más intensivas, en las que el sector privado puede jugar un papel más predominante. Así pues, la financiación institucional o pública debe dar la preferencia a las actividades de repoblación más que a las de acuicultura de tipo más intensivo. A más largo plazo cuando ello fuera necesario y apropiado habría que alentar la participación del sector privado, y en particular los enfoques de tipo comunitario, resolviendo con imparcialidad y equidad los problemas relacionados con los derechos de utilización y acceso a los recursos. Existen ya ejemplos concretos de formas en que esto puede lograrse.

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# 1. INTRODUCTION

## 1.1 Background

This paper was prepared as background material for the International Conference on Sustainable Contribution of Fisheries to Food Security being held in Kyoto, Japan, in December 1995.

## 1.2 Acknowledgements

This review is written for a more general readership and inclusions of large amounts of data and source references are minimised. The trends discussed, prospects presented and conclusions drawn, are considered to reflect a consensus of expert technical opinion. Most conclusions are substantiated by analyses presented in a number of source documents as listed in the bibliography. These were used extensively in the preparation of this document. The inputs of these sources are hereby acknowledged. Fisheries data generally refer to the FAO Yearbook of Fishery Statistics Vol. 74 (1992). Part One of this document also draws heavily on the more technically detailed regional summaries presented in Part Two.

## 1.3 Inland fisheries and food security

This review discusses the relationships, and relevance, of inland capture fisheries to food security. Food security means that "all people at all times have both physical and economic access to the basic food they need". Basic food needs are understood as 2 200 calories per day plus micro-nutrients and the equivalent of 0.75 grams of protein, per kg of body weight, per day for adults. The issues involved with food security, in relation to fisheries, are complex and this review should be considered in conjunction with a multitude of associated factors as discussed and summarised in the main conference document.

Part One provides a general overview of the role of inland capture fisheries including current production, trends in production, constraints and prospects for increasing production from this sector. Features of inland capture fisheries, of particular relevance to food security, are highlighted, as are areas of particular concern or promise. Part Two focuses on more detailed assessments by region.

Inland capture fisheries are complex. They involve a multitude of activities undertaken by people from the widest spectrum of socio-economic classes, for an extensive range of purposes, in a wide variety of environments. Some definitions, interpretations and explanations of various terms are given below. Wherever generalisations are made there will inevitably be exceptions.

In many freshwater bodies, it is becoming increasingly difficult to separate inland capture fisheries and aquaculture activities. In particular, the enhancement of fish catches through stocking is a very important factor in assessing current and future production from capture fisheries in inland waters. Inevitably, there is an overlap between "capture fisheries" and "aquaculture" when discussing inland fisheries (and *vice versa*).

This situation reflects the growing trend for the two sectors to merge. When considering the level of current, or potential, production from freshwaters, where culture-enhanced capture fisheries (i.e., those involving stocking) are concerned, there is an overlap with estimates for freshwater aquaculture production. This should be borne in mind when combining estimates of potential production from both sectors in order to avoid duplication.

This document highlights the importance of inland fisheries. Improved management offers significant benefits, both through sustaining current production, and increasing production from the sub-sector. The management requirements are not complex, nor are they particularly difficult to implement. However, some important issues remain, including the escalation of habitat degradation and declining water quality arising from the activities of other sectors. Multiple use considerations, including integrated resource management approaches, can help ensure that the benefits of inland fisheries will be incorporated into the development process. Nevertheless, there will be times when inland fisheries considerations conflict with other uses of freshwater resources. Where this situation occurs, governments need to make realistic and frank decisions as to whether or not the policy will be to lose these aquatic resources and the fisheries they sustain. If necessary, it is better to lose them in this fashion, than through the continued attrition by neglect witnessed by history.

## 2. DEFINITIONS AND INTERPRETATIONS

*Inland fisheries* are fisheries which are carried out in freshwater or estuaries and whose target species are those that spend all or part of their life-cycle therein.

*Subsistence fisheries* are those essentially to yield food for the fishers, their families and the immediate community. Typically, the catches from subsistence fisheries tend to be unreported in catch statistics. *Commercial fisheries* are where the stock is exploited for commercial gain. *Artisanal fisheries* are usually commercial and where the fishing units are wholly owned by the fishermen who work them, or their immediate community. Catch statistics are usually moderately accurate but the extent of reporting varies greatly between countries. *Industrial fisheries* are carried out by capital intensive fishing units usually financed from outside the fishing communities. Usually these units are worked by hired labour and catch statistics are usually relatively comprehensive. *Recreational fisheries* involve exploitation principally as a leisure occupation, although the catch may be taken for consumption. The activity is not undertaken for the purposes of commercial gain. Although more obvious in the developed world, a significant proportion of people in less developed regions go fishing as a recreational activity. In such cases the importance of the catch as essential food increases. Catches from the recreational sector are not reported in the FAO statistics.

*Informal fisheries* are low profile fishing activities outside the usual formal reporting system and often beyond government control. This is a diffuse sector which is accounted for mainly by combining subsistence and recreational activities (above). Therefore, catches are generally unreported but are known to be significant.

In addition, a considerable proportion of people, possibly the majority in many areas, are involved in such activities.

The definition of *aquaculture* is of paramount importance to the interpretation of the FAO fisheries statistics especially in relation to inland capture fisheries. For FAO statistical purposes aquaculture is defined as:

> '..... the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploited by the public as common property resources, with or without appropriate licenses, are the harvest of fisheries.....'

This definition is open to various interpretations. For the present purposes the issue is the contribution of culture-enhanced capture fisheries (see below) to aquaculture production.

For example, the stocking of fish fry into a large reservoir to be later caught and landed by capture fishery activities, often together with other fish of the same or different species produced through natural recruitment, can be interpreted as either aquaculture or capture fishery production. The concept of ownership in the above definition does not necessarily clarify the situation. For example, the persons recording catches may consider that because fish have been released they are, therefore, "owned", even if not by the fishers. The concept of ownership is particularly problematical in countries with centrally planned economies where there can be an attitude that everything is "owned" (by the State). The interpretation of the term aquaculture in China is of paramount importance because the region accounts for some 80% of world inland aquaculture production; a significant proportion of this is known to originate from enhancement of capture fisheries through culture.

A *culture-enhanced capture fishery* is currently defined, and generally reported, as 'aquaculture' because it involves an aquaculture element. Culture-enhanced capture fisheries are generally where the recruitment of the stock being exploited is dependent upon an element of husbandry (e.g., release of stock from hatcheries). However, other than that input the activity essentially operates as a capture fishery where the production is dependent upon natural processes. Generally, there is no further enhancement of the production through, for example, feeding of the stock, fertilisation of the water body etc.

Essentially, culture-enhanced capture fisheries are a form of extensive aquaculture where exploitation of the stock through capture activities plays a major role. Interpretations often depend upon the size of water body involved. The fished stock in question, in most cases, is not necessarily "owned".

This factor in itself is at odds with the definition of aquaculture and, again, there are problems with the concept of ownership (see above). Alternative or associated terms are *ranching*, *stocking* and *stock enhancement* (but only where the stocking material has been cultured as opposed to caught from the wild).

The inclusion of production from culture-enhanced capture fisheries in the aquaculture statistics has important implications. The popular perception of aquaculture is the more intensive form the activity takes whereby, for example, fish are placed at high densities in raceways, cages, pens or small ponds, and production is dependent to varying degrees on supplemental feed. This has likely resulted in a disproportionate allocation of attention to, and investment in, more formal aquaculture activities, at the expense of attention to the more extensive activities associated with culture-enhanced capture fisheries. There is clearly a need to refine these definitions and interpretations and in particular to establish the contribution of culture enhancement of capture fisheries to total aquaculture production (which is known to be significant). The problem is heightened by the tendency to use the same species for both stocking and more intensive aquaculture.

Therefore, reported production cannot be refined based on species accounts, even where species are identified in statistical returns. This particularly applies to the carps. For example, the silver carp ranks second in importance, to Alaska pollack, on the basis of world total production of aquatic species consumed directly as food by humans (the five other marine species with higher total world catches are all utilised mainly for fishmeal).

Intensive aquaculture accounts for a proportion of this production but it is also a major species utilised for stocking reservoirs in Asia (including China). The latter fact probably accounts for the prominence of the species in catch/production reports. The extent of the problem is further illustrated by official figures for inland fish production for Cuba (see Part Two) where "aquaculture" produces a reported 21 000 mt compared with an inland "catch" of only 1 200 mt; but over 75% of the "aquaculture" production is derived from fisheries exploiting an enhanced stock in reservoirs.

*Fishery enhanced aquaculture* is where the stock used in aquaculture is obtained from wild or feral sources. Recruitment of the stock in question is, therefore, generally dependent upon natural processes and a fishery is required to procure it. The activity is significant. For instance, initially all of the aquaculture production of Indian and Chinese major carps in their native range was based upon wild caught stock (either fry or ripe adults obtained from rivers). With the advent of induced breeding techniques, this stock has recently tended to be replaced from domesticated sources, but a proportion of production still depends on the wild resource. Similarly, the entire world eel production is based on stock caught in the wild. Whereas production from capture fisheries, based on even the slightest element of culture, is often counted as "aquaculture", production from aquaculture, based on an essential element of capture, is not counted as "capture fishery production". Again, the importance of capture activities is neglected.

# 3. STATUS OF INLAND CAPTURE FISHERIES

## 3.1 Interpretation of Statistics

Capture statistics for inland fisheries are not collected independently but have to be derived by subtracting the aquaculture production statistics from total production statistics reported. This leads to difficulties in data interpretation. In addition, aquaculture and capture fishery statistics have only been separated since 1984. In general, the statistical information quoted in this report refers to finfish, as other groups of organisms play a very minor role in inland fisheries.

Currently, recreational catches of fish, crustaceans, molluscs and other aquatic organisms are excluded from the catch data requested by FAO in its FISHSTAT NS questionnaires. Recreational fisheries are becoming increasingly important in a number of countries and account for the major part, if not all, of the catch of some species. The combined total of recreational catch from inland waters is likely to be significant, possibly over 2.0 million mt per year (see below). In contrast, requests for data on catches from subsistence fisheries are included with the questionnaires even though these data are equally difficult to determine accurately. Few countries report such informal activities (i.e., catches which are not landed and recorded at major market outlets). For those countries that do report informal catches, the information is based on rough guesses. These also tend to result in underestimates for reasons outlined later. A further shortcoming in the reported data, is the lack of detail on species composition of the catches. This problem is particularly prevalent in Asia, where "Freshwater fishes nei" account for over 80% of the reported catch.

The improvement of capture fishery statistics is particularly important with respect to the increased need to monitor changes in water quality and biodiversity as a result of the UNCED agreements. Wild stocks are valuable and unique monitors of deleterious changes in environmental quality, as well as providing food critical to food security in rural and urban areas. Whilst it is often difficult to collect such statistics, governments may wish to review the importance of monitoring inland capture fisheries more closely.

## 3.2 Current production

Reported production from inland capture fisheries increased steadily from 1984 to peak in 1990, at a global total of some 6.5 million mt. Since 1990, catches appear to be stabilising (Figure 1). Over the past ten years, and for most of the regions, the average yield of inland capture fisheries on a *per caput* basis has not declined drastically. Globally, the annual *per caput* reported catch is a little over 1 kg. This conceals serious local imbalances in production and consumption.

In recent years, aquaculture has been mainly responsible for maintaining the total supply of freshwater fish. Reported inland aquaculture production for 1993 was approximately 10.7 million mt, or 62% of total inland fish production and 65% of total aquaculture production.

Aquaculture has been increasing progressively in most inland regions and the recorded production from it now exceeds that from inland capture fisheries. China accounts for much of the aquaculture production from inland waters, and, in particular, is responsible for most of the recent increases in overall aquaculture production. Much of the production, and increase in production, from China arises from the intensification of stocking activities (culture-enhanced capture fisheries). It is, therefore, difficult to discuss the status of inland capture fisheries without considering associated data for the aquaculture sector. Any general assumptions and projections made for aquaculture, including culture-enhanced capture fisheries, rely heavily on the accuracy of the data for China and the interpretation of the term aquaculture in that country.

The 6.5 million mt of inland capture fishery production for 1992 is based on *reported* catches, but catches from informal inland fisheries activities are either under reported or not reported at all. By contrast, aquaculture production, being a more formal, controlled, or regulated, activity, is reported much more comprehensively. Consequently, the *actual* production from the freshwater capture fishery cannot be estimated accurately.

Attempts by FAO to obtain data for recreational catches resulted in responses from only 30 countries. These reported an estimated total marine and inland recreational catch of approximately 0.5 million mt, although this included a disproportionate number of developed countries. In Poland, for example, it is estimated that some 34 000 mt were fished by the members of the Polish angler's association. This represents only the licensed catch, but, even so, exceeds the total production from commercial inland fisheries and aquaculture combined. Similarly, in Russia, it is believed that recreational catches are of the same magnitude as commercial landings. In many of such regions, recreational fisheries appear to be important for food supplies. In many cases, they can be considered as subsistence fisheries. Population distributions dictate that most recreational fishing will be undertaken in inland areas. The world recreational catch from inland waters may, realistically, be well in excess of 2.0 million mt per year.

Of more consequence is the known under-recording of subsistence and artisanal fisheries activities. For African rivers, much of the recorded data come from recognised landing areas on the major rivers (i.e., the data apply to artisanal and commercial fisheries). Published estimates indicate that 60% of African riverine catches probably come from lower order streams at an unrecorded subsistence level. Catch reports, generally, are no more comprehensive for other freshwater systems, such as lakes, reservoirs, floodplains and other wetlands. Reported production for freshwaters in sub-Saharan Africa is in excess of that from the marine sector (based on domestic landings), and the inclusion of informal catches might double the reported figure for inland waters. Similar adjustments could reasonably be made for other continents.

Obviously, major problems occur in interpreting available data for the inland capture fisheries sector. Estimates of actual, as opposed to reported, catches inland can only be speculative but it would not be unrealistic to double the reported figure. Therefore, an *indicative figure in the region of 12 million mt per year for production from inland capture fisheries* may be more appropriate.

Moreover, this does not include a further, but significant, allowance for the element of reported aquaculture production that is actually landed by capture fisheries. This discrepancy can arise either from stocking activities, or mis-recording, especially where the fishery is based on an "aquaculture species". For example, production of tilapia outside their native range is often recorded as aquaculture, regardless of whether it is based on exploitation of naturally recruited, feral stocks.

Of course, there is also a discrepancy between reported and actual production in other sub-sectors, but this is by no means as relevant an issue as in freshwaters. Marine fisheries are dominated by industrialised fleets, or other commercial enterprises, and informal activities, whilst present, are relatively less important to reported total landings. Similarly, it is reasonable to assume that informal activities contribute relatively little by comparison to the total aquaculture production reported.

### 3.3 The Relative Contribution and Importance of Inland Capture Fisheries to Food Security

The current (1993) production from the marine capture fishery is about 85 million mt. Based on reported catches of 6.5 million mt (Table 1), inland fish production accounts for about 7% of the world total capture fishery production. However, unlike marine capture fisheries, waste through discards is negligible in inland fisheries, and it is probable that a larger percentage of the volume of fish landed is actually consumed directly by humans than with marine fisheries.

A comparison of the overall contribution, of the marine and inland sectors, is also biased because a large proportion of the marine production is landed by a limited number of countries with highly industrialised fleets. Production by individual country gives a more illuminating picture of the situation (Table 2); even so, for many countries the marine catch is taken mainly from distant waters. Of the 225 countries, or statistical units, where reports are available, in 57 (25.3%), production inland exceeds that from marine waters. Of these, 41 countries (18.2% of the total) have no marine production at all.

Comparisons for Low Income Food Deficient Countries (LIFDCs) are even more striking in relation to food security issues (Table 2). Of the 76 LIFDCs, 33 (43.4%) have higher inland than marine catches, and for 23 of these countries (30.3% of LIFDCs), production from inland areas accounts for more than 95% of total fisheries production. This is particularly so for landlocked countries, especially in Africa, where there is no direct access to marine resources.

However, even a number of countries that do have access to the sea still have their production dominated by freshwater catches. Neither are the aforementioned figures biased by the inclusion of a disproportionate number of small landlocked nations. In fact, the converse is the case: included amongst countries where marine catches dominate are 57 small island states in the Pacific, Indian and Atlantic Oceans, such as Barbados or Tonga. Even a number of these have significant production from freshwaters, for example, Jamaica (31.8%) or Cuba (20.1%) (Table 2).

In the two largest countries in the world, China and India, freshwaters account for more than 40% of the total production (Table 2). Their freshwater production is dominated by aquaculture, but including significant production from culture-enhanced capture fisheries. The combined population of India and China exceeds one half of the world total, expelling any argument that they are merely "exceptions".

The aforementioned figures admittedly take no account of the movement of fish produce between countries. Although in some of the countries, where inland fisheries dominate production, food balances are supported by imported marine produce, for some, this may be offset by export of their own domestic production. Food balances, and consumption patterns are relevant here. However, notably, fish produced inland, with very few exceptions, tends to be consumed domestically. For food security, *domestic* production is arguably what is most important, since this is directly available to, and under the control of, the countries in question. By comparison, imports are more vulnerable to world economic forces, and the political whims of foreign governments. Hence, imported fish, by definition, is an insecure source of food for many countries, especially those lacking the economic might to guarantee supplies. Self-sufficiency in food production would be a major goal of most developing nations. For many of these nations this implies developing freshwater, not marine, resources (Table 2).

Fisheries production from inland waters is clearly much more important to food security than reported figures might first suggest on a comparative weight basis alone. The modes of utilisation of inland catches, and especially the participation of people, further reinforce the importance of the sector to food security. With the exception of a few export fisheries for higher value products (e.g., Nile perch from Lake Victoria), the catches from inland waters, including many recreational fisheries, are chiefly and directly important to local food economies. Therefore, data can be more justifiably expressed as production *per caput* averages, which more accurately indicate the part played by inland fisheries in feeding growing populations. Freshwater fish tend to be consumed by local communities, although, in some countries, the produce may be transported over large domestic distances. Fish provide a wide range of food over a wide range of prices depending on species and size. They also, on occasions, serve as famine crops and are subject to heavy exploitation when other sources of protein are scarce. The nature of the fishery, generally, enables such plasticity in exploitation.

Although refugee camps in northern Uganda depend heavily on food aid, an unrecorded, but significant, proportion of the protein in their food budget arises from informal fishing activities in adjacent freshwaters. The importance of inland waters in sustaining lives under these adverse conditions should not be under estimated. Similarly, in Papua New Guinea, by the late 1970s, the emphasis on fisheries development was strongly orientated towards coastal fisheries. Although not executive policy, freshwater fish were widely excluded from statistical data collection (a practice not restricted to that country), sometimes as an oversight, often on the grounds that they were not "proper" fish, but occasionally because they embarrassingly outnumbered marine species. Improved information gathering for inland areas resulted in an increased awareness of their importance.

In this "Pacific Island" nation, over 87% of the population live inland and have no direct access to the extensive, and more prominent, marine resources on offer. Well over 50% of the inland population, including many women and children, participate in fishing activities, even in areas with limited fish resources. These, generally informal, activities produce modest catches *per caput*, but the total catch from inland waters of Papua New Guinea is now known to be more than from coastal regions (based on domestic landings). For many inland communities in this country, most of which live under marginally food secure conditions, freshwater fish account for over 40% of the intake of animal protein, and much of the remainder is supplied by imports. Neither is this situation unique. This also occurs in most countries where reasonable freshwater resources exist.

For the vast majority of inland fisheries, the concept of "trash" fish does not exist. Rarely are fish discarded as being of "low value". In most regions, fish of all shapes, sizes and forms are avidly consumed, although the catch may obviously be divided and utilised according to prevailing market conditions, where markets actually occur. Particularly among the poorer populations of developing countries, virtually all fish are eaten in practically any state of preservation. Processing and marketing systems for inland fisheries are dominated by low technology, labour intensive, inputs where the majority of the product is utilised fresh, but smoking, drying or salting can play an important role in some areas. Chilling or freezing techniques are less often applied, as are canning, filleting, packaging and other value adding activities, for the majority of the produce.

Where the individual has a choice in the food budget, and as affluence increases, freshwater fish tend to contribute less to the diet. In theory, as sectors of populations become more affluent this can release low cost fish for continued use by the poorest communities. However, in some cases, for example, in India, freshwater species are considered a luxury in preference to marine produce or meat. Conversely, where incomes have declined, even in developed economies, inland fisheries in particular have increased.

For many poorer and isolated communities, access to freshwaters for subsistence fishing is critical to their food supplies. Exploitation is usually at low levels of efficiency (per fishing unit) and yields tend to stay in balance with the available resource. In communities distant from fisheries, and amongst poorer individuals, there is a demand for "secondary" products which are sometimes the conserved by-products of the primary fish processing, where this occurs, or lower value components of the usually multi-species catches. The trade in these products, and the beneficial effects on the food budget of the consumers involved, tend to be ignored in official statistics.

Human population distributions are axiomatic to the importance of freshwater fish production to food security. At the poorer end of the social scale, the major issue is access to low cost fish products or resources that can be exploited at a subsistence level. Only on the smallest of islands do the majority of human populations live in coastal regions (i.e., as defined as having access to marine fishing grounds). For example, most people still live inland even among the Low Income Food Deficient Countries which are also Small Islands States.

In virtually all countries, coastal dwellers are in the minority. For example, consideration of where the majority of the populations of the Indian sub-continent or China reside should soon resolve any controversy in this regard. The low profile of inland capture fisheries, and the often low *per caput* catches in many areas, tend to promote the perception that they are unimportant in comparison to the more visible activities associated with other sub-sectors. But even very modest catches *per caput* are significant, both to the individual and in terms of total catches, where large numbers of people are participating.

Women and children are substantially involved in inland capture fisheries, although this can also vary considerably between regions. Women and children are often involved in the informal sector and their catches generally tend to contribute directly to the family diet.

Compared with either marine capture fisheries or aquaculture, far more people participate per unit mass of produce (on average) in inland capture fisheries. Apart from the much greater number of fishers involved, due both to population distributions and the use of less intensive gears, the dispersed nature of marketing and processing systems for freshwater fish ensure that more people are involved in related secondary activities. The nature of the fisheries will tend to sustain participation in the sub-sector in the medium-term. For example, it will be difficult for capital intensive, low participation, fishing ventures to dominate the majority of the resource. As such, the benefits of inland capture fisheries activities may remain more evenly dispersed than has been the trend in other sub-sectors. However, the current inclination to shift from capture to culture will tend to skew the distribution of benefits of freshwater resource exploitation away from the poorest groups. Hence, if inappropriately managed, the promotion of aquaculture can reduce food security among resource poor communities. Among many inland fishing communities, the concept of a "resource poor" fish farmer is a contradiction in terms; by their definitions, a person who has a farm is considered relatively rich.

Part-time, artisanal, capture fishing and extensive aquaculture (i.e., culture-enhanced capture fisheries) can be carried out without interfering with or removing nutrient inputs from farming systems. This makes such activities a viable alternative to more intensive farming for resource poor communities. Hence, food security can be promoted through encouraging low input, and/or natural, production systems

The role of freshwater fish in the diet can vary considerably within countries. For example, in Ethiopia consumption in riverine areas and around major Ethiopian Lakes has been estimated at 10 kg *per caput* per annum, far above the national average of less than 1 kg. In South-East Asia, in the lower Mekong Basin, fish provides from 40 to 60 % of the animal protein intake of the population living near the river. This is much higher than the national averages recorded for the countries sharing the Mekong river basin. Similarly, the *per caput* supplies of fish for the riverside population are reported to be two to three times the national average. A study in Itacoatiara, Amazonas, in 1981, estimated the daily supply of fish at 104 g *per caput* (38 kg *per caput* per year), whereas the consumption *per caput* in Brazil as a whole in 1990 was estimated at 5.7 kg.

## 4. TRENDS

Production from inland capture fisheries increased relatively modestly over the period 1984-93, at around 1.7% per annum, but this conceals considerable regional differences. The predominant trends over Europe and the former Soviet Union have been negative (see Part 2) principally due to declining habitat quality and over-exploitation of stocks. In Asia and Africa, the two regions making the greatest contribution, production increased significantly over this period. These increases, however, have been achieved against rather different backgrounds. Increases in Africa have come largely from the capture fisheries of the Great Lakes and rivers. These now approach their predicted maximum of some 2.2 million mt. The erratic rainfall over Africa, during the past decade, has caused considerable desiccation of reservoirs and smaller water bodies, thereby reducing their contribution. In contrast, the main surge in fish production in Asia has been provided by China. This has largely resulted from a policy of intensive stocking of large reservoirs built during the recent period of rapid economic development: Parallel programmes have been started in other parts of the continent.

Accurate assessments of the situation are obscured by the rapid responses of many freshwater fish stocks to fluctuating environmental conditions; even more so than with marine fisheries. In some cases, natural environmental cycles occur in a time-frame that exceeds the period of available records. A fishery may be overexploited in one season and, with the same fishing effort, may be under-exploited the next. In some highly productive systems, for example, where known production levels are closely associated with seasonal flood regimes, fishable resources have been known to double or triple from one fishing season to another. However, the consensus is that, on a regional basis, most major inland fisheries are now fully exploited, or in some cases overexploited. Without the aid of stocking or other production enhancement techniques, there are few large inland fisheries with a confirmed potential for significant expansion. Over the last 50 years, new technologies and infrastructures have been introduced into most areas where they can have a relevant application. As exploitation has become more efficient, there has been a parallel development of national physical infrastructures which allow easier access to the resources by continually increasing populations. One major exception may be reservoirs, especially in South America, but also parts of Asia, where the fisheries are often poorly managed and sometimes stocks are exploited well below their theoretical natural yield (i.e., without stocking).

Some stocks are evidently declining beyond the limits imposed by natural environmental cycles. This particularly applies to many river fisheries. In almost every case, the decline has been shown to be principally due to changes in the aquatic environment, invariably brought about by human activities.

The introduction of exotic organisms, physical interference of flowing waters through engineering works, decline in water quality due to pollution effects, the impacts of agriculture, urbanisation and industrialisation on catchments, and other factors, have all taken their toll on inland fisheries.

The accumulated catch statistics also mask significant underlying changes. For example, the general perception of capture fisheries production from the middle and lowland Ganges in India is one of decline. Recent reports of drastic reductions in capture fishery production for the middle Mekong River illustrate how quickly situations can change in response to rapid economic developments and associated human influences.

In other regions, serious problems with pollution and habitat degradation have been offset by increased exploitation, or improved access to key fishing areas. Often, development results in new fishery resources becoming available, such as reservoirs built primarily for irrigation or hydropower. The significance of such developments is reflected in the aforementioned statistics for production from China. In the more affluent countries, an emerging trend is to reverse the decline in the status of inland waters by rehabilitating freshwater habitats.

The rehabilitation of the River Thames in England is an example of the extent of reversal that can be achieved given public support, political will and technical and financial resources. However, such rehabilitation programmes are generally motivated by the desire to use freshwaters for recreational purposes rather than for food production. As countries become richer, a general trend is to replace food fisheries by recreational fisheries in freshwaters. This trend is of less relevance to food security issues as it will inevitably be accompanied by improved economic purchasing power, ensuring food budgets are maintained from other sources.

In some regions, the trend may even be desirable, as it will promote the management and/or conservation of freshwater habitats as natural ecosystems. However, some rivers in developing or industrialising economies are now so badly polluted that it is becoming increasingly economically feasible to rehabilitate them for food fishery purposes alone.

The trend for aquatic habitat degradation and water pollution to increase, as countries develop and become more populated, and/or as they industrialise, followed by increased attention to environmental concerns and rehabilitation as they become wealthier, is likely to be the major influence on freshwaters in the short to medium term. The effects of this trend on total catches from freshwaters will depend very much on the rate of decline compared with the rate by which emerging opportunities for increased production are seized (see below).

A serious decline in absolute inland capture fishery production is unlikely, at least to the year 2010, but significant localised anomalies are likely to occur. The implications of such trends for food security are likely to be most pronounced where people who depend on diminishing freshwater resources have limited opportunity to participate in the economic development process driving such changes.

The problem may become extreme in those regions also subject to rapid population growth. Where freshwater fish is a crucial component of the diet of such communities, food insecurity will become a practical reality. This highlights the need for planned mitigation of this undesirable prospect.

# 5. CONSTRAINTS TO SUSTAINING PRODUCTION

## 5.1 Conflicts of Interest

Inland fishermen continue to face strong competition for the right to use natural fish resources. For example, in Bangladesh there is stark contrast between the need to produce rice as the staple food and the need to produce fish as the major animal protein source and a major provider of livelihood for the land-less. Fishery administrators worldwide, while having the duty to implement government fishery policies, often find it difficult to assist fishermen as they are not in control of the resources. This is particularly true for riverine fisheries where hydroelectric, navigational and other developments, together with pollution, often displace fishermen, or alter the natural conditions in such a manner that fish production declines or cannot be developed. The lack of planning for inland fisheries in development activities is a major constraint to sustaining production from the sector, with resultant threats to food-security. Inevitably, inland fisheries are generally vulnerable to, and often the first to suffer the consequences of, pollution and environmental degradation from other sectors.

## 5.2 Pollution and Habitat Degradation

The biggest constraint to sustaining current yields from freshwater fisheries is pollution and habitat degradation. For countries with a rapidly expanding industrial sector, it is tempting to give priority to growth, at the expense of environmental degradation. However, ultimately, the price of restoration must be paid in order to ensure the sustained participation of all sectors of the economy. Unless measures are taken to mitigate the effects of water control measures, and the decline in environmental quality, these will generally lower the sustainable productive capacity of the river systems and reduce fish stocks. For example, the commercial catch in the Illinois river in 1908 was 10 000 mt, at yields of 77-200 kg/ha. These landings were stated to be equivalent to 10% of the total commercial catch of the whole of the United States. By the 1950s, this had fallen to the equivalent of 43 kg/ha, and by the 1980s was less than 5 kg/ha, entirely as a result of environmental degradation. Unfortunately, this trend is being echoed in many of the world's major rivers.

The floodplain areas represent one of the most productive and, most importantly, sustainable fishing areas in any catchment. They are, however, often seen as "wastelands" and are considered suitable areas to drain and convert to land for agriculture, or, in some cases, urban building. This not only destroys the fisheries, but also tends to disrupt the dynamics of the water flow system, with unwanted side effects, such as floods and erosion downstream.

Alterations in water flows, through channelisation and/or damming, can seriously disrupt the natural production cycles of rivers at both the site, and downstream, of the impoundment. In rivers, production can be significantly reduced below dams. Migration patterns of riverine fishes are particularly vulnerable to dam construction. Such negative impacts on riverine fisheries can be reduced by proper planning, construction techniques and flow control regimes, but fisheries considerations are often a low priority with such projects.

However, comparisons of fish yields inside and outside of existing regulated compartments have shown that yields are by no means eliminated. In Bangladesh, for example, yields from floodplain canals can be higher than those achieved outside, where habitats are subject to more natural water regimes. The construction of large reservoirs, for example, despite the often negative impacts upon riverine fish production downstream, can present significant opportunities for new fisheries. These often have potential yields well in excess of those lost through their construction and are often more productive than natural lakes, particularly when production is enhanced through stocking.

The consequences for capture fishery yields from lakes, as a result of pollution and habitat degradation, is less certain. Many of the smaller water bodies are known to have been badly affected, especially when subject to effluent from urban centres and/or industrial developments. In many of these, the fisheries are known to have collapsed or disappeared. In others, a modest degree of nutrient enrichment appears to have enhanced total production, although generally associated with reductions in biodiversity. The situation in the larger lakes, especially the Great Lakes of Africa, is perhaps of more concern. Whilst the latter are less exposed to the effects of industrialisation than some of the larger water bodies in other regions (Asia, N. America, S. America, and Europe) they are subject to a more discrete form of pollution arising from processes of urbanisation, agricultural development and associated catchment degradation. It is not known how resilient these ecosystems are to environmental perturbations. Due to their size, there could be a time delay between the impacts of pollution and readily observable consequences. A lack of monitoring, and limited knowledge of the ecology of such systems, may make it difficult to detect, or predict, such changes. There is insufficient information to foresee serious collapses of fisheries, but this prospect cannot be ruled out.

Significant regional differences exist in how pollution and habitat degradation are likely to occur and/or affect freshwater resources and the food production systems they support. In the developed regions of Western Europe and N. America, together with Japan, Australia and New Zealand, recent increased investment in environmental protection may well lead to a reduction in, or reversal of, the decline in water and habitat quality. In some regions, significant improvements are already being observed as systems respond to rehabilitation measures demanded by a public increasingly aware of the recreational and aesthetic value of freshwater habitats. However, in some of these regions, the effects of air pollution on freshwaters may remain a problem for some time, especially in Europe. In Eastern Europe (including some of the States of the former Soviet Union) and Asia, without improved mitigation, the effects of predicted rapid economic development will likely severely impact freshwaters, especially through industrial effluent entering rivers. Serious declines in fisheries in some rivers can be anticipated. The increased need for hydropower will inevitably result in the construction of more reservoirs, although the impoundment of, or extraction of water from, the rivers of Eastern Europe and Asia is already relatively well advanced. In most of Asia, these developments will likely be aggravated by an already very high population density, combined with anticipated rapid population growth.

Environmental stresses on freshwater resources will be perhaps the greatest in the Indian sub-continent and South East Asia. The impacts of development will depend very much on the speed of economic growth, and how quickly the benefits of increased wealth will be reflected in improved environmental management, or, conversely, the extent to which the degradation of freshwaters will limit sustainable growth.

In Africa, the main impacts are likely to arise through population pressures, including increased land degradation through agricultural intensification. The scope for further major reservoir schemes is limited but a number of smaller impoundments on minor rivers may develop. In the seriously water deficient regions of Africa, increased requirements for water usage for agricultural purposes may lead to pressures to further drain several important wetlands. By comparison, the effects on rivers in South America, where lakes are less important, may be less dramatic due to the extent of freshwaters and the relatively low population densities in comparison with Asia. However, localised impacts arising from rapid industrialisation, including mining, can be anticipated. The region is also beginning to harness rivers for hydropower in a significant fashion and is experiencing a rapid increase in area of reservoirs. Agricultural intensification, especially to produce large quantities of red meat for both domestic and export markets, is resulting in rapid changes in landscape, especially vegetation, which will inevitably result in shifts in the ecology of much of South America's flowing waters.

Throughout all of the aforementioned regions, local deviations will occur. For communities in these areas who depend on freshwater fish, localised impacts are more significant than regional trends.

## 5.3 The Introduction and Transfer of Aquatic Organisms

Poorly planned introductions and/or transfers of aquatic organisms continue to be a major threat to the sustainability of production from inland fisheries. The effects of alien species, or strains, can range from extremely beneficial to highly undesirable.

For example, several fisheries are known to have collapsed due to the impact of aquatic weeds or the introduction of exotic parasites or pathogens. On the other hand, several important, even crucial, fisheries are based on introduced species. A large proportion of these impacts arise from species used in aquaculture. The transfer of strains of species can cause equally, often more, harmful effects.

For example, the popularity of tilapia in aquaculture is such that it is now very difficult to find pure, wild, strains unaffected by genetic pollution through hybridisation. The increased attention to aquaculture worldwide is certain to escalate introductions, and transfers, as species, or strains, are moved from place to place for experimental or development purposes. The increasing interest in hybridising organisms for aquaculture trials is a disturbing trend, especially when based on limited knowledge of the production performance of existing strains and species, and/or their status as wild resources.

### 5.4 Loss of Biodiversity

The world's freshwater resources harbour a bounty of natural biodiversity of potential benefit to mankind. Historical progress made in agriculture, suggests that there is great benefit to be gained from improving utilisation of aquatic biodiversity by, for example, improving domesticated breeds for culture, stock enhancement or other uses. This field is in its infancy, yet the wild genetic material upon which much of the advances will depend is rapidly disappearing. There is also a view that maintaining biodiversity is desirable, even essential, in terms of sustaining the natural ecosystems upon which much of the world's food production depends. Major losses of aquatic biodiversity are caused by pollution, habitat degradation and introductions and transfers of aquatic organisms. Especially in tropical regions, notably South America, riverine wetlands can support very diverse fish faunas. The fish faunas of some tropical lakes, especially the African Great Lakes, can be equally impressive. The simplification of these fish communities is a widespread trend, globally, and undoubtedly the result of human influence. The impacts of the resultant loss in biodiversity on long-term food security are yet to be ascertained, but are likely to be significant.

## 6. PROSPECTS FOR INCREASED CATCHES AND UTILISATION BASED ON EXISTING RESOURCES

Globally, without stock enhancement, most major inland capture fisheries are fully exploited or in some cases overexploited. The only regional exception might be parts of South America, where large areas of some of the major rivers may be under-exploited, due primarily to low population densities and the inaccessibility of the resource. To increase production from these resources, improved access and infrastructures will be required. In addition, strong consumer preferences in South America mean that only a proportion of the available resources are currently being utilised. As preferred species become increasingly overexploited, consumption patterns may have to change.

There is also a strong preference for red meat in the region. Prospects for increased catches in South America, therefore, depend upon an array of associated factors other than available stocks. The prospects for sustaining current catches *per caput* are reasonably good for South America but, in the medium-term, great increases in catches from the capture fishery are not anticipated. However, again, such regional generalisations mask the possibilities for increases in production in response to localised opportunities and conditions.

### 6.1 Technological Advances

Due to their nature, in general, the scope for increasing catches from inland fisheries through improvements in gear technology is limited. New technology and infrastructures have been introduced into most areas where they can have relevant application. Most modern, high efficiency, gears are, generally, not suitable for use in the diverse habitats and conditions that characterise inland fisheries.

In most areas, a considerably wide range of gears already exists. Whilst individually some of these may be inefficient, collectively they ensure that resources are generally well exploited. The use of more advanced fishing gears, and mechanisation, may be a trend in some of the more open and accessible waters, such as the African Great Lakes, or the large channels of the Amazon.

However, even where such developments occur, rather than resulting in a significant net gain in overall production, the outcome is likely to be a redistribution of catches, through intensification of the fishery; probably accompanied by increased over-fishing. The associated reductions in opportunity for participation of low income groups would be a serious threat to localised food security. This has already occurred in some regions.

There is no scope to increase food production through improved utilisation of discards, as these are already negligible, except in South America. There is some potential to reduce post-harvest losses, through appropriate technological development. In common with much of the marine catch, a proportion of freshwater landings are spoilt and wasted prior to human consumption. Insect pests, in particular, are a problem in some areas, especially where fish is dried without salting. Since the proportion of the inland catch that is preserved has not been quantified, potential gains through reductions in post-harvest losses are difficult to estimate. With some products, losses of up to 50%, with averages of up to 25%, have been recorded. The informal nature of many inland fisheries, especially associated processing and marketing systems, will make it difficult to make rapid progress in this field. Countries are encouraged to investigate local situations with regard to losses through post-harvest spoilage and implement extension programmes where warranted. However, the prospects for global increases in fish supply through this activity are not great.

## 6.2 Improved Management

### 6.2.1 Managing exploitation

In general, the majority of inland fisheries are difficult to manage through controls on exploitation. Therefore, sustaining, or increasing, catches through improved catch management shows less potential than in the marine sector. Exceptions may be in areas where fishing activities are more centralised, visible, and controllable, such as in reservoirs, or where fisheries are industrialising in some of the larger lakes. With the majority of inland fisheries, there is a large participation of people and, hence, a wide, and flexible, distribution of effort. A high proportion of participants fish part-time, often as a secondary and/or seasonal activity.

These factors, together with natural variations in production cycles, result in many inland fisheries being relatively self-managing, in comparison with marine fisheries, since resource availability and exploitation are flexibly linked. The stocks themselves are often much more resilient to large changes in mortality than with many marine species, because natural calamities are common in freshwaters, especially on river floodplains, compared with more stable marine environments.

Certainly, these factors have a greater impact on controlling yields than regulation, especially with informal fisheries activities. Population pressures, increased access, habitat destruction and pollution, however, are all rapidly altering the traditional nature of inland fisheries. Reductions in the ability of stocks to withstand increasing exploitation, with collapses in traditionally robust fisheries, are becoming more common.

In areas where improved management can help sustain, or increase, catches, then much progress can often be made if fisheries authorities accept that community based management systems can offer significant benefits. Greater involvement of participants in management systems is almost universally desirable. Fisheries authorities should consider reviewing their role as facilitators, monitors and representatives (as well as being primarily regulators). Community-based management systems for inland fisheries will often be greatly enhanced where participants have, or are given, legal ownership, use or access rights to resources. In order to improve food security, promoting these rights, where necessary, should be a high priority for management authorities.

### 6.2.2 Managing introductions and transfers of aquatic organisms

There are great opportunities to improve the management of the introduction, or transfer, of aquatic species, or strains, since these activities are dominated by government and commercial sector initiatives. Better management will help harness the potential that well planned introductions and transfers offer, whilst limiting the potential for losses of sustainability through inappropriate actions. This requires that mechanisms for controlling, regulating and managing the movements of aquatic organisms are in place. Particular attention needs to be given to movements of aquatic organisms in the aquaculture sector, including those by government agencies. Recognised, and effective, procedures for evaluating the potential benefits and risks of introductions and transfers are available, and should be used. These include existing codes of practice and guidelines for the movement of aquatic organisms.

### 6.2.3 Integrated resource management

The greatest threats to sustainability of inland fisheries arise from outside the fishery sector itself; as outlined above. Improved management of these influences, therefore, can help sustain existing catches, and increase catches where trends can be reversed. Addressing these problems requires that fisheries administrations recognise their obligation to participate in integrated river basin management, and, especially, to represent the interests of their sector. Such representation should include giving due attention to low income groups, and those communities facing the prospect of food insecurity. Perhaps more importantly, there is an ever increasing need for managers in all sectors, and decisions made by governments, to consider, in full, multiple use issues for aquatic resources. A number of approaches are possible. For instance, a precautionary approach may place the burden of proof on polluters, thereby improving the fishers' position. Experience around the world suggests that the best outcome is obtained where fishers have clearly defined legal use rights for resources.

Hence, they can manage, or defend, those resources in the face of threats from other sectors, or, alternatively, obtain adequate recompense for any losses. Such systems are also desirable by ensuring that aquatic resources are valued fairly.

In the context of inland fisheries, integrated management policies are most appropriate if implemented on a lake, or river, basin basis. It is, however, much more difficult to achieve cross-sectoral integration when basins transcend national boundaries. Many major water bodies are international. The proper use of these depends upon shared responsibilities for exploitation of stocks, the management of water quality and associated factors. The wide ranging impacts of other sectors, such as agriculture and forestry, mean that a policy of catchment area management is required, either at a national, or international, level. There is mounting international pressure towards integrated basin management involving all users. Many regional infrastructures (e.g., CIFA, COPESCAL, APFC) have been operating for more than two decades. But these clearly have no executive or legislative authority, particularly in relation to government policies in other sectors. However, significant progress can be, and is being, made in some areas, for example, with the management of Lake Victoria.

In order for inland fisheries to be given due attention, in integrated management considerations, it is obviously necessary to have quantifiable data on the sub-sector. The lack of these data results in two major problems. First, planners often assume, because data are lacking, that inland fisheries activities are insignificant. Second, even given the opportunity, without quantified data, it is difficult for fisheries administrators to promote their sector relative to others where economic data, forecasts and analyses are, generally, more readily available. There is an urgent need to improve basic data gathering on inland fisheries in order to improve prospects for integrated management. In particular, there is a need to assess the extent of participation in, and importance of, inland fisheries activities in quantifiable economic terms.

Industrialisation, agriculture and urban sanitation requirements are rapidly enlarging as development accelerates and population pressures increase. There is an increasing need to understand, and predict, the most likely impacts of specific inputs into freshwaters on fish and other elements of the aquatic ecosystem. Environmental protection is likely to become more of an international priority. Economic growth, particularly in developing countries, will make it increasingly feasible to let environmental concerns guide economic policies and activities. This may lead to recovery of aquatic habitats, and, eventually, even permit exploitation at higher levels. This can only be to the advantage of food security.

The prospects for improved integrated resource management, leading to global increases in freshwater fish catches, are controversial. Based on previous experiences it is difficult to be optimistic.

On the other hand, there is an increasing awareness of the problems and possible solutions. In the short to medium term, improved integrated resource management would appear to have more relevance to sustaining catches, than to providing any significant increase. Any regional progress may likely be offset by a deterioration in the situation elsewhere.

Nevertheless, without improved integrated resource management, existing fisheries are certainly set to decline. However, one area where improved integrated management will make a significant difference to increasing catches, is where the possibilities for the enhancement of capture fisheries (see below) are incorporated into planning processes.

## 7. PROSPECTS FOR INCREASED YIELDS THROUGH INLAND CAPTURE FISHERY ENHANCEMENT

The general consensus is that any significant increases in yields from inland capture fisheries will, in future, be derived from fisheries enhancement activities, and, in particular, through increased production from culture-enhanced fisheries. In view of this, the prospects for enhancement are reviewed in more detail.

Fishery enhancement can be defined as the effects, on aquatic environments, of human intervention, in order to boost fishery production. This usually means increasing absolute production, in terms of biomass, but can also include improving access to the fishery, or the value of the resource in either monetary or aesthetic terms (e.g., recreational uses). In terms of food security, increasing yields is the obvious concern, although enhancing the value or utility of catches can play a significant role, through improving employment, income and/or participation. The enhancement of freshwater resources, in order to increase catches, can take various forms. Classical fisheries management interventions, such as controlling catches and effort through fishing regulations, whether traditional or based on an analysis of scientific information, can be considered as enhancement activities. Similarly, managing or mitigating the effects of environmental degradation can also enhance fisheries. These aspects, discussed earlier, are not covered in detail here. Of more immediate importance are enhancement activities aimed at modifying the physical, chemical or biological characteristics of water resources, for the specific purpose of improving a fishery.

### 7.1 Enhancement by Modifying and Rehabilitating Aquatic Environment

#### 7.1.1 Modifying water quality

The controlled input of nutrients into freshwaters, particularly reservoirs and lakes, up to a certain limit, can enhance biological production through increasing primary production. This, of course, is a classical enhancement technique in aquaculture through, for example, pond fertilisation. To a degree, this has been achieved in a more extensive fashion in some reservoirs and lakes, although more often by accident than good planning. However, in many cases, nutrient inputs into freshwaters exceed carrying capacities, and serious pollution problems result. The control of water flow to create turbulence, as an aid to maintaining levels of dissolved oxygen, especially in waters with high organic loading, will assist in maintaining optimum conditions and prevent the loss of fish through oxygen starvation. Attention to the position of water take-off points in reservoirs, especially in the tropics, will limit the discharge of poor quality waters (e.g., anoxic bottom waters from deep reservoirs) into the downstream drainage.

The prospects for increased yields through enhancing fisheries in such fashions are difficult to quantify, since considerable improvements in integrated resource management are required. For similar reasons, the extent to which reversals in environmental degradation can contribute to increases in production are difficult to predicted on a regional scale.

### 7.1.2 Control of water regimes

Where water is artificially impounded, or otherwise controlled, it can generally be assumed that, other factors being equal, shallow water bodies, with more frequent turn-over and mixing, will have higher levels of production. Water level control can be a minimal intervention by, for example, the simple retention of wet season drainage waters into the dry season, to allow extended fish growth followed by planned harvesting. Where the flow of water in, and out, of a basin can be controlled, it is possible to allow the water level to rise, or fall, at a rate which maximises the growth of rooted plants, or provides optimum conditions for the reproduction of fish or other organisms.

Modifying the physical features of impoundments, such as 'sculpting', or landscaping, reservoirs or canals, can create highly productive areas of shallow water which can compliment water control regimes.

The potential for such interventions is significant. For example, in many major irrigation networks, fish production can be optimised and, especially in the tropics, environmental health problems caused by water-borne vectors of diseases minimised, by simple alterations in water regimes, without adversely impacting the primary usage of water. Despite this fact, there seems to be no effort made to establish strong co-ordination between irrigation and fisheries authorities.

When dams are constructed, the flow patterns of rivers and estuaries are disturbed. Perturbations of natural water regimes and quality can lead to catastrophic declines in fisheries. In many cases, where other uses of the impounded waters allow, it should be possible to initiate a programme of water releases intended to enhance fish stocks downstream, thus restoring some productivity. A major constraint to achieving progress in this field is that such water resources are generally managed by other sectors, particularly agriculture and hydropower authorities, where these secondary activities are rarely considered. Again, improved integrated management of resources is the key to increasing catches by such means.

### 7.1.3 Habitat enhancement

In many cases, it is possible to manipulate the physical habitat in order to benefit fish populations and improve fisheries. In addition to sculpting reservoirs, the installation of devices, such as fish passes or lifts at artificial barrages, will improve the migratory capabilities of fish passing to, or from, their feeding and breeding grounds. Where poor quality water is discharged from reservoirs, the provision of barriers to create pools and turbulence, will increase the carrying capacity of the water and enhance fish production.

### 7.1.4 Habitat rehabilitation

The prospects that the rehabilitation of freshwater habitats, hence the fisheries they support, will result in realistic global increases in production, depend on a large number of factors. Since many of these involve complex socio-economic considerations, this potential is difficult to quantify. Much will depend upon the policies of governments. However, where policies change, and are implemented, the benefits may be considerable.

There is some reasons for optimism. For example, in India a scheme to rehabilitate the Ganga River has resulted in significant increases in fish production at monitored locations. Rehabilitation of some badly polluted rivers in South America is being considered as a serious option. In China, for instance, it is estimated that the average yield of rivers is perhaps 10% of their original sustainable maximum. Rehabilitation efforts in such regions are likely to have a major impact upon production, and there are growing signs that this option is being taken seriously.

## 7.2 Enhancement by Facilitating Access to the Fishable Stocks

For a given stock of fish, it is often possible to raise yields by making fishing conditions easier. This can be achieved by concentrating fish in an area where they can be captured, or creating a physical environment where fishing is easier. Obviously, such techniques only have potential if stocks are under-exploited.

Fish aggregating devices (FADs) take advantage of the behaviour patterns of the target fish in order to collect them in a confined area and, thus, make them easier to catch. FADs are commonly used in traditional inland fisheries, such as the "brush parks" (acadjas) of West Africa and South-East Asia. These consist of cut branches, bamboo etc., set in specific areas, followed by capture of the concentrated stock. New environments, such as reservoirs, presumably present opportunities for extending the use of FADs to these areas. Historically, the improvement of access to fish stocks, for fishing communities, is a neglected area. In man-made lakes, and reservoirs, there is often much scope for preparing the area, before flooding, to ease fishing activities. For example, the provision of areas free of drowned brush, or forest, can enhance access. Conversely, areas deliberately left as difficult to fish, by leaving, or providing, obstructions, may form refuges for fish, or control the use of active fishing gears, in favour of passive gears, with benefits of increased participation and/or catches.

## 7.3 Enhancement by Biological Interventions (Introductions and Stocking)

Biological manipulations of ecosystems, involving species introductions, or strain transfers, and improvements through culture-based fisheries (stocking), show particular promise. Culture-enhanced capture fisheries activities can be regarded as a form of extensive aquaculture. The present document concentrates on those activities where capture fisheries dominate the cropping of the resource, and where there is little, or no, supplemental feeding once the stock has been released.

### 7.3.1 Species introductions

The most successful, and dramatic, man-made fisheries enhancements, worldwide, have come about through the introduction of fish species to localities where they did not exist naturally. Aquatic organisms have been introduced for a variety of reasons, including to develop food fisheries, particularly in the developing world, sport and recreation, aquaculture, disease and/or pest control, for ornament or simply by 'accident'. In terms of food production, some of these introductions have been spectacular. The establishment of a stable fish population, by the introduction of a species to a water-body, or watershed, can provide yields of a valued species where none existed before. This intervention has probably been responsible for the largest increase in food resources from fisheries, particularly in tropical Africa, than any other activity since the introduction of highly efficient catching gear in the 1950's. For example, in Sri Lanka, introduced tilapia have exploited a niche in reservoirs, and other small water bodies, previously under-utilised by the native fauna, resulting in a productive fishery with a total production of some 27 000 to 38 000 mt/yr.; equivalent to over 300 kg/ha/yr. This has provided over 20% of the fish consumed nationally, but this fishery has recently declined due to a decrease in institutional support for inland fisheries development.

In a number of African lakes and reservoirs, the introduction of a small zooplankton feeding fish has established large, and stable, populations which support important artisanal fisheries. On lake Kariba alone, the 'kapenta' fishery now produces an annual catch of some 20 000 mt, all of which probably represents a real increase in total fish production above levels that could be achieved without such interventions. Where there is a high production of fish with relatively low value, the introduction of a high value predator may convert the low value fish into a high value resource (c.f., the introduction of Nile Perch into Lake Victoria, or the re-introduction of salmon into the Laurentian Great Lakes).

This form of intervention, is a relatively easy, low-cost, option that does not demand an on-going programme for its success. Introducing a known, and valued, species is often seen as the 'obvious' action to take to enhance fish production from a water body. Introductions make most sense where a 'vacant' or 'under-utilised' niche occurs. Whilst the concept of a vacant niche is controversial, from the viewpoint of fisheries production, such opportunities clearly exist. Better utilisation of trophic niches, or replacing a species considered of lesser value, can make great contributions to an existing fishery, or create one where it did not exist before.

Opportunities for species introductions can arise from various sources. Natural factors may have resulted in vacancies, due to natural zoogeographic influences, such as geological isolation or the effects of glaciation. A more recent spate of opportunities for introductions has been brought about by human activity.

Pollution and habitat degradation have resulted in shifts in natural fish communities, sometimes resulting in vacancies. Species may be introduced that are better able to withstand these changes in habitat, and water quality, for the betterment of fisheries production.

In particular, the construction of artificial reservoirs, ranging from massive dam projects for hydropower generation, down to small retentions for cattle watering and small-scale irrigation, inevitably results in shifts from riverine to lacustrine conditions. Despite the water retained generally being of good quality for fish production, invariably the original riverine fish communities are unable to fully exploit the changes in ecological conditions that arise.

Introductions can also be beneficial in improving fisheries in indirect ways. Biological control, by introducing species, would be a case in point. For example, the successful control of aquatic weeds, such as the floating water-fern *Salvinia* spp, can improve fisheries through the enhancement of the environment and improved access to fishery resources.

Introductions, effectively, are one-off activities. Once the introduced species is successfully established, it will usually require no further intervention to maintain the stocks. It is precisely for this reason that introductions are popular, and, if well-planned and managed, they can be very cost-effective ways of providing significant fisheries benefits. The action is usually irreversible in practice. In this regard, introductions differ from "stocking", which is the continual, or repeated, release of stock into the same water body.

### 7.3.2 Enhancement by stocking (culture-enhanced fisheries)

Stocking is generally a form of aquaculture, whereby young fish are, normally artificially, bred and raised, to be later released and dispersed in either a natural or artificial environment. It differs from introductions by being a continual or repetitive process. Stocking of natural, temporary or permanent, small water bodies, and the larger man-made impoundments, offers great potential for enhancing production on a global scale. Stocking can be a beneficial intervention in any body of water where it is known that the production potential exceeds the current yield potential, provided a fishery exists, or will develop, that can exploit the improved resource. It is generally an option where one or more factors limit recruitment into the fishery. For instance, fish species which do not self-reproduce in a particular habitat (e.g., Chinese carps in tropical reservoirs), are often stocked to achieve high yields, through the efficient utilisation of available niches.

Probably the most common reason for stocking a water body is the lack of suitable breeding areas for the fish community, due to human modification of the environment (e.g., blocking access to spawning grounds). This is particularly the case with stocking activities for cyprinids in the Indian sub-continent and China. A shortage of breeding adults, either through over-fishing, or environmental disturbances, is also another common reason why stocking is used to enhance recruitment. Water bodies which dry up every year, represent perhaps the ultimate situation of a lack of recruitment to the next season's growing stock of adults. Although many of such water bodies may be partially restocked from wild fish populations, these are unlikely to provide the numbers, or more importantly the kinds, of fish that are required to support a productive fishery. These seasonal, smaller, water bodies can be extensive, especially in Africa and Asia. Despite their high potential productivity, many are not currently managed through stocking. Considerable potential exists for increasing fish production from this source.

An example of the potential for enhancing temporary waters, or perennial waters that undergo a regular seasonal cycle of flood and draw-down, is the programme for stocking and physically managing ox-bow lakes ('beels') of the Brahmaputra floodplain system in India.

Here, production of the fishery has been increased significantly by the construction of hatcheries, water control works and by consideration of the socio-economic needs of the communities which will exploit the stocks. A very effective system of stocking is also in operation in Bangladesh. In both these areas, as others, there is still further scope for significant improvements.

## 7.4 Advantages of Culture-enhanced Fisheries

Compared with other sectors, such as more intensive forms of aquaculture, the advantages of promoting appropriate culture-enhanced fisheries, through stocking, vary considerably, according to local circumstances. Important advantages often include:

- Production is increased through *low input* systems; primary production is maximised to increase yields.

- In general, species low in the food chain can be used, such as phytoplankton or zooplankton feeders, which helps maximise biological efficiency of production.

- Exploitation of the resource as a capture fishery results in *increased participation.*

- Beneficiaries are generally *low income*, or *resource poor*, groups.

- Existing *water resources* are utilised.

- *No pollution* or environmental disruptions occur (except issues relating to the use of exotic species or strains as noted above).

- *Limited management requirements*: once the stock is released, then management inputs into the rearing process are not generally required.

- *Socio-cultural appropriateness*, especially in areas where farming systems are poorly developed. In many areas aquaculture suffers from socio-cultural constraints particularly where the activity involves alien concepts. However, fishing can often be socio-culturally acceptable. In such circumstances, the products of aquaculture (fish stock) can often be channelled through to user groups more effectively, through enhancing capture fisheries activities.

- The combination of these features results in much of the catch contributing directly to the diet of low income communities, of immediate relevance to *food security* issues.

People new to formal freshwater aquaculture tend to come from agriculturally orientated communities; a process that is often actively promoted. To a large extent, these communities are already comparatively resource rich, since they have access to land. Fishing communities, on the other hand, are often characterised by a lack of access to agricultural land. The promotion of stocking may tend to assist the poorest groups, and, hence, those subject to the highest risks from food insecurity. Increased, or sustained, participation in capture fisheries, brought about through stocking, will also help abate urban drift and/or reduce pressures upon marginal agricultural land, at least in the short term. One often alleged advantage of the development of more intensified forms of aquaculture, is that it will relieve the over-exploitation of capture fisheries. But this general scenario is probably incorrect. In reality, improving capture fisheries, through stock enhancement, is more likely to benefit aquaculture and agriculture than *vice versa*.

## 7.5 Technical Frameworks and Requirements for the Development of Stocking Capabilities

### 7.5.1 Information: data collection and analysis

The preparation, and prioritisation, of programmes of fisheries enhancement, through stocking, will require two broad fields of information:

- an inventory of the water bodies of an area, and their fauna and flora; and,

- an assessment of the current level of exploitation and yields.

The collection, collation and analysis of this information are generally within the remit of government technical departments. There is considerable scope for detailed short-term investigation work to be undertaken by the private sector, academic, and other educational, organisations and NGOs. Once acquired, these basic data will need to be analyzed in relation to the following factors.

Fishery enhancement, particularly through stocking or introductions, is based on the assumption that existing yields are below theoretical limits. Estimates of both of these are, therefore, essential. In many cases, data on current yield are severely lacking, and efforts to improve basic data collection need to be strengthened.

The assessment of potential production relies on an evaluation of a complex of factors that, together, control the energy fixation and energy transfer pathways. Of primary importance are: climate regime, especially seasonal temperatures; water regime, including variations in inflows, outflows and water levels; physical structure of the water body, including area, shape, shoreline development, depth profile; chemical make-up of the water and any seasonal effects; and, the structure of the biological community supported by the water body, especially the fish populations, including the plant and animal communities which support them. In addition, it is necessary to understand the pattern of the human communities that exploit and utilise the resource in question.

In the longer view, it is necessary to consider the impacts of changes outside the water body, such as shifts in land use, changes in climate patterns, or changes in administrative policies or priorities. Whilst for many countries these are daunting tasks, the increased access to Geographic Information Systems (GIS) has reduced the effort needed to construct the required databases. Such advances are likely to be accompanied by improved methods for predicting management options in relation to resource availability. Additionally, countries should not overestimate the level of data and analysis required to obtain basic planning guidelines.

Once data have been collected, compiled and analyzed, potential production needs to be predicted. Currently, methods of predicting fish production from freshwaters are very basic, but can provide rough estimates for rivers, lakes and reservoirs. There is a need for the scientific community, at large, to refine these modelling systems. In particular, there is an urgent need to produce working models of the possible biological/ecological consequences of species introductions, or stocking, on ecosystems, in order to assess the potential benefits, or risks, of such management actions. Whilst there has been much attention in recent years to "fish stock assessment" (i.e., the characteristics and responses of the stock being exploited), there has been only limited progress on this subject in freshwaters. Appraisals also need to shift more towards "fishery assessment", which acknowledges the technical, economic and socio-cultural aspects of fisheries, besides the behaviour of the stocks upon which a fishery is based.

Where there is a significant discrepancy between current and potential yield, which cannot be realised by increasing effort or adjusting some other facet of the fishery, then introductions and/or stocking will be realistic options.

### 7.5.2 Assessments of the economics of stocking

Once it has been established that fish stocking is technically feasible (i.e, natural production is below potential enhanced production), the question still remains as to whether it is an economic option. There has been a remarkable lack of attention to the economics of enhanced capture fisheries. However, two activities have been subject to relatively in-depth study. First, in marine ranching, high value species (usually top level carnivores) are generally released into large areas (literally oceans), with mixed results, and there is limited ability to control or monitor mortality, including that due to unrecorded fishing effort. Second, studies on the economics of stocking for sport fishery purposes (e.g., put and take trout fisheries), are distorted by the high extended economic value of the catch. Neither example is particularly useful for the current purposes, and both apply to economic circumstances prevailing in developed countries.

The high investment requirements for marine ranching, together with limited returns, have helped promote a view that stocking (ranching) in freshwaters will perform similarly. However, stocking requirements for freshwaters and oceans differ considerably. In freshwaters, the target water bodies are usually enclosed, and conditions for managing production, and exploitation, far more favourable than in the marine sector.

Fish have a limited ability to move (range) and freshwater systems, generally, have lower species diversity. The lower number of predators, in particular, together with other factors, can help channel the production in the desired direction, in comparison to marine environments. Freshwaters are also amenable to stocking of fish species low in the food chain, resulting in increased efficiency of biological production, which is reflected in large yields per unit area.

There is little doubt that a number of inland stocking activities have a high economic return on investment. Included here would be the aforementioned activities on floodplains in the Indian sub-continent and the stocking of larger reservoirs in China. Conversely, a number of stocking activities are not even based upon any knowledge of potential to increase fish production, let alone economic logic. For most current, and potential, fish stocking activities, the situation probably falls between these two extremes. Improved techniques for assessing the economic benefits, and costs, of fish stocking activities are clearly required. To be realistic, assessments must include all socio-economic aspects of culture-enhanced fisheries, and make allowances for shared infrastructures and inputs (e.g., shared costs for hatchery management, where a proportion of output is also used in more intensive aquaculture). Equally, where comparisons are made with cost/benefit performances of other sectors, these should be based on objective assessments. In particular, comparisons with the economic performance of more intensive aquaculture should consider the wider costs involved, such as inputs of feed or nutrients, which often have alternative uses, and, especially, the environmental costs associated with any pollution that arises from the activity.

### 7.5.3 Infrastructure and personnel

Fish seed requirements are frequently underestimated with stocking activities. Continuous or repeated stocking, as opposed to introductions, requires large quantities of fish seed. For example, in Pakistan, the current shortfall of seed requirements for major reservoirs varies between 94 and 100%, resulting in an estimated potential loss of some 100 000 mt/yr. from associated fisheries. The size at which fish are stocked is also important, and, in turn, has bearing on the numbers that can be produced where facilities are limited. In China, for example, stocking efficiency is often increased by releasing fingerlings at a relatively large size, in order to limit post-stocking predation. However, in other locations, successes have been achieved by releasing much smaller fish. Under some circumstances, even eggs can be stocked, and this has been a successful strategy with, for example, the release of salmonids into upland streams.

Stocking also requires that fish seed are produced, or procured, fairly efficiently, since the costs of operations are relevant to overall economic performance. Whilst some major stocking activities are based on the capture, movement and release of wild stock, the general trend is to produce stock from fish farms. This requires efficient hatcheries, and trained and motivated staff to run both them and the distribution and release of stock. Technical staff may also be required to manage the fishery that exploits the stock released. As for any intensive capture fishery, monitoring is essential, especially to obtain data on the results of stocking. Without this, it is impossible to evaluate economic factors, or adjust stocking regimes to maximise production and minimise costs.

All of such activities require trained and motivated staff. However, for most countries embarking on a stocking programme, these staff may already be available and requirements met by combining aquaculture and fishery roles.

The requirements for efficient, well run hatcheries, together with some degree of overall expertise in basic husbandry techniques, will mean that stocking and more intensive aquaculture will tend to develop together. Certainly, the successful stocking programmes that are known to exist are in regions where more intensive aquaculture is relatively well developed. Countries embarking on stocking programmes without a substantial aquaculture infrastructure, will find progress more difficult.

## 7.6 Prospects for Increased Catches through Stocking and Introductions

### 7.6.1 Introduction

By definition, this activity implies that the species is released into an area where it does not already occur. The scope for utilising introductions to improve production from natural, relatively undisturbed, water bodies is becoming limited. Usually, natural ecosystems have diverse and well developed faunas, which can be assumed to utilise the available production potential relatively comprehensively. There are a number of exceptions, particularly on islands, where natural factors have led to gaps in the available fish fauna. In most cases, these have already been filled, either intentionally or otherwise. Introductions aimed at changing ("improving") the utility of catches (e.g., economic value), are likely to continue, but it is questionable whether these generally improve the absolute food supply.

Introductions into small water bodies (natural or otherwise) offer considerable potential where fish stocks are known to require initiation, or re-establishment. It is difficult to separate this potential from that achievable through stocking the same water bodies, as discussed further below. However, included under the concept of "small water bodies", should be lower-order (small tributary) streams of river basins. Where these occur at high altitudes in the tropics, and water temperatures are considerably reduced, fish stocks can differ significantly between regions. For example, stocks are virtually non-existent in some regions, such as montane Africa or the highlands of some larger islands, but relatively well developed in others, such as the Himalayas. This suggests that considerable scope exists for introductions of coldwater riverine species in the tropics, with significant potential returns. Whilst floodplains of tropical rivers are known to be highly productive, they generally represent less than 5% of the area of tropical river basins. The remaining 95% is, generally, drained by these smaller tributary rivers and their smaller feeder streams. Both cumulative area, and length, of these usually greatly exceeds that of the main river channels. The large catchment area can also results in a larger number of people having access to these smaller rivers. Preliminary data suggest that productions, per unit area, of these streams can rival that from larger, lowland, rivers. Historically, introductions into such areas have usually involved salmonids (mainly trout), enthusiastically distributed in colonial times for recreational purposes. Managing such water resources for food fishery purposes is a more recent concept in many areas.

The greatest scope for further introductions, however, arises through activities aimed at establishing fish faunas able to fully exploit artificial impoundments, including both large and small reservoirs. The majority of existing impoundments have already been subject to a range of introductions. In most cases, it is not known if the production potential achievable through introductions has been fully realised. Hence, scope for further introductions is difficult to quantify. What is known, is that each new reservoir or water body created will offer opportunities for introductions. In addition, the use of species tolerant of adverse environmental conditions is in its infancy. Such introductions would appear, on face value, to offer considerable promise in view of the extent of polluted freshwater habitat becoming available.

Where appropriate, well-planned and successful, introductions do occur, they have the considerable advantage of being very cost effective. They are, generally, the first management option, where enhancement activities are considered appropriate, and may often be the main option for countries with limited infrastructures and hatchery capacities. Introductions are generally followed by stocking activities in those countries with developed or developing aquaculture sectors.

### 7.6.2 Stocking

Despite a number of uncertainties, it is possible to determine that the potential increase in production achievable through stocking activities is very substantial. Where the technique is used properly, it is clearly successful. But in many regions, and types of water body, stocking is still in its infancy. Even in areas where stocking is vigorously practised, it is not known if the sustainable limits to increased production have yet been reached.

A large potential, for increasing production through stocking, is available from the small bodies of water. These are natural depressions, or man-made impoundments, retaining water either seasonally or permanently, for such purposes as irrigation, cattle watering or domestic use. Many are currently derelict. This potential has received some attention in recent years, but the definition of a small water body varies from region to region. Here it is understood to mean anything larger than about 5 ha up to about 1 000 ha. Water bodies smaller than this are effectively "fish ponds"; those in excess of this are larger lakes and reservoirs. However, included in the consideration of small water bodies should be smaller tributary rivers, canals and other diversions which are often neglected but can be significant in extent.

There are an estimated 20 000 small water-bodies (less than 1 000 ha), and nearly 13 million kilometres of rivers and streams up to 100 km in length, in Africa. This total for static waters is probably badly underestimated; Zimbabwe alone has over 10 000 small dams. Small water bodies generally lend themselves to various stock enhancement techniques to the point where these grade into those of extensive aquaculture. By their nature, small water bodies are exposed to intensive human interference, but this can also be beneficial, by increasing participation in enhancement actions. They are also generally at risk from excessive exploitation and degradation.

Small water bodies are numerous and disperse. Stocking them, therefore, helps supply fish directly to local communities, to the benefit of localised food security. Many are allowed to dry up, or are drained, and for others the use for which they were originally constructed has ceased. If management guidelines were available for these, the individuals and communities that control them would be likely to put them into production. Because small water-bodies are more likely to be under some form of "ownership", there is increased potential for efficient intervention and rational exploitation. Interestingly enough, published estimates for Africa, made in 1966, suggested that stocking small storage reservoirs was up to twenty times more cost effective than promoting other forms of aquaculture; subsequent investment generally ignored such assessments, often to its cost.

Initiatives in ox-bow lakes, and other natural or man-made depressions on flood-regulated floodplains, can provide considerable yields. Stocking activities are particularly well developed on the important floodplains of major rivers in India and Bangladesh. In the latter country, for example, catches from ox-bow lakes regularly exceed 2 mt per hectare. These water bodies function, are managed, and are considered here as "small water-bodies", although they differ in that units can be relatively highly concentrated in specific areas.

Considerable potential for stocking, and introductions, is also afforded by medium and larger sized man-made reservoirs. From the mid-1950s, to the end of the 1970s, numerous large impoundments were constructed throughout the tropical and sub-tropical regions. The design of many is less than ideal for fish production and, almost without exception, at the planning and design stage there was no consideration given as to their potential for fisheries. Despite this, a number support highly valuable fisheries (e.g., Lake Kariba). More recently, new reservoirs are being constructed with potential for secondary fisheries activities in mind. These considerations can include fish ladders, modifying water regimes, or sculpting landscapes, so as to enhance potential production.

The requirements for power generation, to fuel industrial development, will promote a substantial increase in reservoir construction over the next two decades. This will especially occur in South America and Asia. With adequate stocking, reservoirs represent one of the major opportunities for increasing fish yields. In Asia, and especially China and India, culture-enhanced reservoir fisheries make a significant, and possibly the majority, contribution to the amount of fish on the inland market. The newness of many of these impoundments, and the high degree of control that is exercised over access and fishing activities, means that yields can be optimised. Stocking activities for reservoirs, particularly in South America, are still in their infancy. In many areas, yields are well below theoretical maximums.

Limited increased production from stocking is anticipated in Western Europe, North America and other developed regions, despite theoretical potential. Water bodies in those regions are likely to be increasingly managed for recreation. Whilst recreational fisheries already provide a significant yield, much of which is consumed, large increases in production for food security are unlikely to arise.

Production per unit area is generally higher in small water-bodies, compared with large reservoirs and lakes, and they can be managed more intensively. However, the dispersed nature of small water bodies, in some areas, means that many are not accessible through existing infrastructures. They can be less cost effective to manage (per unit) than larger water-bodies. Management actions for small water bodies will, therefore, tend to be dominated by introductions and, in the longer-term, stocking activities will need to be promoted among local communities, with larger numbers of satellite hatcheries supplying localised demands for fish seed. This will require a large degree of extension services, and training, amongst local communities. With larger water bodies, or where small units are more concentrated and/or more accessible, stocking activities, and hatchery support services, can become more centralised, intensive and cost-effective. The assumption that small water bodies offer a greater potential than larger water bodies, therefore, does not always hold. Much will depend on local circumstances. However, wherever small, or large, water bodies occur, both usually offer significant potential through introductions and stocking. Appropriate investment in both areas can often be justified.

The potential that is on offer is illustrated by the fishery in Sri Lanka, where the total yield from such small water bodies has been 27 000 to 38 000 mt/yr.; equivalent to over 300 kg/ha/yr. This production is derived mainly from a capture fishery based on introduced tilapia. Also, the potential production from seasonal reservoirs of Sri Lanka, which could be derived from stocking of carps and tilapia, is estimated to be about 1 mt per hectare per year, without any supplemental feeding or fertilisation.

In Sub-Saharan Africa alone, the potential fisheries yield from small water bodies is estimated to be in the order of 1 million mt per year. For Africa in total, the potential could be in the order of 3 million mt per year. This does not include the potential for improved stocking of some 53 000 $km^2$ of reservoirs, with individual areas larger than 1 000 ha, that also occur in the region. In tropical and sub-tropical Asia, the total area covered by the larger reservoirs is in the order of 86 000 $km^2$, with this total expected to rise to some 200 000 $km^2$ by the year 2000. By this time, reservoirs will exceed the area of natural inland waters. This increase in area alone would account for a potential production of 2.28 million mt per annum, based on an average yield of only 200 kg/ha. In Pakistan, the current shortfall of seed requirements for major reservoirs results in an estimated potential loss of some 100 000 mt/yr. from associated fisheries. Yields per unit area achieved by stocking existing, or future, reservoirs in Asia might be much higher than this. It has been calculated, for example, that the application of Chinese management approaches to stocking existing reservoirs in Southeast Asia would result in a *theoretical increase* in production of 2.85 million mt. As a rough figure, there is perhaps a potential increase in production of 2 million mt per year for existing and planned reservoirs in South America, although in this region the level of exploitation may not be as intense as in Asia. It is conservatively estimated that fisheries production from reservoirs in central Europe, and adjacent countries of the former Soviet Union, can be increased between 4 and 6 fold by improved stocking. This translates to a potential increase in production of between 2.8 and 4.5.3 million mt per annum. In Russia, a declining marine catch, and/or access to marine landings, has resulted in increased attention to inland waters, where production could realistically be doubled in the next decade; equivalent to an increase of about 0.4 million mt per annum.

However, the distinction between *theoretical* and *realistic* potential increases in production that can be achieved through applying, or improving, stocking must be clearly made. Theoretical estimates are based on the physical size, and nature, of resources available, potential primary production. They also assume that production is maximised through efficient stocking, and other management actions, and the resource is exploited in an optimal fashion. It is assumed here that the adverse impacts of environmental degradation, including water pollution, do not escalate. Realistic estimates must consider the theoretical potential in the light of socio-economic constraints that can vary considerably between regions.

Successful increases in production per unit area achieved by modest management of stocking in some areas, certainly indicate that, *in theory*, potential increases available from freshwater capture fisheries, through stocking, are certainly in excess of 25 million mt. Whilst this figure has limited utility, it does serve to indicate that *theoretical* production is not a constraint. Obviously, it is important to consider more *realistic* estimates of potential. Actual increases in production will depend on a complex array of socio-economic considerations. These will likely vary considerably between regions, together with potential resource availability. For example, levels of production per unit area achieved by stocking small reservoirs and floodplain depressions in India, or Bangladesh, will not necessarily be immediately attained in Africa. The latter region currently lacks the infrastructure, organisation, population pressures, market and demand systems that contribute to this success elsewhere.

Similarly, despite probable similarities in theoretical yields, production achieved through stocking reservoirs in Asia will not necessarily be realised in South America, because of differences in hatchery capabilities, exploitation levels, consumer preferences and population distributions. Much will also depend on how local demand for fish stimulates increases in production and supply. Developments in associated sectors, such as agriculture and industry, will also play a significant role, as will regional variations in population increases and their impacts. An important point here is that, given suitable local conditions, freshwater capture fisheries in most areas are *able to expand* through culture enhancement activities.

Examples of increases in freshwater fish production that have been, or might realistically be, achieved in some areas have been given. Based on these, on a global scale, and by the year 2010, through moderate stocking, combined with moderately improved management, a *realistic* increase in production would be in the order of at least 5 million mt per annum. It would *not be unreasonable* to suggest that an increase in production of 10 million mt per annum could be achieved, given rational management effort.

This is particularly true because of the availability of small water bodies, where culture-enhanced fisheries could be developed which do not involve sophisticated technology. There will, of course, be considerable discrepancies in improvements between regions and the methods by which this increase is achieved. Where production is enhanced further by applying nutrient enrichment techniques to water bodies, then potential increases in production would be very much higher. However, this prospect ventures more into the consideration of aquaculture.

Significantly, these realistic estimates of increases in production that can be achieved do not require any major technological change. The management requirements are well known and not particularly complex. It is, generally, simply a matter of implementing such techniques. As such, therefore, the prospects of achieving this realistic increase are good. There will likely be significant differences between regions in realising this increased production, according to the extent of existing management infrastructures. Generally, Asia (including central Asia) can be expected to perform well, South America relatively moderately, with Africa performing least well. However, the prospects are such that the less optimistic scenario for Africa may still represent significant progress.

In an approximate order of ranking, for potential increases in aggregate yields, the main areas of stocking intervention are: existing small ponds, tanks and medium sized reservoirs; newly constructed medium and larger reservoirs; and existing lakes and river systems.

### 7.6.3 The potential for utilising genetically modified organisms

Significant progress in enhancing production from certain types of aquaculture has, and is, being made by using genetically modified organisms, such as improved breeds or strains, hybrids or other technologically altered organisms. These developments are, primarily, relevant to prospects for increasing production from more intensive aquaculture. There is limited attention to applying such techniques to stock enhancement activities and this situation can be expected to continue in the short-term. There are, however, two areas where advances in technology may have a significant immediate impact. First, progress in the ability to economically mass produce sterile fish (e.g., through triploidy) will increase the feasibility of stocking in circumstances where uncontrolled reproduction in the wild is a problem. This will also enable feral stocks to be managed more closely through greater control of recruitment. Second, the development of techniques to economically mark mass produced fish, e.g, using genetic techniques ("genetic tags"), will encourage private sector involvement in stocking activities (since it will be possible to discriminate hatchery contributions to the stock and, hence, ownership or rights to resource).

## 7.7 Constraints to Achieving Increased Catches from Stock Enhancement Activities

The effects of pollution and habitat degradation are obviously a major constraint to achieving increased catches from stocking, as for sustaining production from capture fisheries (see above).

Conversely, pollution and habitat changes can also present opportunities for stocking, although generally by necessity rather than through rational planning. Constraints, obviously, also include shortfalls in requirements to achieve progress as outlined above; for example, insufficient trained personnel and technical expertise and, in particular, limited capacity for fish seed production.

In theory, all of these constraints can be resolved through rational planning processes and budgetary support.

The ultimate constraint to increasing catches through stocking, or introductions and transfers, is primary production in the aquatic systems in question. Where primary production is enhanced through fertilisation of the water, then significant increases in yield per unit area can be achieved. This appears to be one way in which production from stocking reservoirs in China is continuing to grow, and relates to trends for intensifying aquaculture. For the present purposes, habitat availability for stock enhancement will be the main constraint. Habitat utility, however, will vary constantly. For example, as natural habitats come under the influence of environmental degradation, their faunas will change, providing stocking or introduction opportunities. Similarly, as reservoir construction increases, so will production potential from their enhanced fisheries. As development progresses, there will also likely be localised shifts, from stock enhancement for food production, to enhancement for recreation or habitat rehabilitation. Such trends may ultimately affect food production, but are unlikely to seriously affect food security, as they will be accompanied by improved economic well-being.

The purpose of stock enhancement is to manage fish production, through the controlled manipulation of the fauna and flora, so as to achieve the desired result. Unmanaged, or inappropriate, introductions and transfers, therefore, are a significant constraint. Since it is usually difficult, if not impossible, to reverse introductions or transfers, it is particularly important that these management options are based on considerable forethought and planning. The widespread neglect of existing codes of practice, or guidelines, for the introduction and/or transfer of aquatic organisms, illustrates this constraint.

Perhaps the greatest constraint, to achieving significantly increased production from stock enhancement, in the short-term, is the attitude and approach of managers and planners, including those in some institutions. The prospect of "aquaculture" development is often seen as a panacea for increased fish production. This view is based mainly on historical progress achieved in Asia and, therefore, generalisations are particularly vulnerable; especially as China alone dominates production from freshwaters. But to many the term "aquaculture" implies the higher profile intensive, or small-scale, operations the activity is more popularly known for. Such activities are also dominated by business and commercial interests, which can further distort the perspective of the field, and investments in research. Lower profile activities associated with culture-enhanced fisheries tend to be ignored, yet are likely responsible for a disproportionate amount of current freshwater aquaculture production, possibly the majority, and certainly offer significant potential for increase.

The situation is not helped by the tendency for "aquaculturists" and "capture fishery" personnel to polarise, leading to a continued, and increasingly illogical, dichotomy of the two fields. Significant progress is unlikely to be made, until the potential for increased production that combining the two fields offers is more widely acknowledged. This process may be considerably hastened if the reporting of aquaculture, and capture fishery statistics, were refined. This might enable production involving both activities to be clearly identified, with trends, and the contributions of various activities, clarified. One way to assist this may be to define a range of aquaculture activities based on the method of exploitation (harvest) of the stock.

With more formal aquaculture, many of the technical advances seen over the past decade, or so, have been driven by the private sector, often with limited government input. A major constraint to increasing production from stocking, is that the private sector is unlikely to be heavily involved with its development, unless issues relating to the ownership of stock are addressed. Of course, the private sector often dominates the production of stocking material (for example in India and Bangladesh), but the activity is usually driven and/or subsidised by government. It is rare for the private sector to be involved in the management, development and or cropping of the resource, unless the activities occur in individually, corporate or communally owned water bodies. Most of the major areas, where increased production from stocking is anticipated, are open access (in itself not undesirable). It is unlikely that the private sector will embark on programmes to release valuable seed material into such areas without guarantees over returns on this investment. There are solutions to these problems, but these are likely to arise slowly on a case-by-case basis.

Whilst private sector involvement in seed production, stocking, cropping and marketing is to be encouraged wherever possible, generally, there will be short-falls in involvement. Consequently, in many cases, the *institutional or government sector* will be required to take the *major initiative* and provide the major investment (or underwrite private sector investment), if production from stocking programmes is to increase significantly. To a large extent, this differs from the potential for increased production from other aquaculture activities, which can be expected to be, and should be, driven more by the private sector. *This conclusion has a major bearing on institutional and government investment policies and programmes.* In brief, governments and institutions should consider funding stocking activities. In the longer-term, private sector management of stocking activities should be encouraged, where necessary and appropriate, by resolving issues over resource use, or access rights, on a fair and equitable basis.

In general, the success or failure of any intervention rests on the abilities of local administrations to organise initial assessments, provide scientific and technical back-up, initiate and support ongoing programmes of inputs and regulation, liaise with, and obtain the co-operation and involvement of, the local communities, and undertake the appropriate programmes of training and extension.

## 8. CONCLUSIONS

### 8.1 General

The contribution of inland capture fisheries to food production is well in excess of what reported statistics might suggest. Factors further increasing the significance of freshwater catches to food security include: levels of participation, the extent of utilisation of the catch, the involvement of women and children and the diffuse and dispersed nature of fishing, processing, marketing and local distribution systems.

The overriding tendency for local consumption of the product, with negligible discards and limited wastage, is testament to the value of the product among local communities. Catches from inland fisheries can be more accurately expressed as consumption *per caput* figures than for other sectors.

Notwithstanding the importance of informal aspects of inland fisheries, there are a significant number of important commercial/artisanal fisheries in many regions. Fisheries in the larger open water regions, for example, are beginning to resemble marine industrial fisheries, having similar management requirements and problems. A significant number of fisheries in other areas are equally as important as these in generating income and employment: for example, artisanal fisheries on the Amazon River or those associated with the exploitation of the Kafue floodplains in Africa; similarly for Europe, Asia, North America, and Oceania.

Whilst inland capture fisheries produce a relatively high value product in much demand by more affluent communities in some regions, in many other regions freshwater fish represent an essential, and often irreplaceable, source of high quality animal protein crucial to the balance of diets in marginally food secure communities. In this respect, the food security of many resource-poor communities is threatened by the ever-increasing effects of environmental degradation and, in particular, the damming or diversion of rivers, industrial water pollution, and land degradation arising through agriculture and forestry activities. The impact of the resulting decline in inland capture fisheries will very much depend on the level of improved integrated basin management and/or the potential for affected communities to participate in the benefits of the development processes fuelling these changes. Optimism for progress will increase as these factors become more recognised.

The need for improved integrated resource management, on a basin-wide basis, should be clearly noted by governments. Decisions relating to the allocation of water resources need to incorporate multiple use considerations for aquatic resources. For this to occur on an equitable and sound economic basis, governments need to gather more information on the current value and utilisation of freshwater habitats. Where projects will have major impacts on freshwater resources, governments need to make clear, unequivocal, decisions on whether or not they wish to keep the resources in question. These issues must often be considered in stark, realistic, terms. In some cases, technical inputs into political decision making processes would be greatly enhanced if there were national infrastructures able to analyse the available options on the basis of cross-sectoral impartiality.

Without enhancement or rehabilitation, on a global scale, the potential for increasing catches from inland fisheries is limited. It is likely that any increased catches from localised areas, or regions, where feasible, will be offset by declines, or collapses, in fisheries elsewhere. It is on this basis that absolute catches from the sector may be sustained. However, serious and widespread attention to the potential for rehabilitation of freshwaters would lead to a significant increase in production from associated fisheries, particularly for rivers. Nonetheless, the greatest significance of inland fisheries, to food security issues to the year 2010, is the extent to which catches can be increased through enhancement activities, especially stocking.

Culture enhancement of fisheries, or stocking, has likely been responsible for most of the increase in *per caput* yields from freshwaters (aquaculture and capture combined) on a global basis over the past few years. There are good reasons to believe that this trend will continue. Stocking offers significant increases in landings based upon low input systems (extensive aquaculture), with improved biological efficiency (using fish species low in the food chain) and with opportunities for high levels of participation by people. For this potential to be realised, appropriate infrastructures will need to be improved and/or developed. Management actions will require the combined efforts of both aquaculture and capture fisheries personnel. This is already occurring, and to such an extent that the division between the two disciplines will become even more superfluous.

One reason for optimism, regarding the prospects for stocking, is that the management systems involved are relatively simple and based on proven technologies. More importantly, they do not require gross changes in approach or, necessarily, result in conflicts with other sectors or users of resources. The nature of culture-enhanced fisheries, however, currently requires that, at least in the short-term, much of the initiative will have to be taken by governments and institutions.

## 8.2 Perspectives for Future Production from Inland Capture Fisheries - Three Hypothetical Scenarios to the Year 2010

### 8.2.1 Limited optimism

To those familiar with the extent, and escalation, of environmental degradation of freshwaters, and aware of, and sympathetic to, the dependence of low income groups on freshwater fisheries, pessimism comes easy. Without improved attention to such issues, freshwater capture fisheries are unlikely to be sustained and major regional collapses may occur. Where opportunities for participation in alternative food production and/or economic activities are limited, localised food insecurity will become a fact. Many people are currently vulnerable to this scenario, especially those dependent upon on unregulated tropical river floodplains or relatively undisturbed major lakes. If the opportunities are ignored, there is a real possibility that losses in total regional production from freshwater capture fisheries will not be offset by increased production arising from enhancement activities. The resulting picture is distasteful but, fortunately, unlikely, except on a local scale.

### 8.2.2 Realistic

There are reasons for optimism. Governments are becoming increasingly aware of the issues involved and, more importantly, willing to do something about them. More affluent societies are beginning to rehabilitate freshwater environments to such an extent that some badly affected areas now approach their natural condition. Demands of a public, increasingly aware of the aesthetic and recreational value of these resources, are primarily driving these changes. Neither is such progress limited to the developed world.

There are a growing number of examples in industrialising and developing countries that indicate attitudes are changing. Even modest improvements in basin-wide integrated resource management are slowing down the decline of water quality in some regions. For a number of areas where conditions are critical, governments are more willing to invest in management actions that promote the sustainable use of freshwater resources.

The benefits of improved, sustainable, inland fisheries are, in many instances, being acknowledged as sound economic arguments for rehabilitation programmes. Increased population pressures, however, will remain a major constraining factor in a number of areas, particularly Africa. The opportunities for culture-enhanced fisheries are now being seriously addressed outside of regions where significant progress has already been made. Recreational uses of freshwaters will increase, especially in the more affluent industrialised economies.

On a localised scale, serious deteriorations in freshwater capture fisheries are likely to continue to be experienced. Improvements in other localities, however, may compensate and total regional catches may be sustained. Increased landings, achieved chiefly through improved or extended stocking activities, combined with other management interventions, can be realistically anticipated.

It is not unreasonable to expect that these increases will be in the order of 5 million mt globally. These increases might be much higher, if the possibilities for nutrient enrichment of water bodies are considered, especially where demand is high and there is access to large cumulative areas of reservoirs. This scenario requires only modest and realistic expectations of improved management.

### 8.2.3 Optimistic

The increased awareness of the value of freshwater resources may escalate into significant global improvements in integrated resource management. Governments may be increasingly willing to moderate short-term economic considerations, in favour of long-term sustainability of freshwater habitats for the benefit of both food security and improved lifestyles.

The net result may well be a reasonable increase in total catches from freshwaters, achieved without increases in stocking activities. Locally, these increases may be substantial. Significantly improved management of culture enhancement of capture fisheries (stocking), on a regional or global basis, could provide dramatic increases in overall production, especially if combined with artificial enrichment to enhance primary production. The quantified level of this increase will depend very much on associated economic factors, such as trends in demand etc. However, there is *technical potential* to maintain world *per caput* supplies of fish to the year 2010 through these activities alone.

This scenario does not depend on technical advances but on significant changes in management strategies and infrastructures. Therefore, estimations of the likelihood of this situation being achieved can only be speculative.

## 9. TRENDS, PROSPECTS AND ISSUES BY REGION

Total inland capture fishery yields by continent for the period 1984 to 1993 are indicated in Figure 2.

### 9.1. Africa Region

The species composition of catches in Africa is very diverse with fisheries capturing many tens of species. This is reflected in the high proportion of "others" in the data which would include principally mormyrids, characins and catfishes. The high proportion of Nile perch has arisen almost entirely from the large commercial fisheries of Lake Victoria. Total catches for the region have risen fairly steadily until 1990 and have subsequently levelled-off. The possible decline between 1977 and 1981 was largely due to the effects of the Sahelian drought on the fisheries of the arid sub-Saharan zone.

Fisheries in rivers of Africa form an important source of food and income, especially in rural areas of the continent. Fisheries tend to be multi-specific with a wide range of species being acceptable. In rivers, up to 60% of the catch is taken from higher order streams and tributaries within the catchment area. Here, most of the fishing is occasional or part-time and often conducted by women and children. This aspect of the catch is almost certainly under- or un-recorded. The Nile delta is perhaps one of the most intensively farmed areas anywhere in the world. The presence of a major dam on the Nile, the Aswan High Dam, behind which is the man-made lake, Lake Nasser/Nubia, is typical of most major African rivers. Lake Kariba on the Zambezi was the first of the major impoundments on tropical rivers. Like most subsequent major dams in Africa, the main purpose is for hydropower but some are multipurpose. All of the major man-made lakes have developed significant fisheries. A considerable number of smaller impoundments on minor rivers are used for irrigation and or watering cattle or other livestock.

A second feature of Africa is its large natural lakes. These are being increasingly subjected to water pollution, especially siltation and the effects of discharges from urban settlements. Several of these lakes have natural thermoclines below which pollutants can accumulate. Seasonal mixing can cause serious problems for the biota in upper layers. The extent to which nutrient enrichment of waters will contribute to increased fish catches is not known. Of greater concern is the potential for collapses of fisheries due to excessive nutrient inputs. A widespread impact over Africa, especially eastern Africa, is the overall consequence of an increasing rural population and the attempts to use extensive unimproved agriculture to feed the expanding population in lake catchments. This manifests itself as increases in deforestation and land clearance for both the growing of crops and for fuel wood and animal forage. Consequently, the conversion of original forest/woodland cover to grazing land or subsistence agricultural fields is occurring in a fashion clearly parallel to current developments in river basins. Many African Lakes have naturally very clear water accompanied by high fisheries production based on a deep zone of primary production. Increased turbidity due to such external impacts could very well trigger serious declines in their fisheries.

### 9.1.1 Sub-region: Africa north of the Sahara

*[Algeria, Libya, Morocco, Tunisia, Western Sahara]*

North of the Sahara are the Mediterranean coastal countries with climatic regimes of high summer temperatures, very low rainfall and in consequence little surface water. Access to marine stocks and the dearth of inland Water-bodies means that fish production from inland waters plays a very small part in their economies.

#### Production

As would be anticipated from the arid nature of these countries, production from inland waters is very low. In 1992, the total inland fisheries catch reported for the five countries of the sub-region was 2 009 mt. **Algeria** reported an inland fisheries production of 288 mt and **Morocco**, which has some 500 $km^2$ of impoundments, reported some 1 800 mt. Both countries have showed a small increase in recent years. However, it is probable that all of this increase is obtained from culture-enhanced fisheries. **Libya, Tunisia** and **Western Sahara** report no catches from inland waters. The inland waters of the sub-region, excluding the harvest from fish, have provided an average of 27 g *per caput* over the years 1987 to 1992.

#### Issues

Inland fisheries play a very minor role in the food economies of this group of countries. Due to the scarcity of freshwaters it can be presumed that any significant increase in fish from inland sources will only come about through the adoption of aqua practices and the stocking of any impoundments that may be utilised for water storage for consumption or irrigation. Recreational uses of freshwaters are not reported but may be modest and likely to increase.

### 9.1.2 Sub-region: Trans-Saharan Africa

*[Chad, Djibouti, Egypt, Mali, Mauritania, Niger, Somalia, Sudan]*

The countries of this group straddle the Sahara, and are generally subject to climatic regimes with high temperatures and very low rainfall. However, in many cases, they also have significant fisheries resources from lakes and river systems which are on the edge of the arid zone or, in some cases, traverse it. Fisheries production levels throughout this region are highly dependent on the rainfall regimes, both from season to season and within the long-term cycles of drought and recovery. The fish production of seasonally inundated areas dominate the catches. The stocks exploited are typically large masses of fast growing young fish taken either directly from the floodplains or by fishing the concentrations of fish in the residual rivers and lakes. The most highly productive regions are the Inland Delta of the Niger and Lake Chad. Lake Chad, which occupies a shallow depression on the edge of the desert, shares some of the characteristics of a floodplain fishery with that of a shallow tropical lake.

The changes in the size of landings appear to be almost totally a reflection of the cycle of rainfall and flood and, apart from strictly local conditions, there is little significant evidence of excessive fishing effort leading to destructive over-fishing. The floodplain environment enables a rapid recovery of stocks after heavy exploitation.

Fishing is carried out using simple technologies and with the participation of large numbers of, often migrant, artisanal fishermen. This pattern of exploitation is very responsive to the fluctuating levels of production.

Throughout the area, consumer demand is rising rapidly with the increase in populations, a condition exacerbated by the migration of large numbers of people due to political or climatic disturbances.

Between 1987 and 1992, this sub-region produced an annual average of 5.966 kg *per caput* from its inland water capture fisheries.

**Production**

In this sub-region **Egypt** reports the largest production from inland waters with a total of 169 814 mt for 1992. Of this total, some 30 000 to 35 000 mt is derived from the fisheries of Lake Nasser (of which Egyptian territorial waters total 5 811 km$^2$ or 85%). This total is close to the estimated maximum sustainable yield from this resource. Production from the delta lakes, the River Nile, Lake Nasser and the exploitation of the large network of irrigation canals and associated impoundments, appears to have been steady since 1987.

The fish resources of Lake Chad, which at its maximum expansion covers some 22 200 km$^2$, are shared between the countries of **Chad** (50%), **Niger** (18%), **Nigeria** (25%) and **Cameroon** (8%). To a great extent, the production is relatively mobile and marketed in the countries where the fish fetch the highest prices (currently Nigeria). Under these conditions the extent of the territorial waters, and the partitioning of the lake, is not very significant to the functioning of the fishery. In addition to natural perturbations such as the change in the water area due to climatic conditions, there have been a number of serious political upheavals over the last few decades which have disrupted the fishing and which have caused catch records to be unreliable.

Annual landings for Lake Chad rose from 29 000 mt in 1969 to 220 000 mt in 1973, falling to the lowest level of 21 700 mt in 1981. Since then, yields have varied between 30 000 and 80 000 mt with the 1989 record being 55 000. The fluctuations in yield follow the changing area of the lake and in the driest conditions both Niger and Nigeria have no territorial waters.

The markets of **Niger** are highly reliant on the fish yields from Lake Chad. The Sahelian drought of the 1970s effectively removed this source, with fish yields dropping from 16 400 mt (greater than 2 000 ha) in 1972 to 4 715 in 1977.

In 1991 and 1992 production was only some 3 120 and 2 039 mt respectively. From being an exporter of fish, particularly to Nigeria and Benin, since 1982 Niger has been a net importer of marine fish from Senegal, Ivory Coast and Mauritania, with imports rising to about 25 000 mt by 1990.

For **Mali**, some 85% to 90% of the total fish catch derives from the Central Delta of the Niger. Since 1966 the national fishery has been in a steady decline with a fall from 129 000 mt in 1966 to 63 000 mt in 1984. Since this date the catch has not exceeded 99 000 mt and in 1992 was reported as 68 467 mt.

During the period 1966 to 1989 the numbers of fishermen active in the Central Delta region rose from 43 000 to 63 000 whilst the annual catch per fishermen fell from 1 900 kg to 740 kg. There is some evidence of localised over-fishing. This fishery is highly dependent upon the seasonal extent of the floodplain and the change in the catch levels is influenced by the prevailing rainfall patterns.

**Chad** has an annual catch estimated at 65 000 mt in 1992 and estimates over the last 6 years have varied little from this total. These data were estimated reflecting the difficulty of collecting statistics from the remote areas around Lake Chad and the floodplains of the south of the country. These floodplains, with an area of some 50 000 km$^2$, are a potentially large fishery resource, which appears to be currently under-exploited.

**Mauritania** is generally arid and short of inland water resources. From some 42 km$^2$ of lakes and 600 km length of the River Senegal, Mauritania, produced an estimated 6 000 mt in 1992.

**Sudan** has access to the productive resources of the River Nile including the Sudd wetlands (from *c.* 50 000 to *c.* 100 000 km$^2$ in area) to the south of the country and, at high water, 1 144 km$^2$ (15%) of Lake Nubia/Nasser behind the Aswan High Dam. There are also a large number of small reservoirs associated with irrigation schemes. The area to the south of the country has been involved in civil war for the last thirty or so years which makes any attempt to estimate production, or gather statistics, almost impossible. It is estimated that in 1992 some 30 000 mt of fish (97% of the total landings) were taken from the inland waters, mostly by the artisanal sector.

A considerable resource potential occurs in reservoirs, but particularly canals, of the extensive irrigation schemes located between the rivers of the Blue and White Nile. For stock enhancement to lead to significantly improved catches (and environmental conditions) integrated management of the canals should be improved for multiple use.

**Somalia** has few inland water resources. Estimates suggest that it produced some 300 mt in 1992 from its wetlands and rivers.

**Djibouti** has no inland fisheries resources but has access to ample marine stocks.

**Issues**

With high ambient temperatures and poorly developed transport systems the product tends to be a relatively low value sun-dried, dried-salted or smoked fish destined for small rural and urban markets. However, it is doubtful whether there is any benefit, in economic or food value terms, in improving the quality of the product. There may be some scope to reduce post harvest/processing losses.

Any management interventions, or even evaluating the scope of the fisheries of this sub-region, is difficult as the fishing, processing and transportation to markets is undertaken by numerous, dispersed, small, highly mobile artisanal units. These often work from temporary camps. The industry crosses many national boundaries where there is little control and most of the activity is carried out remote from central administrative centres. It is against these practical difficulties and the fluctuating environmental parameters that inter-country co-operation for management of the fisheries, as exemplified by the Lake Chad Basin Commission based on Ndjamena, is proving very difficult.

### 9.1.3 Sub-region: East Africa south of the Sahara

*[Burundi, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zaire, Zambia, Zimbabwe]*

In this sub-region are found some of the major freshwater resources of the African continent. These include the large deep lakes of the two arms of the African Rift Valley (lakes Turkana, Albert, Edward, Tanganyika, and Niassa/Malawi) and the relatively shallow lakes (Chilwa, Rukwa and Victoria). Many of these Water-bodies are shared between two or more riparian states. The area is subject to a climate generally characterized by a high temperature regime, modified locally by elevation, and with a wide range of environments from heavy rainfall forest areas to dry savannah and semi-desert. Fishing is dominated by the production of the great lakes and to a lesser extent the rivers and wetlands in their catchment areas.

The inland fisheries of the sub-region produce an annual average of 4.963 kg *per caput* although this figure includes the quantity of Nile Perch which is exported.

**Production**

The major single fishery is that of Lake Victoria which is yielding some 500 000 mt a year, shared between Kenya, Tanzania and Uganda. The catch is predominantly Nile Perch with a considerable contribution from Nile Tilapia, both introduced species.

The total value of landings is some US $ 250 000 000 with associated activities valuing the fishery in excess of one billion US $.

**Burundi** shares Lake Tanganyika and has territorial waters covering some 2 600 km$^2$ (8% of the total water area) of the highly productive north-east portion of the lake. The total country-wide production was 22 983 mt in 1992, of which most came from the Lake Tanganyika fishery. This represents an increase of some 100% since 1989. Recent years have seen a change in the fishery from that of commercial purse seiners to an artisanal fishery using catamarans with liftnets (introduced in the 1970s). It is estimated that from 1993 Burundi was a net importer of fish, mostly from Tanzania.

**Tanzania** has access to the fish stocks of two of the largest lakes in Africa, Lakes Victoria and Tanganyika. Total inland fisheries production was reported as 275 100 mt in 1992 of which Lake Victoria accounted for some 231 600 (1990) and Lake Tanganyika 64 900 (1990). Tanzanian catches increased to peak in 1986, mostly through the increase in the landings of Nile Perch, and since that time have remained fairly stable. Tanzania has built up a considerable export trade in Nile Perch with some 35 000 mt being exported to Kenya in 1991. There is a considerable cross-border trade which is not recorded both for the export of Nile Perch to Kenya (probably 30% more than the officially recorded trade) and for Ndagala (*Limnothrissa* sp and *Stolothrissa* sp) from Lake Tanganyika, as dried products to neighbouring countries, particularly Burundi. Tanzania has a small territorial area of Lake Malawi, although this is little fished as the landings are too far away from significant markets.

Most (94% in 1991) of the inland fisheries production of **Kenya** comes from Lake Victoria, a total of 190 000 mt for each year between 1990 and 1993. Kenyan territorial waters cover 3 785 km$^2$ (69%) of the lake, but this includes the highly productive north east portion which accounts for the Kenyan catch being some 86% of the total for the lake. Other lakes and rivers, including the Kenyan part of Lake Turkana, contributed only a further 3 800 mt (1991). The processing and export of Nile Perch has become a very important external currency earner. This trade is amplified by the, generally unrecorded, processing and exporting of fish derived from the cross-border trade in Nile Perch and other fish from the Tanzanian and Ugandan fisheries. The fisheries resources of Kenya appear to be exploited near, or over, their sustainable maximum.

**Uganda** possesses a rich fisheries potential which in part is shared with neighbouring countries; Lake Edward and Albert/Mobutu with Zaire; Lake Victoria with Kenya and Tanzania. In addition, within its borders are Lakes Kyoga and George, many small lakes and wetlands. Countrywide production has remained at between 200 000 and 250 000 mt a year since the mid 1970s.

The stability of the annual totals disguises a change in the contribution of the individual lakes. After a decline in the 1970s, Lake Victoria contributed increasing catches as the fishery for Nile Perch gained momentum. The dominant position of Lake Kyoga in the mid 1970s has gradually been lost. The Ugandan export trade in fish is now building up, in particular Nile Perch to the processing plants in Kenya and the direct export of processed Nile Perch from processing plants within the country.

**Rwanda** has a small inland fisheries sector of some 3 500 mt of which half comes from Lake Kivu which it shares with Zaire. This lake fishery exploits *Limnothrissa miodon* which was introduced from Lake Tanganyika in 1959. The small lakes of the Kagera Basin produce small amounts of fish, mostly cichlids. It seems that there is little scope for increasing inland fisheries yields as all national waters are being exploited at or above their theoretical maximum.

**Ethiopia** has a number of large lakes, mostly at high altitude, making a total of 8,500 km$^2$, of which area Lake Tana contributes 50%. However, the reported catch of only 4 505 mt in 1992, all of which are claimed to be tilapia, suggests that there is a considerable under-reporting. It is estimated that the potential should be at least ten times this tonnage.

**Zambia** possesses a small area to the south of Lake Tanganyika, the man-made Lake Kariba (shared with Zimbabwe) and the major lakes Bangweulu and Mweru-wa-Ntipa. Numerous floodplain areas are associated with the river systems. Over an eight year period total reported landings have been stable at some 65 000 mt a year from all sources. Most stocks are apparently heavily exploited and the only potentials not yet exploited are the pelagic fish of some of the large lakes and the wetland fish populations.

**Malawi** relies on Lake Malawi/Niassa, of which its territorial waters are some 50% of the total lake area of 30 000 km$^2$, for some 50% of its freshwater fish production totalling 64 000 mt in 1992. Although it shares this lake with Mozambique and Tanzania, these latter countries do not exploit the lake fisheries to any great extent. The Malawian demersal and inshore resources of this lake are being exploited at close to the maximum level sustainable. Stocks of the pelagic clupeid *Engraulicypris sardella* have been identified as a possible resource for additional exploitation, but the viability of an economic fishery based on these stocks has not yet been confirmed. Other important lakes such as Chiuta, Chilwa and Malombe are over-fished, and in the case of Malombe, ease of catching and heavy demand from local populations have almost destroyed the stocks.

**Mozambique**'s inland fisheries resources are dominated by its access to some 6 400 km$^2$ (21%) of Lake Malawi/Niassa and the man-made Lake Cahora Bassa. However civil war and the ensuing turmoil have meant that virtually nothing is known about the exploitation of these waters. It is estimated that no more than 5 000 mt are currently taken throughout the whole country. Potential catches of 20 000 to 25 000 mt for Lake Malawi/Niassa and 15 000 mt for Cahora Bassa, have been estimated.

**Zimbabwe** has limited freshwater resources, apart from the shared resource of Lake Kariba and numerous small Water-bodies, currently under-utilised. The fishery for *Limnothrissa miodon* of Lake Kariba currently lands about 21 000 mt a year compared with an estimated potential of all species of some 30 000 mt.

The pelagic stocks are now exploited at close to their maximum. An additional 5 000 mt is landed from other waters. It is estimated that there is the potential to double this production especially by utilising small water bodies.

Zaire is the second largest country on the continent and encompasses fisheries of the great lakes to the east and the rivers and wetlands of the rain forest to the west. Unfortunately, catch reports are lacking for this country and production over the past five years has been estimated at between 148 000 and 164 000 mt per year.

Apart from the shared resources of the eastern lakes of the rift valley (Edward, Albert/Mobutu, Kivu, Mweru, Tanganyika) the rest of Zaire's fishery resources are small lakes, rivers and floodplains scattered throughout the country. The current estimated catch is possible one third to half of the theoretical catch.

Madagascar reported freshwater fish catches as 27 500 mt for 1992. There is evidence of a decline of about 30% in this total over the previous five years. The country does not experience the same fisheries regime or the same general climate as other members of this sub-region.

Issues

Throughout this sub-region, due to the easy access to efficiently exploited stocks, a good transport system and ready national and export markets, most of the waters are exploited to, or above, their optimum for sustainability.

There is also evidence that the major fishery for Nile Perch on Lake Victoria is exploiting a stock which is still ecologically unstable and liable to cyclical fluctuations in stock density. This instability poses significant questions for government and commercial policy and investment strategy decisions.

Most of the exploitation of the highly productive Water-bodies throughout this sub-region is carried out by small-scale artisanal fishermen. This is also true even for the highly commercialised and export-orientated Nile perch fishery on Lake Victoria, where some 90% of the catch is still taken by the artisanal sector. This provides for a dispersed, highly flexible response to changing stocks and is socially cohesive in maintaining the "health" of the lakeside communities.

The substitution of such systems by capital intensive, high technology, fishing units and their associated land-based infrastructure and transport systems, has repeatedly been shown to be commercially non-viable and counterproductive in maintaining the sustainability of the resources and the stability of the fishing communities. Such developments have inevitably led to increase food insecurity amongst vulnerable low income groups.

There is much scope for further research and field investigations to track the changing conditions in these highly productive systems and to elucidate the basic parameters which govern the production and disposition of the fish stocks. Important large-scale fisheries investigations are currently being undertaken, with national and international co-operation, on Lakes Malawi/Niassa, Tanganyika and Victoria.

### 9.1.4 Sub-region: West Africa south of the Sahara

*[Angola, Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Comoros, Congo, Cote d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Lesotho, Liberia, Mauritius, Namibia, Nigeria, Reunion, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Togo]*

Although being relatively homogenous in the way in which the inland fishery resources are exploited, it is obvious that a sub-region with such a diverse geography, nationalities, political administrations and s will be reflected in the degree of exploitation of the fish resources and will differ also in the future trends and potentials.

Individual countries will also cover different ecological zones. The countries to the south and the west of the sub-region tend to be dry and hot and have much in common with countries associated with the Saharan belt.

Generally it can be assumed that most of the countries possess water resources which will exhibit high levels of fish production in response to the high ambient temperatures and often high nutrient loadings.

**Production**

The major fisheries of this sub-region have undergone a steady development in the techniques, yields and demands from increasing populations over the last half century. The point has now been reached where most of the resources are now exploited at or near their maximum or may be over-exploited.

**Gambia, Mauritania** and **Senegal** share the resources of the Senegal River. For Gambia these inland fisheries are not an important economic activity. The damming of the lower reaches of the Senegal River has restricted fish movement and the low flows in the drought periods have suppressed the production. Total yields in the Gambian portion of the river have fallen from some 4 000 mt (before the onset of the Sahelian drought in the 1970s) to 2 000 in 1987. Mauritanian catches are also low, recorded as 7 900 mt before the drought and a decline to 3 200 mt by 1987. Senegal, prior to the drought landed 15 600 mt per year from the Senegal River but this total fell to 10 000 mt by 1987. Senegal also benefits from the production of the Lake De Guiers where catches have remained more stable at some 2 500 to 3 000 mt a year. The total catches for 1992 were in the region of 26 000 mt. This is a rise of some 50% on the average of the years 1987 to 1991.

The Republic of **Guinea** lands some 8 000 to 10 000 mt a year of which some 75% is caught in the Niger basin. The remaining catches are from Couliba and other river basins. In addition, Guinea exploits some 2 000 $km^2$ of floodplains with an estimated annual fish production of 40 kg/ha or an estimated total catch of 8 000 mt a year most of which is currently unreported.

**Ghana** possesses the productive resources of Lake Volta, which, with an area of 8 276 km$^2$, is the largest man-made lake in Africa. In 1965 (before it had reached maximum volume) it produced 3 437 mt, with catches reaching a peak of 61 783 mt in 1969. Since this peak, the catches fell to stabilise at about 40 000 mt by 1979. The number of fishermen showed a steep rise from 18 358 mt in 1971 to 82 460 by 1991. During this time, the annual catch/ha remained steady at about 45 kg, whilst the catch per fisherman fell from 2 132 kg to 440 kg. The establishment of this reservoir fishery has compensated for the loss of the fisheries below the dam, and the possible effect on the populations of the coastal lagoons.

In 1992, Ghana reported total catch of 57 000 mt from its inland waters. Since 1987, these total catches have remained stable.

**Liberia** has reported an annual inland catch of exactly 4 000 mt since 1987. This value approximates to the estimated potential maximum sustainable yield for the country and the reliability of the data is therefore doubtful.

**Nigeria**'s most important inland fisheries resources are Lake Kainji (which covers some 1 270 km$^2$ impounded by the Kainji Dam), part of Lake Chad (5 500 km$^2$ or 25%) and the Niger and Benue rivers, and an estimated 2 750 km$^2$ of numerous small reservoirs. Nigeria reports a total annual production in the region of 90 000 mt.

**Congo** shares with Zaire the fish resources of the lower Oubangui-Zaire/Congo River system. The resources include some 30 000 km$^2$ to 45 000 km$^2$ of wetlands of the "Cuvette Congolaise" which are estimated to have a potential yield in the region of 60 000 to 100 000 mt a year. The reported catches have shown a steady increase from 15 400 mt in 1987 to 27 200 mt in 1992. It is likely that the fish trade involves a considerable import and export across the river with Zaire and these reported totals may not reflect this.

**Cote d'Ivoire** reported catches of 15 700 mt in 1992 which represents a fall from the average of 25 400 mt a year for the previous five years. Lake Kossou provides some 50% of this total. For the whole of the Cote d'Ivoire a total potential yield of 62 000 mt a year has been assessed.

**Sierra Leone** produced an estimated 16 000 mt in 1992, but the data are not reliable as they are based on estimates for at least the previous six years.

The freshwater resources of **Cameroon** include some 3 000 km$^2$ of lakes (including 800 km$^2$ or 8% of Lake Chad), 1 500 km$^2$ of rivers and some 5 500 km$^2$ of floodplains. The total yield for 1992 was estimated as a total of 20 000 mt .

**Central African Republic** reports a total of 13 338 mt for 1992 a figure which probably includes aquaculture and is of doubtful value as it effectively has not changed since 1987. It is estimated that about 80% of the total catch is derived from the river and floodplain fisheries.

The reported statistics probably do not take into account the considerable export trade in fish from the northern floodplain areas (some 30 000 km$^2$) to Chad and the Sudan.

The inland water resources of **Burkina Faso** are estimated at a total of between 1 500 and 2 000 km$^2$, comprising a number of rivers, floodplains and numerous small dams or ponds, and two large reservoirs (total 350 km$^2$). These resources are currently estimated by FAO to produce some 6 000 to 7 000 mt of fish a year which is estimated to be approximately half of the potential yield.

**Togo** reported catches of 5 500 mt for 1992. Although it has nearly doubled the catches of tilapia in the previous six years it is likely that this production was derived from aquaculture related activities.

**Gabon** has only estimated catches for the period 1987 to 1992. These have remained constant at some 1 200 mt a year and appear to represent catch levels well below the potential sustainable yield.

**Benin** reported 20 750 mt in 1992 but this figure has been an FAO estimate for the last three years. Population pressure and associated agricultural developments have brought about a severe decline in quantity and quality of catch from the Oueme floodplain and the coastal lagoons, Lake Nokoue and Lake Aheme.

**Guinea** has inland fisheries catches estimated at 4 000 mt for 1992. This figure appears to be some 50% of the potential sustainable yield.

**Angola** reported 7 000 mt in 1992. Although this total has remained fairly stable in recent years, during this time it is likely that political problems have made data collection very difficult. The potential resources are large and include some 20 000 km$^2$ of floodplains on the Upper Zambezi, 15 000 km$^2$ of the Okavambo floodplains and some 500 km$^2$ of the coastal river floodplains.

**South Africa** reported a total freshwater catch of 2,200 mt for 1992.

In this sub-region are a number of predominantly arid countries with very small inland fisheries resources. **Botswana** is an arid landlocked country, with considerable fish resources in the Okavango Delta wetland region in the north of the country.

It would appear that there is little exploitation of this area as the total catches for 1992 have been estimated as only some 1 900 mt. **Lesotho** has an inland catch estimated at 30 mt and it is likely that this all may come from d sources. **Namibia** has an estimated total annual catch of 150 mt. **Swaziland** produced an estimated 100 mt in 1992. **Guinea-Bissau** has negligible inland fisheries resources, estimated at 400 mt for 1992. However, these small catches may be locally important for food security, especially in land-locked areas.

The sub-region also includes a number of small islands with easy access to marine stocks and no significant inland fisheries. These include: **Cape Verde, Comoros, Equatorial Guinea, Mauritius, Reunion, Sao Tome & Principe,** and **Seychelles.**

**Issues**

Throughout this sub-region it appears that most of the major lake and river fisheries are fully exploited, with their fisheries supported by large local populations and well-developed marketing systems. There are a number of localised exceptions as listed above. The dominant methods of exploitation and marketing are based on the small-scale, artisanal units serving both the urban centres and the dispersed rural communities. Further development of this system is difficult as the strategy in place in most countries is economically and socially efficient and well able to respond to the natural fluctuations in the resource base. To move away from these systems is to risk over-investment in inflexible infrastructure such as boats and shore facilities.

A major resource which is still under-exploited is the large area of floodplains. These are very productive with yields as high as 5 mt /km$^2$/year. Total yields are highly variable as the areas flooded depend on the rainfall patterns for any given year. Floodplains are unattractive to human settlement and any fishery has to exploit large areas without basic permanent infrastructure and export the product to distant markets.

These fisheries tend to be based on temporary fishing camps and marketing installations and are therefore very difficult to control and develop to their maximum theoretical potential. These fisheries produce a low-value product usually travels large distances to provide an essential food input to remote populations. Development of these fisheries will depend very much on improving physical infrastructures and access to markets.

Wetland fisheries are constantly at risk to the need for agricultural land created by increasing populations. These areas are often considered of little use and the value of their fish resources and the part they play in the hydrological cycle, are often ignored.

A number of countries in this region have established, or are developing, irrigated agriculture. Such schemes present opportunities for enhanced capture fisheries by stocking and controlled fishing of the storage reservoirs and other water-bodies that are integral to these schemes.

To determine the resources of this region and to estimate the degree of utilisation under the confused circumstances of dispersed effort by small units, with cross-border transfer of fish and fishermen, is very difficult.

Development analyses and proposals should be based on detailed knowledge of discrete resource and any global approach is likely to be less productive. The contribution of freshwater fish to food security is evident in all but a few countries.

## 9.2 North American Region

*[USA including Alaska, and Canada]*

Throughout Canada and the United States, there is emphasis on the recreational and environmental aspects of the use and conservation of fish stocks. Interest in the commercial exploitation of stocks for food is slight except for the fishing of some riverine stocks, the offshore commercial exploitation of migrating salmonids and the fisheries of the Laurentian Great Lakes. Nevertheless, up to 250 000 mt of freshwater fish were captured in North America in 1987 after a period of more or less steady increase. Subsequently catches have declined. A wide range of species are captured. The group "other" which dominates the composition patterns consists of a range of catastomid, cyprinid, percid and centrarchid species. A recent development has been the "serial" intensive fishing of small and medium sized lakes in Canada and the north of the U.S. ("high grading"). There are other small commercial fisheries on some of the larger rivers and small impoundments. Despite the lack of interest in the strictly commercial fishing activities, there is no doubt that a considerable proportion of the fish taken by the recreational fishery goes to domestic consumption. The importance of sport fishing can be gauged from the statistic that, in 1985, 99 million individuals fished for a total of 117.4 million days.

Within the region, fisheries management concepts are chiefly being applied to recreational fisheries and the maintenance of environmental quality. These management measures include the need to control the exploitation of watersheds in order to maintain or improve water quality, the limitation of access and levels of fishing pressure, the charging of license fees for access to public resources and interventions such as stocking to maintain fish populations or allow the establishment of favoured species.

**Production**

It has been assumed that, since the beginning of the century, there has been a steady decline, both in quantity and types of fish species, taken from the river and lake fish populations across the North American continent.

This general decline in the fish stocks is the result of the diversion or manipulation of the water-bodies for agricultural or industrial uses, including power generation, leading to the loss of backwater and ox-bow lakes, the draining of wetlands for urban developments and agriculture, the disturbance of the watershed by mining and deforestation, and the increase in urban and industrial pollution of the waters.

In addition to this overall decline in the stocks, in many areas that are subject to human interference, the quality of the fish taken may be seriously affected by persistent toxic pollutants to the point where they may be unfit to eat. The predominance of bottom feeding fish in the catches creates a risk of contamination due to the accumulation of toxic materials from the bottom sediments.

It is difficult to define the current state of the fishery. Although the high yielding "virgin" fisheries of natural waters have for the most part gone, the inland fisheries landings in Canada were reported as 61 243 mt in 1992 and in the USA. 62 532 mt.

Although there has been some fluctuation in these totals, there has been no obvious trend and, except for a fall of some 30% in the years 1990 and 1991, catches have remained little changed since 1984.

In Canada, apart from the serial fishing of the lakes, the commercial fishery is mostly carried out by native peoples with a catch in the Churchill Basin of 4 210 mt /yr. and the McKenzie Basin 2 820 mt /yr. for the period 1973-4 to 1981-2.

The general decline in quantity and quality of the North American fish stocks now appears to be arrested and some reversal is seen. The increased environmental awareness of the public and the response of legislators suggest these improvements will continue despite a foreseen population increase of some 70 million people over the next 30 years. Throughout this sub-region, the activities that are undertaken to rehabilitate the fish populations are not related to the economic or food value benefits, but generally relate only to intangible social and cultural benefits.

Issues

On a global scale, the total yield from the inland waters is very small, with possibly the bulk of the harvest being unrecorded and consumed domestically by sport fishermen.

There is no reason to suspect that current rising trends in the demand for recreational facilities will stop. This will have a dual effect in that the pressures on the aquatic environments will increase with the demand for access. At the same time there is likely to be an increased awareness of the need to maintain the quality of freshwater fishery resources. Such developments offer hope that attention to environmental rehabilitation will eventually result from improved resources management in the industrialising nations, once a certain level of development has been attained. However, throughout its history the North America has been subject to relatively low population pressures in comparison to, for example, much of Asia.

## 9.3 South American Region

The small island states have, for the most part, been excluded from this discussion as their inland capture fisheries resources are generally rather small and their markets have easy access to marine fishery products.

South America contains two of the world's largest river basins, the Amazon and the La Plata, as well as two others of considerable significance, the Magdalena and Orinoco. The region comprises a range of climatic zones from close to the Antarctic to the tropical zone north of the equator.

Climatic conditions are modified by altitude with some of the countries of the region almost totally in the mountain zone of the Andes. Two sub-regions have been somewhat arbitrarily designated and in part reflect the extent of the inland water resources and the production levels that would be anticipated from them. The Northern sub-region is essentially the countries influenced by tropical climate regimes of relatively high temperature and rainfall. The fisheries are dominated by the exploitation of river systems. The Southern sub-region encompasses those states with a generally cooler and drier climate. In this sub-region the fisheries exploitation is generally from small water-bodies, lakes and reservoirs.

Current catches from the Amazon are well below the potential catch. The fishery, however, is very selective.

Fisheries statistics are reported nationally and it is necessary, therefore, to accept the "country" as the smallest unit. It is obvious that some countries contain within their boundaries a wide range of climatic zones, areas of distinctly different types of inland water resources, etc. Catches over the continent increased until 1988 following which there has been a decline in catch. Species diversity is especially rich in South America where the Amazon contains the most varied fish fauna in the world and the two other major rivers the Orinoco and the La Plata system are also very complex. Fisheries are generally dominated by characins and catfishes, although introduced species such as tilapia, black bass, common carp and *Plagioscion squamosissima* are assuming increasing importance. Consumption of fish in South America is relatively low due to a traditional preference for meat.

Human population densities are much lower in tropical South America compared, for example, to southern Asia and the rivers and their floodplains still retain some of their pristine features. Pressure on the use of water tends to come more from the drive for industrialisation rather than demand to house and feed large numbers of people. Even so, in South America as a whole, a recent survey has shown that agriculture is definitely seen as being the major source of water pollution in terms of silt, fertilizers and pesticides. The construction of hydropower dams and the extraction of gold and heavy metals are two major short-term sources of impacts upon major rivers. It is estimated that only 10% of the hydropower potential of the Amazon basin has been realised, mainly by Brazil. Dam construction is well advanced on the Rio de la Plata and its associated tributaries. For example, on the upper Parana River, by the year 2000 it is anticipated that 69 hydro-schemes with areas greater than 200 ha will have been built in the Brazilian portion alone.

Along the floodplain or "varzea" region of the main stem of the lower and middle Amazon, extending perhaps 45 km either side of the river, are farming communities which make use of the rich soils and the flood regime of the river for subsistence agriculture.

They traditionally grow a mixture of subsistence and cash crops but the collapse of the jute market and the prevailing competition for land with ranchers has forced increasing numbers from mainly agricultural or mixed subsistence into purely fisheries.

Such examples illustrate the flexible nature of inland fisheries, their importance for supporting low income groups, providing both cash income and food and, hence, their significance to food security issues. However, this trend is putting them into competition with the commercial fishery in the Amazon which, unusually for inland fisheries, tends to be based on mechanised boats with a hold capacity of up to 30 mt.

This commercial fishery can handle up to 22 400 mt per year from a fleet of up to 800 boats which can travel 3000 km. In some respects, this fishery is taking on the features of commercial marine fisheries such as over-capitalization accompanied with over-exploitation.

Lakes are less important in S. America, compared with, for example, Africa. A number of important lakes do, however, occur. Most of these have, and are, being subject to the adverse effects of adverse human impacts. For example, Lake Po_po is one of the largest of the shallow, cold Andean Lakes. It has a rich fishery which has provided a major source of fish for the urban populations of the altiplano in Bolivia and a principal livelihood for some of the poorest people in this inhospitable region. Wastes generated by mineral extract have resulted in the bio-accumulation of copper, zinc and cadmium in fish of between four and forty times the normal level. Catches from this fishery are declining to such an extent that only emaciated fish in the last stages of starvation could be found. It seems, generally, that it is specific human activities, largely related to development, which mainly threaten the lake fisheries of South America rather than the pure pressure of population density and demand for land in the catchment area which typifies Africa. Although regionally less important than rivers in South America, lake fisheries are, of course, significant to food security in the local contexts where they occur.

The tendency for release of heavy metals into the large river systems is a serious potential threat to sustaining regional fisheries production. The use of mercury, for example, in the extraction of gold is leading to the release of large amounts into the rivers. It is clearly accumulating in fish and the migratory nature of many species is ensuring that mercury is being effectively distributed throughout some of the largest river basins of the world. What effect this will have upon the fish populations, the fisheries they support, the aquatic ecosystem as a whole and the riverside fishing communities in entirely unknown. Concerned parties in Brazil, for example, have described the whole process as a "time bomb".

### 9.3.1 Northern Sub-region

*[Belize, Bolivia, Brazil, Colombia, Costa Rica, Cuba, Dominica, Ecuador, El Salvador, French Guiana, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Venezuela]*

Fisheries of this sub-region are dominated by the production of the Amazon Basin. The main river is some 5 193 km in length and drains one third of the total land area of the South American continent, some 6 112 000 km$^2$. If the catchment of the Tocantins river is included the total area rises to 6 869 000 km$^2$.

The basin is shared by nine countries: Brazil (58%), Peru (16%), Bolivia (10%) and the remaining 16% divided between Colombia, Ecuador, Venezuela, Guyana, Suriname and French Guiana. The waters of the region tend to be either "black waters" which drain forest lands and which have a low productivity, and the turbid "white waters" which drain the Andean uplands and have a higher productivity level.

The sub-region supports an export trade in ornamental fish which after a decline in the mid-1970s has now increased slightly in volume but with considerably increased value.

**Production**

The land area of **Brazil** dominates the continent of South America and encompasses 58% of the Amazon Basin of which 3 900 000 km$^2$, and 2 921 km of main river, lies within Brazil. The potential yield from the river and its tributaries within Brazil is estimated at some 500 000 mt/year. Half this total was recorded as landings in the mid-1980s. Data are few and unreliable and relate mostly to landings at the urban centres and do not take into account the considerable production for subsistence and the catches from recreational fishing. The country has a number of man-made impoundments, particularly for hydropower located along the Upper Parana basin with 10 on the River Grande and 4 on the River Paranaiba. From a total of some 200 impoundments on the Parana river system it is estimated that some 30 000 mt/year are produced from the Brazilian portion of this drainage. The total area of impounded waters is estimated as 60 000 km$^2$, including large and small reservoirs. Over 90% of Brazil's power generation comes from hydro-projects. In the north-east region these small impoundments are thought to produce some 20 000 mt/year. From the Sao Francisco river system there is an estimated yield of 30 000 mt /year from small impoundments and the major Sobrandinho and Tres Marias reservoirs. Little is known about the potential or current exploitation of these or of the large areas of savannah wetlands. In general, reservoirs in Brazil are grossly under-exploited and their fisheries poorly managed.

It would appear that the bulk of the recorded catches from the Amazon basin are derived from the rich fisheries of the estuarine waters which accounted for some $13 million in export revenues in 1980. In 1984 the estuarine fisheries landed a reported 155 140 mt, equivalent to 17% of the total fish landings (assumed to include marine) of Brazil. In the period 1984 to 1992 the reported annual total landings have remained fairly stable at approximately 200 000 mt a year, although there are data which show that the river landings have been steadily rising over the last 20 years by some 200 or 300% over that time. The maximum for the period was 219 664 mt in 1987 and a minimum of 182 536 mt in 1992.

The fisheries of the Tocantins/Araguaia basin produce about 6 000 mt/year including some 1 500 mt/year caught in the Tucurui Reservoir.

There is a large and growing recreational fishery sector the production of which is not recorded. A small trade in ornamental fish is valued at some US $ 200 000 a year, which is possibly a gross underestimate.

Many rivers, and in particular the Araguaia basin, are highly polluted, particularly near urban centres and near mining activity, where the mercury used tends to accumulate in the food chain. Many areas are also subject to environmental degradation due to floodplain deforestation.

An estimated 66% of the territory of **Bolivia** (723 000 km$^2$) lies within the Amazon Basin. This area includes a seasonally inundated floodplain of 100,000 to 150,000 km$^2$. From 1984 to 1992 Bolivia has reported a fairly steady annual catch of fish from inland waters. The total varied from 3 871 mt in 1986 to a maximum of 6 909 mt in 1990. The 1992 total was reported as 4 905 mt. The bulk of this small production comes from the Pilcomayo river (*ca.* 20%) and the river systems of the Amazon catchment, Madre de Dios and Mamore rivers *(ca.* 50%). There is also a small fishery on Lake Titicaca, which Bolivia shares with Peru, producing some 1 500 to 2 000 mt annually (*ca.* 30%). After a steady rise in reported catches between 1980 and 1986, the total reported landings have stabilised. The reported catches are insignificant when compared with the potential fish resources of the country which, including the floodplains, must represent a sustainable yield of at least 100 000 to 200 000 mt/yr. The development of these resources will probably depend upon the access to the stocks and improved access to markets.

The main fishery resources of **Colombia** are the River Magdalena and the extensive drainage to the Amazon basin. After some decline in total annual catches to a minimum of 19 431 mt in 1991 there appears to be some recovery towards the totals in the range of 47 700 to 61 000 mt for the years 1984 to 1988. The decline was probably due to excessive exploitation of migratory stocks and local pollution.

Intensive management of small lakes and reservoirs have provided **Cuba** with an annual reported catch of 1 226 mt in 1984 to 1 899 mt in 1986. In 1988 and 1989 reported catches fell to very low levels to recover in the last three years of the review period. However, Cuba is a good example of the misleading reporting of its inland production. Of the much larger production of about 21 000 mt from aquaculture in 1992, 16 541 mt was actually caught from reservoirs which had been stocked. The State administration system is geared-up for stocking and harvesting of reservoirs. In comparison, private sector development of more intensive aquaculture is discouraged. The reporting of this production as "aquaculture" disguises these factors. Cuba is also a good example of culture-based fisheries ensuring food security. In the recent economic and food crisis, the steady inflow of fish into the public distribution systems ensures some protein supply. The rest of the food supply has virtually collapsed. Cuban reservoirs are well managed, and produce over 200 kg per hectare per year.

Both **El Salvador** and **Guatemala** report a highly successful increase in inland fisheries production. El Salvador showed an increase from 1 695 mt in 1984 to a reported 5 141 in 1992. Guatemala shows an even greater increase from 47 mt in 1985 to 3 700 mt in 1992. For El Salvador it is likely that these statistics reflect an improvement in the collection of data and the result of heavy eutrophication of some of the major reservoirs.

**Mexico** has employed a national policy of maximising the fisheries potential of its lakes and reservoirs through the systematic stocking of carps, black bass and tilapia. This policy has succeeded in increasing its total annual catch from around 110 000 mt in 1984-86 to some 160 000 mt in 1991-92.

**Paraguay** possesses considerable potential fish resources derived from the high production of the floodplains of the Paraguay river. Since 1984, when the annual landings were recorded as 5 000 mt, the national fisheries have shown 300% increase to a total of 17 930 in 1992.

The major part of the fish production of **Peru** is derived from the river systems of the Amazon basin, with some 9 100 mt being landed at Iquitos in 1992. These landings have shown an increase since 1981 to a relatively steady state over the last few years. These resources are locally very heavily fished with the decline of the large fishes *Arapaima* sp and *Colossoma* sp. In addition to the resources of the Amazon basin, Peru shares the fish resources of Lake Titicaca with Bolivia.

**Venezuela** reports catches in the region of 15 000 mt to 30 000 mt from 1984 to 1992. In 1992, this total was 19 870 mt. It is estimated that most of this catch is derived from both the rich estuarine and delta regions at the mouth of the River Orinoco and from the internal delta at the confluence of many tributaries from the Andes and Llanos.

The potential yield from the Orinoco basin is estimated at some 100 000 mt/year and it is thought that about a third of the potential is landed at the different urban centres along the Orinoco-Apure Axis. A national policy to promote the inland fisheries in reservoirs has been defined recently with the goals of increasing the total freshwater fish production.

A group of countries in this sub-region have a negligible catch from freshwater resources, either because these resources are absent or because the proximity to ample marine stocks makes the development of the inland resources unnecessary. **Costa Rica** exploits the production of numerous small lakes which provide an annual catch that has been steadily increasing from 197 mt in 1984 to 520 mt in 1991 with a slight decline to 406 mt in 1992. **Haiti** has reported an annual catch from its inland waters of some 300 to 400 mt, but the data from this source are very unreliable. **Dominican Republic** has a small annual catch in the order of 536 mt in 1992. The data from **Jamaica** show large fluctuations, with a recorded catch of 720 mt a year for the last two years of the period covered. **Ecuador** reports only a small inland fishery with annual catches which appear to have been slowly declining from 994 mt to 595 mt throughout the period 1984 to 1992. **Guyana** has a considerable fishery potential from the large water conservation areas which fringe the coast.

Reported statistics are, however, very unreliable and estimated annual totals have remained fixed at 800 mt. Guyana also benefits from a small but locally important trade in ornamental fish.

Although **Nicaragua** possesses two large lakes (Managua and Nicaragua) and numerous river and wetland systems on the east coast, its reported catches from inland fisheries are very low with a maximum of 340 in 1992. The inland waters of **Suriname** support a small fishery with catches that have ranged from 107 to 564 mt in the eight years to 1992. Since 1989 these catches appear to have stabilised at the higher levels.

**Belize, French Guyana** and **Panama** all report no or negligible catches of freshwater fish.

In general, the sub-region lacks any concentrated large-scale fishery and relies on the production from dispersed sources such as rivers and floodplains. This precludes the development of a mass processing and marketing structure and will rely on the activities of many small units throughout the industry.

The consequences of this small-scale structure is that fisheries are susceptible to local over-fishing, local pollution effects and the degradation of the waters through watershed mismanagement.

Particular problems are presented by the discharges from mining, particularly mercury, with the eventual contamination of the stocks of fish intended for consumption. Removal of forest cover and degradation of land under cultivation reduces water and substrate quality through increased turbidity and sedimentation from the run-off.

### 9.3.2 Southern Sub-region

*[Argentina, Chile, Uruguay]*

**Production**

Between 1984 and 1992 **Argentina** reported fairly stable catches ranging from a minimum total of 7 995 mt in 1987 to a maximum of 11 827 mt in 1992. The Parana-Paraguay river systems are the major sources of the fish catches, with some minor fisheries exploiting salmonid stocks in the Andean lakes. For a country with such a large surface area and extensive river systems, the current production is very low when compared with the potential available. In part this resource is ignored due to the overwhelming consumer dietary preference for meat.

**Chile** has effectively no reported inland fisheries production except small catches of crustaceans, of between 5 and 32 mt, are reported in the years 1988 to 1992.

With catches mainly based on the fisheries of the Rio Negro and the Salto Grande reservoir, **Uruguay** reports variable annual catches ranging from a low of 303 mt in 1988 to a high of 1 224 mt in 1987. Catches in 1992 are reported as 881 mt.

Issues

It is likely that fish will continue to play a small part in the diet of the main populations of this sub-region. The dominant cultural preference for and easy access to supplies of cheap meat, implies that the small-scale fisheries of rivers and lakes will remain of strictly local importance to small groups of people. This does not mean they are unimportant for localised food security. There is a growing recreational fishery in the major rivers and the Araucan lakes of Chile and Argentina, which is leading to a preoccupation with the quality of the environment.

## 9.4 Asia

The Asian region covers a vast land mass stretching from the Arctic to the equator. In an attempt to provide comparisons of fisheries which have similar attributes, the region has been divided into sub-regions which, admittedly using subjective parameters, show a degree of homogeneity. The problem of lack of specificity with regard to species composition of catches is particularly serious for Asia for which "Freshwater fishes nei" accounts for over 3 million mt out of total capture yield in 1992 of 3.8 million mt (or about 80%). Most of these are Chinese and Indian carps although the species diversity of some of the larger river systems is very high. Catches have risen fairly steadily to peak in 1989. The decline in catch between 1978 and 1979 is not explained but probably arises from differences in collecting and reporting statistics.

The fish production of one single country dominates the region - China. This country is considered as a single sub-region. In 1990, it contributed some 52.3% of the *total world yield* from inland capture fisheries. Interpretation of the reported statistics for China, therefore, are crucial to elaborating global trends in freshwater capture fisheries. The situation is worse for freshwater aquaculture where China accounts for over 80% of world production.

Islands which have no inland waters and which have ready access to marine stocks (e.g. Cyprus, Bahrain) have been omitted from this regional listing. Also omitted is Russia which reports its fishery statistics as a single area although its borders encompass both European and Asian land areas. For convenience Russian data has been included in the statistics for the European Region.

For the region as a whole, despite a considerable growth between 1980 and 1990, the *average* supply of fish remained below 10 kg *per caput* per year compared with a global peak of 13.5 kg *per caput* in 1989. Fish represented some 28% of the animal protein intake until the mid-1970s. At about this time this share decreased despite a slight increase in production of fish. In East and Southeast Asia, where fish have always played a very important part in the diet, in the early 1960s fish made up some 40% of the protein intake. By the mid-1980s, this proportion had declined to stabilise at slightly below 30%. Clearly, increases in production of fish have not kept pace with those for other foods. Future developments will rely on maximising the production from the large number of small water bodies found in many of the countries throughout the region and improving stocking activities in existing and planned medium to large reservoirs.

Saline water-bodies are increasing in some countries (e.g. Turkey, Thailand) especially as a result of the use of water for irrigation schemes. Consideration should be given to methods of putting these into production (e.g. mullets, seabass, tiger prawn, and Artemia).

Attention is also being given to the development of cold water fish resources. This development is particularly valuable at higher altitudes where there are abundant water supplies. It is likely that such fisheries will be -based fisheries supported by technically efficient hatcheries.

Bangladesh, Sri Lanka and India have the world's highest population densities amongst developing countries and the Ganges Basin itself contains 300 million people, making it the most heavily populated area of the sub-continent. The resulting pollution of the Ganga causes considerable problems and is known to have significantly reduced fishery yields. It is promising that the Government of India has expressed its awareness of these problems through the Ganga Action Plan, a package of long-term monitoring and mitigation measures, largely centring around increased construction of sewage treatment plants.

In a similar way, the other great river system of the region, the Mekong, harbours 48 million people within its 791 000 $km^2$, which is projected to increase to 61 million by the year 2 000. These river basins, therefore, illustrate some aspects of future trends which may emerge in currently less intensively utilised catchment areas.

As with much of South America, tropical and sub-tropical Asia is naturally dominated by large river basins and lakes are relatively small. There are a number of local exceptions.

For example, Laguna de Bay in the Philippines supports a significant capture fishery (and cage ) which has possibly to some extent been enhanced by massive inputs of nutrients but conversely is often subject to fish kills from die offs of algal blooms in particular. Increasing levels of industrial effluent also threaten sustainability.

Both the Caspian and Aral Seas have shown marked environmental deterioration over the past three decades as a consequence mainly of agricultural and industrial intensification. Significant fisheries in both seas have declined dramatically and, especially the Aral Sea, have effectively disappeared.

However, in Asia in general, there is extensive development of large reservoirs, often to such an extent that the expanse of man-made habitat exceeds that of natural habitat available. These support important fisheries managed generally through stocking. Their environmental quality of these is beginning to be influenced by factors previously described for trends with natural lakes.

### 9.4.1 Sub-region: Western Asia

*[Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen]*

This sub-region includes countries that mostly have extensive coastlines and small populations so that marine catches can provide for the demand in fish for food. Low rainfall regimes dominate their environments to the extent that much of the land areas of the sub-region can be classified as desert.

Despite the prevalence of arid conditions, some countries of this sub-region have significant inland water resources in the form of lakes and reservoirs (e.g. Israel and Turkey).

#### Production

**Israel** is short of inland water resources but reports a stable annual production of 1 500 to 2 000 mt, which mostly comes from Lake Kinneret. **Syria** has a similar climate and resource base but production appears to be steadily declining from 2 552 in 1988 to 1 100 in 1992. The bulk of this catch is derived from Lake Assad.

**Turkey**, which for the convenience of this report is considered with the rest of the Asian Region, shows a stable annual yield, probably since the mid-1970s, with a catch of 44 543 mt in 1992. The inventory of the country's inland water resources varies between about 9 000 km$^2$ and 11 000 km$^2$, including 1 480 km of running waters.

These are generally small rivers and streams, apart from the Euphrates and the Tigris. In the arid areas of the country many of the smaller Water-bodies are saline or alkaline and are of value only as sources of high value fish and fish products from their adjacent waters.

**Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, United Arab Emirates** and **Yemen** all report no, or negligible, totals for fish obtained from inland waters. These are all arid countries with virtually no open water resources.

#### Issues

Apart from Turkey, which has significant inland water resources, most of the countries in this sub-region are arid with no prospect for the development of any substantial inland fisheries. They have small populations and access to marine fisheries which are able to satisfy any consumer demand.

Countries in the sub-region with active programmes of water control and impoundment, particularly Turkey, have a large scope for future increases in fish catches from the man-made water bodies.

### 9.4.2 Sub-region: Southeast Asia

*[Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam]*

This sub-region groups the countries that lie in the basins of the Irrawaddy and Mekong river systems with the peninsular/archipelagic countries influenced by high ambient temperature and high rainfall climatic regimes. The countries of this sub-region possess rich freshwater resources provided by their river systems and associated floodplains. Common to this area is the important part played by fish, including seafood, in the local diet. These sources provide from 25% to 65% of the total animal protein consumption (excluding landlocked Laos). Throughout the period 1984 to 1992 the annual production from inland capture fisheries remained stable totalling 1 032 161 mt for the region in 1992.

#### Production

The inland capture fisheries of this region has stabilised at about 1,000,000 mt annually over the period 1984 to 1992. This stability probably reflects a balance between increasing exploitation pressure and declining production due to increasing environmental disturbance of the water-bodies. Throughout the sub-region, removal of forest cover and the pressures of agricultural developments on the catchments have changed the flow patterns of the major rivers and their floodplains and increased the sediment flows, usually to the detriment of their fish production. In **Cambodia**, inland capture fisheries provide some 60% of the total fish production, reported as 68 900 mt in 1992. The major part of this catch is derived from the production of the floodplains downstream of Phnom Penh and the inundations of the Great Lake by the Tonle Sap River. The major fishing areas cover an area of 1 000 to 2 000 $km^2$ depending upon the season. Although these inundation fisheries are, to a great extent, renewed annually, there has been a considerable loss of potential since the 1960s when 100 000 mt was landed each year. This loss has been attributed to a continuing environmental degradation and increasingly intense fishing pressure. The environmental changes have resulted from soil erosion due to mismanagement of the catchment and increased agricultural pressures, and the silting of many of the connecting canals which are important to the dynamics of the water flow and floodplain access for the fish. The highly organised fisheries of the Mekong and Tonle Sap were disrupted during the civil disturbances of the 1970s but fisheries have become re-established. Although from 1984 to 1992 the landings increased by some 15%, catches per boat are falling and the size, and therefore value, of the fish has decreased. **Indonesia** possesses some 550 000 $km^2$ of inland waters, of which lakes cover some 18 000 $km^2$. Inland fisheries production, from all sources including aquaculture, have risen by a total of 62% since 1983. A total production in the region of 430 000 mt was reported for 1992. Although little information is available on the fisheries of **Laos** a steady decrease of some 40% in the capture fisheries is apparent between 1984 and 1992. The total production from inland waters has been increasing steadily throughout this period due to the increasing contribution from aquaculture. In 1992, the total inland catches were assessed at 30 000 mt.

The recent statistical reports from **Malaysia** have been poor, but it is estimated that the total inland production is in the region of 16 000 mt for 1992. There appears to have been a steady decline in the catches from the capture fisheries, which is almost certainly the effect of the degradation of the environment in the watershed and the pollution of many of the natural waters. Most of the rivers in the country are considered to be severely degraded with an almost total collapse in their fisheries. Malaysia has a number of wetlands, although these are generally of a low basic productivity. Numerous abandoned tin mining pools present the opportunity for the future development of culture-based fisheries in these small water-bodies. The statistics from **Myanmar** are sparse, although they appear to show a moderate increase in catches from some 4 000 to 7 000 mt in recent years. Much of this is derived from seasonally inundated areas.

The **Philippines**, possesses some 2 000 $km^2$ of lakes and 910 $km^2$ of multi-purpose reservoirs. In the years 1983 and 1992 inland water production varied between 534 000 and 658 000 mt with a reported total of 580 987 mt in 1992. Inland capture fisheries provided some 50% of this in the second half of this reporting period.

In **Thailand**, swamps and lakes cover only some 300 $km^2$, while the area of reservoirs totals some 2 850 $km^2$. Despite a decline in the years 1987 and 1988 and a slight fall in 1992, there has been a steady increase in the production reported from inland waters. Capture fisheries provided a little over 50% of this production. Large and small impoundments yield 35%, rivers 25%, rice fields 25% and swamps and ditches 15% of the total inland catch, which totalled 233 000 mt in 1992. Inland capture fisheries are principally concentrated on the Chao Phrya River and the central plain. In the past, floodplains produced 40 000 mt per year, but this has now fallen to 10 000 mt due to the regulation of the rivers for irrigation and other purposes. This loss was, to some extent, compensated by the production from reservoirs, but now further large reservoir construction has stopped. There is however a steady increase in catches from a large number of medium and small water bodies constructed for rural development but which offer opportunities for fisheries.

**Viet Nam** has 10 036 $km^2$ of inland freshwaters of which 3 975 $km^2$ are represented by medium and large reservoirs, 580 $km^2$ are small lakes and ponds and, in season, 580 $km^2$ are flooded paddy fields. The major inland fisheries are in the deltas of the Hong and the Mekong rivers. Inland capture fisheries seem to have stabilised with 1992 total catches reported to be 270 598. The conversion of some 1 000 $km^2$ of mangrove swamps in the Mekong delta to shrimp ponds is thought to have been the reason for the decline in the capture fisheries of this area, from 160 000 to 48 000 mt.

A little more than 50% of the total inland production has been derived from capture fisheries although since 1983 there has been an increase of approximately 40% in the production from aquaculture. Aquaculture production in 1991 and 1992 represented over 50% of the total production. More recent data for 1993 suggest that the collapse of the Mekong capture fishery is escalating. **Brunei Darusalaam** and **Singapore** are two small countries with negligible inland fish production and easy access to marine stocks.

Issues

Over the whole of this sub-region the major problem is how to achieve sustainable growth in fish production against a background of degradation of the water resources and increasing fishing pressure. Degradation of the environment is chiefly being brought about by development of the catchments for agriculture and, to a lesser extent, urban and industrial use. Increased siltation, untimely or changed water-flow patterns, and the general pollution from urban and industrial waste all have a part to play. This trend is a reflection of population pressure for increased access to agricultural land or to exploit natural forest resources, particularly in countries with rapidly increasing populations. On the other hand, countries with well developed industrial economies tend to have problems with pollution from the urban and industrial environments, and the need to manipulate natural waters for irrigation, urban water supplies and power.

The water-body types most vulnerable to degradation are the highly productive floodplain environments and the rivers which become the recipient of much waterborne waste and whose estuaries can often become tidally stagnant. River biota are at risk, especially at times of low flow and high ambient temperatures, as the water volumes are insufficient to dilute the inflow of polluting materials. The major centres of industrialisation in Thailand and Vietnam lie outside the Mekong basin but further diversion of the Mekong's waters for agricultural and industrial use are likely. The Chao Phrya River, however, is subject to intense industrial and other pollution.

The highly productive floodplains represent a source of easily drained land that can be converted to agricultural use. This often results in the loss of a highly productive and self sustaining fishery. The dynamics of the water regime in inundated areas are very susceptible to the engineering of water flows by regulation through impoundment and canalization. The decline in the stocks is also exacerbated by increasing fishing pressure. Increased populations and therefore consumer demand arises at the same time as transport becomes easier and the techniques for improved fishing become more readily available.

It can generally be assumed that the degree of exploitation of inland waters of this sub-region is close to, or greater than, the sustainable maximum. There is little prospect of finding new techniques or new stocks that may be exploited to provide significant increases in overall catch.

Enhancement of the present stock levels, and thus potential production, can only come about by reversing current trends in pollution and over-exploitation, offsetting the effects of engineering works by stocking or otherwise mitigating the adverse effects on the fish populations. Where the infrastructure and state of development of rural services allow, intensive aquaculture, including cage-culture in natural waters, will in part replace lost production from capture fisheries, although these activities themselves will lead to pollution effects. Aquaculture is better able to expand in line with population growth and consumer demand.

### 9.4.3 Sub-region: South Asia

*[Bangladesh, India, Pakistan and Sri Lanka]*

**Production**

In **Bangladesh**, in 1992, 477 503 mt of fish, approximately 70% of the national total, came from inland fisheries. Of this total some 100 000 to 200 000 mt was derived from catches of the anadromous clupeid fish, *Hilsa*, in the Lower Ganga. This fishery is in serious decline above the Farakka barrage/dam which impedes the migratory habit of the species. Fishing of the inland waters is intense but apparently maintaining steady countrywide yields. For the dense population the *per caput* catches are remaining stable at some 4 000 g, but there is much, unrecorded, small-scale fishing on the extensive floodplains which must have a significant beneficial effect on the food security of some of poorest groups.

Production in the inland waters of Bangladesh is highly dependent upon the flood regime of the Brahmaputra and Ganga rivers and their confluence, and is likely to vary greatly from season to season. The development of culture based fisheries on the extensive systems of ox-bow lakes and residual waters has raised overall yields from about 150 kg/ha to about 700 kg/ha for ox-bow lakes and from 70 kg/ha to 250 kg/ha for floodplain depressions. Productions of over 2 mt per hectare are reported from some of these small water-bodies.

In Bangladesh, the inland fisheries are of paramount importance, indeed traditionally in Bengal as a whole, including the State of West Bengal in India, fish eating is more customary than over most of Hindu India, with its vegetarian. In Bangladesh, there is a stark contrast between the need to produce rice as the staple diet and the need to produce fish as the major animal protein source and a major provider of livelihoods for the land-less.

Inland fisheries production in **India** has fluctuated during the period 1987 to 1992, with a maximum catch of 591 827 mt reported for 1990 and a minimum of 351 772 mt in 1992. The main exploitation is of rivers, reservoirs and floodplains. There is evidence that the natural water fisheries are in some decline brought about by environmental degradation and high fishing pressures.

However, this shortfall is being made up by an increasingly effective management of the fisheries of the major reservoirs through stocking and controlled fishing. India has approximately 3 million hectare of reservoirs which currently yield an average of just 20 kg per hectare per year. Considerable scope exists for improving yields in these reservoirs through the promotion of culture enhancement techniques.

**Pakistan** utilises only some 35% out of a total of 86 000 km$^2$ of inland water resources for fishery purposes. Since 1983 there has been a steady increase, averaging 5% per year, in the catches from inland waters. The reported catch for 1992 was 109,067.

Most of this catch results from the stocking of the major reservoirs and the subsequent increases in yield. This intervention is now being undertaken as a sustainable programme of development which exhibits substantial promise. In 1992 *per caput* production was 874 g.

**Sri Lanka** has ample access to, and a good infrastructure for, marine stocks but in 1992, the freshwater fisheries still provided 23 000 mt or 12% of the total fish catches. This total declined to 18 000 mt in 1993.

The cause for this decline is thought to be the withdrawal of government support for the inland fishery include support for stocking activities. It is estimated that sustainable yield of about 40 000 mt could be obtained by rehabilitating the inland capture fisheries. A further 10 000 mt could be produced through the development of culture enhancement techniques for capture fisheries in small reservoirs.

**Issues**

The countries of this sub-region have considerable inland fisheries resources in either their delta regions (Bangladesh, India), man-made reservoirs (India) and numerous small multipurpose impoundments ("tanks"). The natural wetland Water-bodies are highly productive and capable of very intensive exploitation and represent an important sustainable resource. This is currently under threat from engineering works intended to mitigate flood damage and to prevent river erosion of settled and agricultural land. As the seasonally flooded areas are diminished so is the fish production which depends upon these areas.

The numerous man-made impoundments, both large and small, and many residual water-bodies on the floodplains, represent a considerable opportunity for the development of high-yielding -based fisheries. For such programmes to be successful it is necessary to have in place the necessary infrastructure to sustain the seasonal input of seed fish.

In Pakistan it is known that the current production from these sources is some 100 000 mt/year less than the potential under efficient stocking regimes. This shortfall is principally due to lack of priorities in the sustained development of the fish seed supply farms. The development of man-made impoundments in Turkey suggests that there is also a large opportunity to increase yields from culture-based fisheries there.

### 9.4.4 Sub-region: East Asia

*[Japan, Korea D.R., Korea Rep.]*

This sub-region groups three countries where traditionally fish have been an important element in the diets of their populations. Inland water resources are few and production is restricted by a temperate climate.

**Production**

Between 1987 and 1992 **Japan's** inland fish catches have remained stable in the region at 100 000 mt a year. Population growth has lowered the contribution of these catches to the national diet with a *per caput* fall in inland fisheries production from 1.064 kg in 1987 to 0.779 kg in 1992.

**D P R Korea** has maintained a steady production averaging 93 000 mt a year between 1987 and 1992. This represents a high *per caput* contribution of some 4.50 kg.

**Rep. Korea** reported a fall of 40% between 1987 and 1988 thereafter catches have roughly stabilised to total 25 000 in 1992. This represents a *per caput* fall in production from 1.0 kg to 0.50 kg over this period.

**Issues**

There is evidence that increasing affluence, particularly in Japan and Republic of Korea, is causing a change in dietary habits and the substitution of meat for fish. However, consumer demand will remain high for the foreseeable future. Accompanied by such trends may be a shift towards more recreational uses of freshwaters.

### 9.4.5 Sub-region: China

**Production**

**China** currently produces over half the world catch from inland waters. This has been achieved in the face of a drastic deterioration of much of its fisheries resources, particularly the degradation of the river fisheries.

The Yangtze River, which once provided 70% of China's total freshwater catch, experienced a fall in fish production from 458 000 mt in 1954 to 226 000 mt in the late 1970s. Increased fishing pressure raised yields slightly during the period 1980 to 1985, but thereafter fish stocks have continued to decline. Catches in the lower reaches of the Huanghe (Yellow) River have fallen from 5 000 mt in the 1950s to less than 150 mt in the early 1980s.

Despite the decline in the river fisheries, from 1985 to 1990, annual inland capture fisheries production rose from 475 127 to 1 033 593 mt. During the same period, aquaculture production increased from 2 379 188 to 4 204 028 mt.

The evaluation of these figures is difficult as increasing intensity of exploitation prevents clear distinction between the yields derived from -based fisheries and those from aquaculture in extensive systems (including cage and pen ) in large water bodies.

The extent to which the decline in the contribution of the rivers has been offset by an intensification of the exploitation of the natural lakes and artificial impoundments. This has been in response to the increase in the population and its living standards and the political will and technological capacity to maximise the use of all available resources.

The consequent environmental degradation has reduced some 80% of the 50 000 km of major river systems to a water quality standard too poor to sustain fisheries.

Lesser tributaries tend to be more heavily polluted than the main rivers. Mitigation of this loss by the enhancement of the yields from other water-bodies has mostly come about through the application of aquaculture principles to all forms of fish farming from fish ponds through to pen and cage in lakes and impoundments. The aquaculture infrastructure of breeding farms has allowed heavy stocking of impoundments with subsequent high yields.

The decline in the river fish populations has also removed a source of seed fish for fish farming - a shortfall that has been replaced by the intensification of fish hatchery operations.

Stock enhancement procedures are one of the mechanisms behind the increasing trends in inland fisheries output still being recorded in China. Mean yields from stocked lakes and reservoirs are of the order of 360 kg/ha and 210 kg/ha respectively. To achieve these yields, however, often means the control or eradication of natural predatory species including the destruction of their spawning grounds.

Apart from helping to explain and interpret the statistics for China, such figures suggest a great potential for increased production from freshwaters by applying similar stocking and management practices elsewhere. Comprehensive techniques for fish production from smaller reservoirs, which involve efficient stocking strategies, improvement of natural food levels, and improved harvesting methods, are reported to yield over 7.5 mt/ha/yr.

**Issues**

The pressures on the inland water resources of China present a model for the general trends in all countries that are undergoing a rapid development and are maintaining large and growing populations. Increasing intensification of the exploitation of all available resources has led to serious environmental degradation of many Water-bodies and river systems.

This is chiefly caused by the, mostly uncontrolled, discharges of urban and industrial wastes; the increase of sediment loads from run-off from agricultural areas and erosion from other over-exploitative land use; the interference in water flow regimes by the construction of water control works for electricity generation, water storage for irrigation and urban use. The effect of these impacts is to lower production levels, even to the point where no life can exist, or disturb the ecology of the stocks (particularly migratory stocks). Under these impacts fish populations will decrease in size and possibly change their species composition.

It is theoretically possible to recover water quality, by the enforcement of control measures to prevent water quality degradation (control of discharges, land management on the catchment, etc.). Environmental rehabilitation is a long-term activity which is both costly and which requires a large administrative input. In practice only minimal mitigation can be achieved.

The enhancement of capture fisheries by the introduction of valued species and optimising recruitment by stocking with farm raised fish is being done to great effect. China has the necessary technology and trained personnel to maintain and increase these programmes. It should be noted that although technically successful these operations are not open to economic cost benefit analyses, and it is not known to what degree this food resource is subsidised.

### 9.4.6 Sub-region: Central Asia

*[Afghanistan, Bhutan, Georgia, Iran, Iraq, Kazakhstan, Kirgizistan, Mongolia, Nepal, Tajikistan, Turkmenistan, Uzbekistan]*

The sub-region comprises a group of typically arid countries where some 95% of total water discharges are used for irrigation. High evaporation rates ensure that the drainage waters have a raised salinity and may form evaporation pans. Much work has been carried out on selection of species, food organisms etc. which, coupled with water conservation measures, may allow significant fisheries to develop in these harsh environmental conditions.

**Production**

In 1992, **Kazakhstan** reported the largest total for the sub-region with 80 000 mt. **Iran** and **Turkmenistan** reported 40 000 mt each, and **Azerbaijan** 36 371 mt for the same year.

In 1991, **Uzbekistan** reported catches of 27 439 mt but for some reason these had fallen to a third the following year.

**Nepal** reported a production of 7 145 mt in 1992, about 67% of which is said to be from the river systems. The previous five years showed a fluctuating total with minima of 5 281 mt in 1987 and 1981. Programmes to breed and restock cold water rivers with indigenous species have had some success. A considerable catch is not reported from informal fisheries in such regions. Nepal has considerable hydropower potential through the construction of further dams. If built, these will no doubt be associated with both problems and opportunities.

**Iraq** reported a steady decline in catches from a total of 11 000 mt in 1987 to 4 400 mt in 1992. This decline is probably due to the degradation of the formerly highly productive southern marshlands. **Armenia** reported a similar total of 4 500 mt .

**Afghanistan, Bhutan, Georgia, Khirgizistan** and **Mongolia**, all reported inland fisheries yields of less than 2 000 mt for 1992.

**Issues**

Due to recent political changes and national disturbances, many fisheries production data from this sub-region are sparse and only reliable for 1991 and 1992. Little information is available on the origins of much of this production. At present it is not possible to comment on any long-term changes in the levels of production.

## 9.5 Europe

Capture fisheries in Europe have been traditionally important in the East but in the Western countries the emphasis has been more on recreational uses of inland water systems. While there is relatively low species diversity, reporting by species is not good and the "others" category is very large and contains mostly cyprinids. In the former Soviet Union, catches peaked in 1980 and have declined steadily ever since.

The following sub-regional classification is somewhat arbitrary, although it is based on broad differences in the way that the inland fisheries resources are managed in the various areas. Some sub-regional borders, however, do not naturally conform to national borders. For instance Germany would be divided between Eastern and Western sub-regions. France would be in part classified with the Southern and Scotland with the Northern sub-regions. Furthermore, although most countries in the European Region belong to FAO statistical area 05 (European inland waters), Cyprus belongs to area 04 (Asia), but is included in Southern European sub-region. Israel and Turkey also lie in area 04, but because of the size of their fisheries sectors are reported separately.

### 9.5.1 Sub-region: Eastern Europe

*[Belarus, Bulgaria, Croatia, Czech Republic, Russia, Hungary, Moldavia Republic, Poland, Romania, Slovenia, Slovakia, Ukraine, ex-Yugoslavia states]*

The countries of this sub-region experience a continental climate of hot dry summers and cold winters.

Throughout the sub-region there is a tradition of eating freshwater fish, which is supported by -based fisheries and fish .

**Production**

This sub-region has always been the major producer of fish through freshwater capture fisheries, landing 74 160 mt (53% of the total for the European Region) in 1987.

Since 1988 the reported catches from the Eastern European Sub-Region fell by some 30% to 56 997 mt in 1992 accounting for about 52% of the European total. In 1992, four countries dominated the catch totals, Russian Federation (292 209 mt), Poland (20 800 mt), Hungary (15 206 mt), and Belarus (15 000 mt). The Ukraine recorded a catch of 9 319 mt, Yugoslavia F R 6 060 mt, Moldova 5 000 mt and Romania, which reported a total of 4 510 mt, mostly from the exploitation of the extensive aquatic resources of the Danube delta. The remaining countries in this sub-region Bosnia Herzegovina, Bulgaria, Croatia, former Czechoslovakia, Macedonia, Slovenia, and Yugoslavia S F R all reported annual totals of 4 000 mt or less.

For the sub-region as a whole the *per caput* catch in 1992 was 1 050 g.

Since 1988, production has declined in most of the countries of the sub-region. There is recent evidence that this decline is now levelling off and forecasts are that there will be some growth in the future.

There is an increasing interest in recreational fishing, which is likely to grow with the general improvement in economic conditions and the increase in leisure activities. It should be noted that "recreational fishing" includes a component of food production on a small-scale and for local consumption. Polish and Hungarian yield figures would be considerably higher if the large recreational catch was included.

Since 1984, the only country to register an overall increase has been Poland where catches were about 30% higher in 1991 than 1984. This increase was probably due to the attempts to manage the fisheries of the Mazurian lakes through stocking.

In 1991, the freshwater catches of the Eastern Region were dominated by cyprinids, some 70% of the total, with the major contribution from the common carp, *Cyprinus carpio*, (24%) and silver carp, *Hypophthalmichthys molitrix* (15.5%). Unspecified fish species accounted for a further 24% and the salmon (*Salmo* spp) the remaining 6%.

Issues

There is an apparent change in consumer preference away from cyprinid fishes. There is therefore a need to investigate alternative uses for these stocks should the consumer demand become negligible.

There are considerable environmental questions raised by engineering works intended to divert water for energy, irrigation, urban use and, to a lesser extent, flood protection. This is particularly acute where the current projects on the Danube may seriously affect the fish resources.

These developments must be seen against the shortfalls anticipated in total water supplies in the next decades.

The water resources of the region will come under increased pressure for recreational use. It will be necessary to assess the risks and benefits from various programmes of use and to incorporate the findings into protocols and legislation for the exploitation of the limited water resources available.

The performance and data recording of the fisheries sector in this sub-region has been seriously affected by the political and economic changes that have taken place in recent years. These changes have often disrupted the infrastructure of fisheries management and administration, transferred many of the commercial enterprises from public to private control and divided the national responsibilities for shared water resources.

The changes to national entities that have recently taken place have created a need for a revision of existing fisheries legislation and the establishment of frameworks for international co-operation for the exploitation of shared waters. This is particularly important for the Danube and the smaller rivers of Central and Eastern Europe.

### 9.5.2 Sub-region: Northern Europe

*[Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden]*

The countries in this sub-region are subject to cold winters and short relatively mild summers. In general, they have ready access to marine fish stocks and there is not a strong tradition of freshwater fish in the diet.

#### Production

Much of the reported total annual production from this sub-region (41 000 mt out of 47 800 mt in 1991) was derived from Finland's large recreational fishery. Whitefish, *Coregonus* spp., made up some 42% of this total. The salmon, *Salmo salar,* contributed a further 14%. Although the major part of this recreational fishery was consumed, the catches were not included in the country total after 1986. Since this period the total reported catches for the sub-region have declined at an average of 5.5% per year.

#### Issues

The decline in the reported commercial catches is to be viewed against a background of steadily improving environmental conditions and increasing affluence (especially for Finland, Norway and Sweden).

Increasing pressures for recreational and amenity facilities have led to a decline in commercial and subsistence fishing with a replacement by recreational fishing and associated tourism. Management policies are increasingly incorporating a whole-environment approach and anticipated increasing ease of movement of fish products and people across present national boundaries.

In general, it is considered that the sub-region has a large unexploited commercial fisheries potential , but that this is constrained by lack of effective fisheries management and inadequacies of current markets and consumption patterns.

The Scandinavian countries have strong programmes in place and popular support for the protection of the environment, of which the aquatic resources play a major part. The need to consider the effects of local pollutants and non-point-source pollution such as acid rain, require intergovernmental co-operation both within and outside the region. Throughout the region, the prevailing climate restricts production levels.

The importance of fisheries in the food economy is therefore relatively low. However, leisure interests and environmental concerns play a part in maintaining the importance of inland waters and their fish stocks.

Estonia, Latvia and Lithuania currently share the same problems of economic and political transition as the countries of the Eastern sub-region. Historical factors and present day economic conditions mean that there is considerable scope for improving much of their aquatic environment for the benefit of fish production in the short-term and recreational and amenity value demands as these rise in the future.

### 9.5.3 Sub-region: Southern Europe

*[Albania, Cyprus, Greece, Italy, Malta, Portugal and Spain]*

The countries of the sub-region generally experience hot dry summers and short mild winters. Although such a climate creates conditions for high productivity the region is dry and not rich in inland Water-bodies.

#### Production

Catches in Southern Europe declined by about 4.8% a year from 1984 to 1991. The main cause of this loss was the gradual erosion of the large Italian catch from 23 753 mt (62.3% of the sub-regional total) in 1984 to 11 023 mt (40.1%) in 1991. All other countries in the sub-region showed a slight increase over the same period.

The major proportion of the catch (58%) is recorded as unclassified, with *Cyprinidae* contributing an additional 14% (*Cyprinus carpio* 4.5%). The only other significant components of the 1991 catch are *Mugilidae* with 6% and *Salmonidae* with 6.5%.

#### Issues

Inland waters are not abundant in this sub-region and fisheries are coming under increasing competition from other users of the available water resources (agriculture, industry, urban and recreational use).

Demand for recreational fishing and water-sports is increasing and displacing commercial fishing. The result of these pressures is that the inland fisheries appear to be in structural decline with incomes decreasing and the average age of those employed in the industry, increasing.

The climate of environmental conservation provides opportunities to protect and improve the limited inland water resources. In a region where a considerable part of the economy of many of the countries is dependent upon the tourist industry, the amenity value of inland waters and the promotion of recreational fishing will provide opportunities for increasing this sector.

### 9.5.4 Sub-region: Western Europe

*[Austria, Belgium, Denmark, France, Germany, Ireland, Netherlands, Switzerland and United Kingdom]*

The sub-region experiences a mild climate and sufficient rainfall to support productive rivers and other Water-bodies.

#### Production

Western Europe was the only European Sub-Region to show an increase in catch levels with a mean increase of 2% per year from 1984 to 1991 when the catches totalled 20 050 mt, although much of this might be attributable to aquaculture. Inland fisheries alone totalled 12 106 mt in 1992.

The contribution of the extensive recreational fisheries is also unclear. For 1992, Germany recorded the largest total with a reported 6 299 mt followed by Switzerland with 2 670 mt. Apart from the Netherlands with 1 064 mt, all of the other countries in the sub-region reported catches less than 1 000 mt.

Production increased slightly or remained stable in most countries. Catches of Atlantic salmon increased in most countries particularly in 1990 and 1991 (13% of the total). 16% of the production was unclassified. Cyprinids accounted for 32% of the catches with roach, *Rutilus* spp. accounting for 22%. The bream, *Abramis* spp. (5%), and unclassified Cyprinidae (3%) were the other major components. Significant contributions were made by *Osmerus eperlanus* (10%), perch, *Perca fluviatilis* (7%), and the eel, *Anguilla anguilla* (4%). For the whole sub-region the *per caput* yield was only some 50 g per year.

#### Issues

Although inland fisheries are not important to most of the countries in this sub-region, it is evident that the statistics relating to the inland fisheries sector are in need of clarification.

Some countries within this sub-region report conflicts arising where stocks are shared between recreational and commercial fishers. In particular this applies to the economically important "game" fisheries for salmonids.

Recreational fishing is becoming increasingly important, both within countries and as an element of the tourist industry. This activity may involve a considerable element of food production which goes unrecorded.

## 9.6 Oceania

*[Australia, New Zealand, Papua New Guinea. Many small oceanic islands of this region are not considered here as they have virtually no reported inland fishery catches.]*

Australia and New Zealand cover a range of climatic regimes from the desert of central Australia through temperate to tropical areas. The Papua New Guinea experiences a tropical climate with high rainfall.

### Production

Inland fisheries do not play an important part in the economies of **Australia** and **New Zealand**. The emphasis is on their value as a recreational asset, and in this they have many of the attributes of the inland fisheries of the North American region.

Catches for Australia have been stable over the last six years varying between 2 000 mt and 2 500 mt. In this same period, New Zealand has seen a steady rise from a reported 489 mt in 1987 to 1 242 mt in 1992.

For **Papua New Guinea** inland fisheries are very important with catches stable in the region of 17 000 mt a year, which is equivalent to a *per caput* production of about 4.0 kg. Prior to the mid 1980's much of this catch was unreported as the fishery is dominated by informal activities.

These circumstances point to the need to consider previously unreported catches in planning considerations. Although a Pacific Island nation, the country has an extensive interior which is traversed by three large river systems. Population distributions result in 87% of the people living inland.

Total inland catches are, therefore, higher than catches from an extensive marine resource in terms of fish caught and consumed domestically.

National production figures, as for many countries, are biased by large marine catches taken by foreign fleets which are never landed in the country. A similar situation may exist in the neighbouring Solomon Islands, but to a lesser extent.

## Issues

With small affluent populations who have easy access to the sea and where meat production is important to their economies, the lack of inland water bodies makes it very unlikely that inland fisheries will play any significant role in the food economy of Australia and New Zealand. However, the extent of involvement of aboriginal peoples in inland fisheries in these countries is largely neglected.

Papua New Guinea has a rapidly increasing population and sustained increases in production from freshwaters are crucial to local food security issues; possibly more so than increased production from the marine sector in the short-term. The situation is exacerbated by the lack of natural alternative animal food resources and the relatively poor development state of agriculture. Consideration should also be given to the fact that the country imports large quantities of cheap animal protein, mainly tinned fish and sheep off-cuts, in order to feed the urban and rural populations. However, stocking programmes for inland waters are anticipated to supply much of the future demand and improve longer-term food security.

There is local risk of damage to stocks in some of Papua New Guinea's rivers through discharge from mining operations. These losses can be serious for the local populations that rely on this food resource. More generally, a slower process of gradual environmental disruption is occurring through forestry activities and agricultural intensification.

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## 11. FIGURES AND TABLES

### Table 1: Reported regional inland capture fishery production for 1992 Figures in Brackets

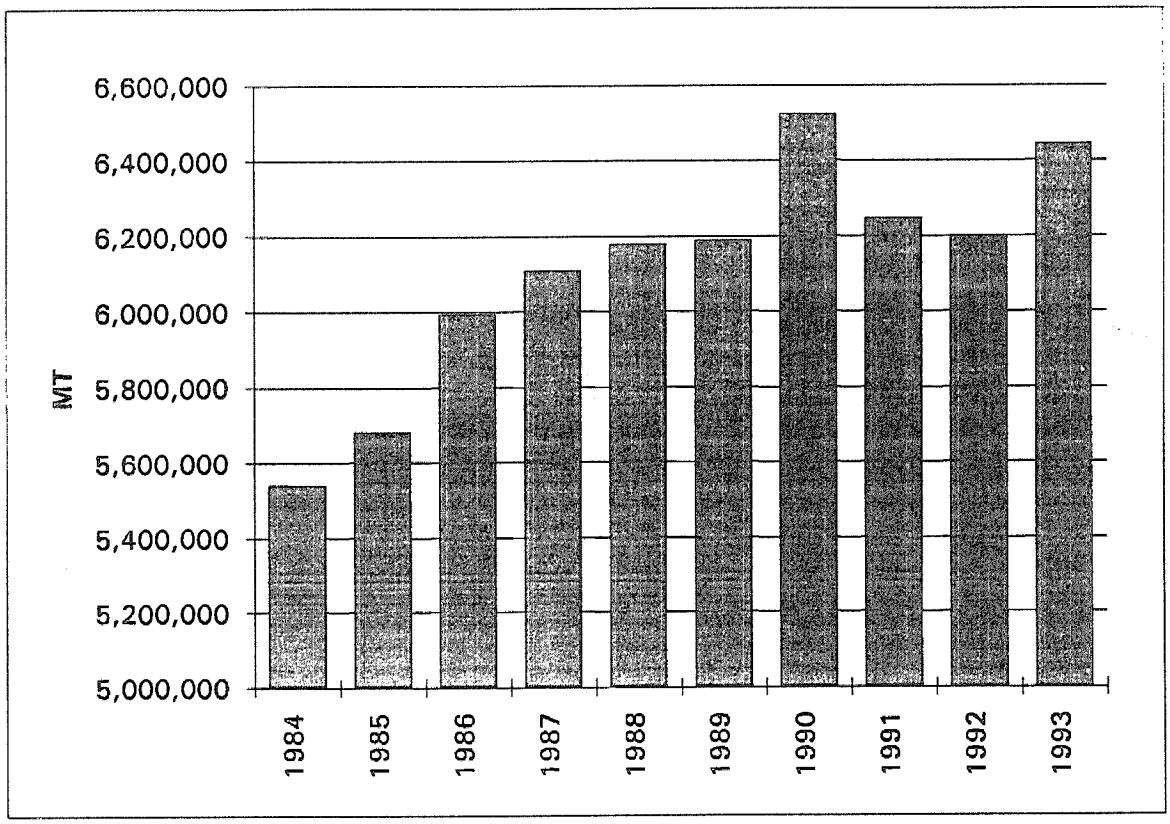
| Region | Total Production ('000 mt) | *Per Caput* Production (kg/yr) |
|---|---|---|
| **Africa Total** | 1 748 (+6.4%) | |
| **Africa** | | |
| - North of the Sahara | 2 (+43%) | 0 (+23.1%) |
| - Trans Saharan | 342 (+13%) | 2.9 (-0.4%) |
| - East, South of the Sahara | 108 (+5.9%) | 4.5 (-9.6%) |
| - West, South of the Sahara | 328 (+1.6%) | 1.2 (-12.7%) |
| **N.America Total** | 124 (+1.2%) | 2.4 (+15.6%) |
| - Canada | 62 (+30.2%) | 2.2 (+21.8%) |
| - USA | 62 (-16.9%) | 2 (-21.0%) |
| **South America** | 474 (-12.4%) | 1 (-23.7%) |
| - Northern Sub-Region | 462 (-13.2%) | 1 (-24.7%) |
| - Southern Sub-Region | 12 (+33.4%) | 1 (+25.1%) |
| **Asia** | 4 (+26.7%) | |
| - Central Asia | 224 (+543%)[1] | 12 (+251%)[1] |
| - Western Asia | 158 (+22.3%) | 1 (+6.2%) |
| - Southern Asia | 846 (-9.4%) | 1 (-18.0%) |
| - South-Eastern Asia | 1 032 (+5.6%) | 2 (-0.04%) |
| - East Asia | 218 (-19.3%) | 112 (-24.2%) |
| - China | 124 (+110%) | 1 (+94.7%) |
| **Europe** | 436 | |
| - Eastern Europe | 378 | 1 |
| - Northern Europe | 0 | 0.4 |
| - Southern Europe | 34 | 0.2 |
| - Western Europe | 12 | 0 |
| **Oceania** | 168 (0.009%) | 1 (-9.6%) |

[1] Figures for increases between 1987 and 1992 for Central Asia are possibly reporting anomalies due to changes in the statistical units in the region following the break-up of the Soviet Union.

Table 2: Inland catches, as a percentage of total catches, by country. Data are based on catch statistics for 1992. (* indicates Low Income Food Deficient Countries, LIFDCs).

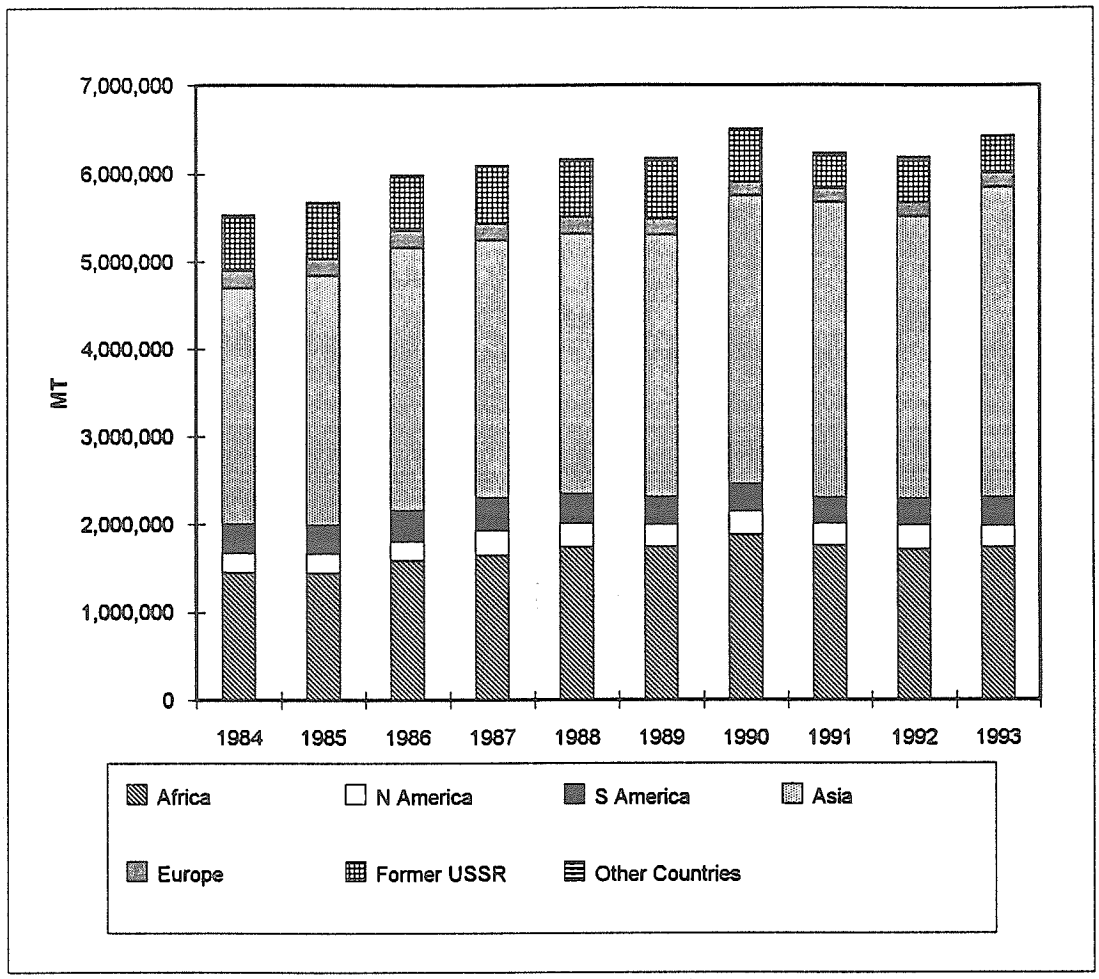
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Afganistan* | 10 | Dominican* | 12 | Luxembourg | 10 | St. Pier Miqu | 0 |
| Albania* | 26 | Ecuador* | 1 | Macau | 0 | St. Vincent | 0 |
| Algeria | 0 | Egypt* | 72 | Macedonia* | 10 | Samoa* | 0 |
| Am. Samoa | 0 | El Salvador* | 41 | Madagascar* | 26 | San Marino | 100 |
| Andorra | 10 | Eq. Guinea* | 10 | Malawi* | 10 | Sao Tome* | 0 |
| Angola* | 9 | Estonia | 3 | Malaysia | 25 | Saudi Arabia | 4 |
| Anguilla | NA | Ethiopia* | 98 | Maldives* | 0 | Senegal* | 8 |
| Antigua Bar. | 0 | Fiji | 13 | Mali* | 10 | Seychelles | 0 |
| Argentina | 1 | Finland | 6 | Malta | 0 | Sierra Leone* | 28 |
| Armenia* | 10 | France | 6 | Marshall Isl | 0 | Singapore | 2 |
| Aruba | NA | Fr. Guiana | 1 | Martinique | 1 | Slovenia | 15 |
| Australia | 16 | Fr. Polynesia | 1 | Mauritania* | 7 | Solomon Isl* | 0 |
| Austria | 10 | Gabon | 9 | Mauritius | 0 | Somalia* | 2 |
| Azerbaijan* | 10 | Gambia* | 11 | Mayotte | 0 | South Africa | 0.5 |
| Bahamas | 0 | Georgia* | 6 | Mexico | 14 | Spain | 2 |
| Bahrain | 0 | Germany | 15 | Micronesia | 0 | Sri Lanka* | 10 |
| Bangladesh* | 71 | Ghana* | 13 | Moldova* | 10 | Sudan* | 95 |
| Barbados | 0 | Greece | 7 | Monaco | 0 | Suriname | 5 |
| Balarus | 10 | Greenland | 0 | Mongolia* | 10 | Svalbard etc. | 100 |
| Belgium | 2 | Grenada | 0 | Montserrat | 0 | Swaziland* | 100 |
| Belize | 0 | Guadeloupe | 0 | Morocco* | 0 | Sweden | 2 |
| Benin* | 78 | Guam | 16 | Mozambique* | 11 | Switzerland | 100 |
| Bermuda | 0 | Guatemala* | 58 | Myanmar | 23 | Syria* | 72 |
| Bhutan* | 10 | Guinea* | 11 | Namibia | 0 | Tajikistan* | 100 |
| Bolivia* | 10 | Guinea Bis.* | 4 | Nauru | 0 | Tanzania* | 83 |
| Boznia Herzg | 10 | Guyana | 2 | Nepal* | 10 | Thailand | 8 |
| Botswana | 10 | Haiti* | 10 | Netherlands | 1 | Togo* | 5 |
| Brazil | 26 | Honduras* | 1 | Neth. Antiles | 0 | Tokelau | 0 |
| Brunei Darus | 3 | Hong Kong | 2 | New Cale. | 0 | Tonga | 0 |
| Bulgaria | 26 | Hungary | 10 | New Zealand | 0 | Trinidad Tob. | 0 |
| Burkina Faso* | 10 | Iceland | 0 | Nicaragua* | 5 | Tunisia | 0 |
| Burundi* | 10 | India* | 41 | Niger* | 10 | Turkey | 11 |
| Cambodia* | 67 | Indonesia* | 26 | Nigeria* | 34 | Turkmenistan* | 100 |
| Cameroon* | 24 | Iran I. R. | 25 | Niue | 0 | Turks Caicos | 0 |
| Canada | 5 | Iraq | 83 | N. Marianas | 0 | Tuvalu* | 0 |
| Cape Verde* | 0 | Ireland | 0 | Norway | 0 | Uganda* | 100 |
| Cayman Isl. | 0 | Israel | 83 | Oman | 00 | Ukraine | 5 |
| Cen.Afr.Rep* | 10 | Italy | 10 | Pakistan* | 22 | Utd Arab Em. | 0 |
| Chad* | 10 | Jamaica | 32 | Palau | 0 | UK Eng Wales | 5 |
| Chile | 0 | Japan | 2 | Panama | 0 | UK Scotland | 1 |
| China* | 41 | Jordan* | 92 | Pap.New* | 52 | UK N. Ireland | 4 |
| Christmas Isl. | NA | Kazakhstan | 10 | Paraguay | 10 | USA | 6 |
| Cocos Isl | NA | Kenya* | 96 | Peru | 0 | Uruguay | 0 |
| Colombia* | 30 | Kyryzstan* | 10 | Philippines* | 26 | Uzbekistan* | 100 |
| Comoros* | 0 | Kiribati* | 0 | Pitcairn | 0 | Vanuatu* | 0 |
| Congo* | 53 | Korea Rep. | 6 | Poland | 10 | Venezuela | 6 |
| Cook Isl | 0 | Korea Rep. | 2 | Portugal | 1 | Viet Nam | 25 |
| Costa Rica | 11 | Kuwait | 0 | Puerto Rico | 10 | Virgin Isl. Br. | 0 |
| Côte d'Ivoire* | 20 | Laos* | 10 | Qatar | 0 | US Virgin Isl. | 0 |
| Croatia | 20 | Latvia | 1 | Reunion | 0 | Wallis Fut. Isl | 0 |
| Cuba | 20 | Lebanon | 6 | Romania* | 36 | West Sahara | NA |
| Cyprus | 3 | Lesotho* | 10 | Russian Fed. | 7 | Yemen* | 1 |
| Former Czech | 10 | Liberia* | 45 | Rwanda* | 10 | Yugoslav SFR | 34 |
| Denmark | 2 | Libya | 0 | St. Helena | 0 | Yugoslav FR | 97 |
| Djibouti* | 0 | Liechtenstein | 10 | St. Kitts Nev | 0 | Zaire* | 99 |
| Dominica | 5 | Lithuania* | 3 | Saint Lucia | 0 | Zambia* | 100 |
| | | | | | | Zimbabwe* | 100 |

Figure 1: World total inland capture fisheries production 1984-1993




Source: Fishery Data, Information and Statistics Service, FAO, 1995.

Figure 2: Total Inland Capture Fishery Production by Continent 1984-1993




Source: Fishery Data, Information and Statistics Service, FAO, 1995.