Mekong River Commission

Fish migrations of the Lower Mekong River Basin: implications for development, planning and environmental management

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Summary

In the Mekong River Basin, most fishes are migratory. Many of them migrate long distances, often across international borders during their seasonal movements. People throughout the basin depend, directly or indirectly, upon the migrating fish for food and livelihood. Water management projects such as hydroelectric dams could adversely impact those migrations and thus negatively effect the livelihoods of a large number of people.

This report identifies some key features of the Mekong River ecosystem that are important for the maintenance of migratory fishes and their habitats. The report further discusses ways in which available information about migratory fishes can be incorporated in planning and environmental assessments.

Three distinct, but inter-connected, migration systems have been identified in the lower Mekong River Basin, each involving multiple species. These are respectively the lower (**LMS**), the middle (**MMS**) and the upper (**UMS**) Mekong migration systems. These migration systems have evolved as a response to the hydrological and morphological shape of the Mekong in its lower, middle and upper sections.

In a complex, multi-species ecosystem, such as the Mekong River Basin, single-species management is not feasible. Instead, a more holistic ecosystem approach is suggested for management and planning. The migration systems mentioned above could be used as the initial, large-scale framework under which ecosystem attributes can be identified and, in turn, transboundary management and basin development planning can be implemented.

The important ecological, or ecosystem, attributes of migratory fishes are identified for each migration system. The emphasis is on maintaining critical habitats, the connectivity between them and the annual hydrological pattern responsible for the creation of seasonal floodplain habitats.

The Lower Mekong Migration System (LMS)

Dry season refuge habitats: Deep pools, particularly in the Kratie-Stung Treng stretch of the Mekong mainstream.

Flood-season feeding and rearing habitats: Floodplains in the Mekong Delta in Viet Nam, in southern Cambodia, and in the Tonle Sap system.

Spawning habitats: Rapids and deep pool systems in Kratie-Khone Falls, and in the Sesan catchment. Floodplain habitats in the south (e.g. flooded forests associated with the Tonle Sap Great Lake).

Migration routes: The whole Mekong mainstream from the Mekong Delta to the Khone Falls, including the Tonle Sap River (longitudinal connectivity). Between floodplain habitats and river channels (lateral connectivity). Between the Mekong mainstream and the Sesan sub-catchment (including the Sekong and Srepok Rivers).

Hydrology: The annual floods that inundate large areas of southern Cambodia (including the Tonle Sap system) and the Mekong Delta, and the annual reversal of the Tonle Sap River, are essential for fisheries productivity.

The Middle Mekong Migration System (MMS)

Dry season refuge habitats: Deep pool stretches of the Mekong mainstream and within major tributaries.

Flood-season feeding and rearing habitats: Floodplains of this system that are mainly associated with major tributaries.

Spawning habitats: Rapids and deep pool systems in the Mekong mainstream. Floodplain spawning habitats associated with tributaries.

Migration routes: Connections between the Mekong River (dry season habitats) and major tributaries (flood season habitats).

Hydrology: The annual flood pattern that causes inundation of floodplain areas along major tributaries.

The Upper Mekong Migration System (UMS)

Dry Season refuge habitats: Occur throughout the extent of the Upper Mekong Migration System, but are most common in the downstream stretch from the mouth of Loei River to Louang Prabang.

Flood-season feeding and rearing habitats:Floodplain habitats are restricted to the floodplains that border the main river, as well as smaller floodplains along some of the tributaries.

Spawning habitats: Spawning habitats that are situated mainly in stretches where rapids alternate with deep pools.

Migration routes: Migration corridors between downstream dry-season refuge habitats and upstream spawning habitats.

Hydrology: The annual flood pattern that triggers fish migrations and causes inundation of floodplains.

These ecosystem attributes should be taken into account when assessing impacts of development activities. A pre-requisite for impact assessments is a valuation of the impacted resource (e.g. migratory fishes) from a fishery perspective. Undertaking such a valuation of migratory fishes is extremely difficult because they are targeted throughout their distribution range in many different ways, and with many different fishing gears and operations. Given the scale and complexity of such an undertaking in the Mekong River, it is probably not possible to fully assess the economic value of migratory fishes.

However, a partial assessment of value, together with an assessment of information gaps is in many cases sufficient for planning and assessment purposes. It is also important to emphasise that in the decision-making process, qualitative information and knowledge from various sources should be included on equal terms with quantitative data. Furthermore, along with the direct value of fishery resources, the Mekong River ecosystem provides numerous intrinsic, non-quantifiable goods and services.

To ensure that the Mekong River Basin can continue to provide these important goods and services, we propose that development planning and environmental assessment should be based on an ecosystem approach within which the ecological functioning, productivity and resilience of the ecosystem are maintained. Experiences from other river basins suggest that from an economic, social and environmental point of view, this is best way to utilise a river.

xmsarsegb³

enAkgGagTenemKg RtIPaKeRcInCaRbePTRtIb I asT I. PaKeRcIné nBBkRtIb I asTEtgeFI cracrpvqa yedayqgkatRBRbT I GnrCatkgrdvb I asTrbsBkva. RbCaCnkgGagTagm I BgEpkeday pa I redayRbeya I eTAe I RbePTRtIb I asTsrabCanbGahar ngCvPaBrsenA. KeragRKbRKgTkCaeRcIn dcCaTnbvarGsKnGacCH\TB I GaRkkyagFnFrd I karb I asT rbsRtI ngCa I Tp I p I p I bHBa I CaGvCmand I CvPaBrsenArbsRbCaCnCaeRcIn.

GtbTenHngbga j nv I kN³BessCaKnHmycnnénRbBneGkTenemKg Ed I mansar³sxan d I karEfrkSaRbePTRtIb I asT ngCrkrbsRtRbePTenH. GtbTenHngp I CabEnmnvvFEd I eygGacTT I)anBtmansGBRbePTRtIb I asTEd I Rtv)aneKdakbBa I eTAkgEpnkar ngkar vaytéIbrsannana.

RbBnb I asTcnnbepSg²KaEd I manTnakTngKaeTAv j eTAmk Rtv)aneKktsKa I eX I j man enAkgGagTenemKgeRkamEd I RbBnnmy²CabTakTgKaCamyBCRtICaeRcIn. TagGsenHCa RbBnb I asTdacedayELk²BKarvagEpkxageRkam EpkkNa I ngPaKxage I énTenemKg. RbBnb I asTTagenH)aneqJytbeTAngRTgRTayC I vTa ngrbsaRsénTenemKgenAEpkxageRkam kNa I ngxage I rbsTenenH.

kgRbBneGkcrHRbePT ngsa j amydcCaGagTenemKg karRKbRKgRbePTeTa I NamyenaHK mnGaceF)aneLIy. pyeTAv j eK)anes eGaymankarRKbRKgmy ngkardakEpnkartamTs edAsrabRbBneGkTagm I. ra I RbBnb I asTEd I)anbryayxage I GaceRbR)askgRkbxN énkarcabepIm bkgvsa I PaBmyT I ayEd I kgenaHGtsBaaNénektn³PNRbBneGkTag enH)anRtvbga j eGayeX I j ngCabn eTbkarRKbRKgqgEdn ngkareFEpnkarGPvDÆnkgGag GacGnvteTA)an.

ektn³PNdsxanrbsRbBneGk reGkLsénRbePTRtIb I asTRtv)aneKsKa I eX I j ceBaH RbBnb I asTnmy². sar³sxanKkarEfrkSara I CrksxanÉ PaBTakTgKaeTAv j eTAmkrvagCrk ngdeNIrC I vTaRbcaqaEd I Fanad I karbegteGaymanCrkenAdbn I cTktamrdvCaeRcInkEng.

RbBnþlasTenAtenemKgPaKxageRkam

CrkrsenArdvR)ag³ GngeRCA²CaBessenAextRkecHngextsgERtgtambeNayTenemKg. cNGahamardvTkdeLg ngCrkbBC³ TnabþlcTkkgdbndsNrTenemKgénRbeTsevotNam dbnPaKxagt,gRbeTskmCa ngtamRbBnTensab.

CrkBgkn³ RbBnGngeRCA²ngfbRbHTkenAkgextRkecHþl,akexan ngdbnrgTkePøgénTenessan. CrkCaeRcnenAkgdbnþlcTkPaKxagtg ¬]> dbnéRBþlcTkCvj bgTensab¦.

pvcracrRt³ RbBnTenemKgTagmþlcabBdbndsNrTenemKgrhtdþlþl,akexan rmbBaþl TagTensab¬TnakTngExSrysbeNay¦. rvagCrkdbnþlcTkngTemana¬TnakTngépþlat¦. rvagTenemKgngGndbnrgTkePøgénTenessan¬rmbBaþlTagTeneskgngTenERsBk¦.

CþlsaRs³ CnnRbcacpyagFþlgeþlyEdþlþlcdbnCaeRcnénPaKxagt,gRbeTskmCa¬Kt bBaþlTagRbBnTensab¦ ngdbndsNremKg RBmTagkarhrRtLbrbsTensabmansar³ sxanNasceBaHpþltPaBCþlpþl.

RbBnþlasTenATenemKgPaKkNaþl

CrkrsenArdvR)ag³ manenAtamGngeRCA²énTenemKg ngenAtamédF²énTenemKg.

cNGahamardvTkdeLg ngCrkbBC³ CrktamdbnþlcTkPaKeRcnCaBessCabtamédTenF².

CrkBgkn³ enAtamRbBnGngeRCA² ngdbnfbRbHTkTenemKg. enAtamCrkBgkndbn þlcTktamédTen.

pvcracrRt³ CabKarvagTenemKg¬CrkrdvR)ag¦ ng tamédTenF²¬CrkrdvCnn¦.

CþlsaRs³ RbePTRTgRTay ngvsaþlPaBTkCnnRbcacpbNaþleGayankarþlcdbnTnab énédTenF².

RbB½nÆ Ê asÞTenAT enemKg PaK Xag eÊI

CrkrsenArdvR)ag³ ek½tmanenATTag RbBn½TenemKg eÊI bÉn PaKeRcInmanenA kgdbn PaKXag eRkamcab B½mat énTene Êyd Ê Êg R)a)ag.

cNIGa harnardvTkde L¶g ng Crkbn B C³ Crkdbn Ê cTk CaeRcInmanenAdbn Ê cTkEd Ê CaRBRbT ÊénTenF² kdcCadbnva Ê Tnab t² tambeNa yédTen t²my cnn.

CrkBgkr¼ CrkBgkn ft enACaBe ss tamtbn fRbHTkEd Ê man Gn geRCA².

pvcracrRt³ pvrebogb Ê asÞTmanenAcen aH Crkr senAnardvR)agenAPaKXag eRkam ng CrkBg knenAPaKXag eÊI.

C Ê saRs³ RbePT RTgRTa y ngvsa Ê PaB TkCnn Rbca q CaKrHCr j eGa ymankarb Ê asÞT rbsRt ngeGa yman TkCnnd Ê TnabkN Ê Ê.

ektn³sm,t RbBn eGkTagenHKb,Rt v)aneK ykct TkdakenAeB Ê eFIkarva yté Ê B p Ê bHBa Ê bNa Ê mkB sk m PaBGPvDÆnnana. kar tRmveGa ymankarva yté Ê CamnB p Ê bHBa Ê KCakar va yté mnvFnFan Ed Ê GacTT Ê rgkarbHBa Ê ¬] › RbePTRt b Ê asÞT ¦ e Ê vsyC Ê p Ê. kareFI karva yté Ê RbePTRt b Ê asÞTÉbbenHKmankar Ê)akCaTbp t BeRBaHeKRt vkN teKa Ê edArbs va tamry³karerobcCaRkm²eda yvFepS g²ceBaHRbePTRt tTagenaH ng tamrebobénkareFI ensaTng RbePT] bkrN ensaTepSg²eTot. eda ysarEt vsa Ê PaB ng PaBs RKsa j énkar Gnv tn Ébben HenAkg TenemKgdecHeh Ê y eTIbeKmn Gacva yté mCarm)an GB sar³sxand Ê esdkcrbs RbePTRt b Ê asÞT .

eTaHCayagNak kgkrNCaeRcInkarvaytél myEpkNaRBmCamyngkarvaytél e lkgH xatEpkBtmanGacRKbRKansrabkareFEpnkar ngberEKa l edAkarvaytém. vaCakardca)ac pgEdrEd l fa kgdeNIrkareFescksercct ceNHdg ngBtmanEd lmanKNPaBBRbPBepSg ²Kb,IdakbBa l eGayesIKangTmyCabrmaNpgEdr. bEnme l senHeTotrmCamyngté l pa l énRbPBFnFanC l p l RbBneGkTenemKgp l eGaynvmCÄnk³yagsem,Im RTBüsm,t mnGackatéf)an ngesvaCaeRcIn.

edIm,Fana)anfa GagTenemKgGacbnp l nvRTBüsm,t ngesvadmanté l TagenH eygxesfa karksagEpnkarGPvDÆn ngkarvayté l brsanKb,Qre l m l danTsSn³RbBneGkEd l kg enaHeygRtvrkSaeGay)annvkarRbRBtTAénRbBneGkLs p l tPaB ngKnkarbHBa l d l RbBneGk . bTBesaFnTagLayEd l)anmkBbNaGagTenepSg²p l eyab l fa ceBaHvsy brsan sgm ngesdk cenHCavFmyd l bptkgkareRbR)asTen.

ບົດສະຫລຸບຍໍ້

ໃນອ່າງແມ່ນ້ຳຂອງ, ປາສ່ວນຫລາຍແມ່ນມີການເຄື່ອນຍ້າຍ (ຂຶ້ນ-ລ່ອງ). ຊຶ່ງມີປາຫລາຍຊະນິດ ເຄື່ອນຍ້າຍເປັນໄລຍະທາງໄກ ຂ້າມຜ່ານເຂດແດນລະຫວ່າງປະເທດ ໃນລະດູການເຄື່ອນຍ້າຍ. ປະຊາຊົນໃນທົ່ວອ່າງແມ່ນອາໄສຊ່ວງດັ່ງກ່າວທຳການຈັບປາເພື່ອບໍລິໂພກ ແລະ ການດຳລົງຊີວິດ. ໂຄງການ ການພັດທະນາກ່ຽວກັບການໃຊ້ນ້ຳຕ່າງໆ ເຊັ່ນ ເຂື່ອນໄຟຟ້າ ສາມາດເປັນອຸປະສັກກີດຂວາງທາງເຄື່ອນຍ້າຍຂອງປາໄດ້ ແລະ ກໍ່ໃຫ້ເກີດຜົນກະທົບທາງລົບຕໍ່ ການດຳລົງຊີວິດຂອງ ປະ ຊາຊົນຈຳນວນຫລາຍ.

ບົດລາຍງານສະບັບນີ້ ໄດ້ຊີ້ໃຫ້ເຫັນບາງລັກສະນະທີ່ເປັນຂໍກະແຈ ຂອງລະບົບນິເວດ ຂອງແມ່ນ້ຳຂອງທີ່ສຳຄັນ ເພື່ອຮັກສາ ທີ່ຢູ່ອາໄສຂອງປາທີ່ມີນິໄສເຄື່ອນຍ້າຍ. ບົດລາຍງານ ຍັງໄດ້ກ່າວເຖິງຊ່ອງທາງໃນການນຳເອົາຂໍ້ມູນກ່ຽວກັບການເຄື່ອນຍ້າຍຂອງປາເຂົ້າໃນການວາງແຜນ ແລະ ການປະເມີນ ທາງດ້ານສິ່ງແວດລ້ອມ.

ມີ 3 ລະບົບແຕກຕ່າງກັນໃນການເຄື່ອນຍ້າຍຂອງປາ ທີ່ຄົ້ນຄ້ວາພົບໃນອ່າງແມ່ນ້ຳຂອງ, ແຕ່ວ່າ ແຕ່ລະລະບົບແມ່ນມີການພົວພັນຊຶ່ງກັນ ແລະ ກັນ, ແຕ່ລະລະບົບແມ່ນມີຫລາຍຊະນິດປາເຄື່ອນຍ້າຍຮ່ວມກັນ. 3 ລະບົບເຄື່ອນຍ້າຍດັ່ງກ່າວ ຄື: ເຂດແມ່ນ້ຳຂອງຕອນໃຕ້ **(LMS)**, ເຂດແມ່ນ້ຳຂອງຕອນກາງ **(MMS)** ແລະ ເຂດແມ່ນ້ຳຂອງຕອນເໜືອ **(UMS)**. ລະບົບເຄື່ອນຍ້າຍດັ່ງກ່າວ ແມ່ນໄດ້ຈຳແຍກໂດຍອີງໃສ່ລັກສະນະ ທາງອຸທົກກະສາດ ແລະ ຮູບຮ່າງ ລັກສະນະຂອງ ແມ່ນ້ຳຂອງ ແຕ່ລະພາກ ເຊັ່ນ: ລຸ່ມ, ກາງ ແລະ ເໜືອ.

ໃນຄວາມສະລັບຊັບຊ້ອນ ຂອງລະບົບນິເວດ-ນານາພັນ ເຊັ່ນ ອ່າງແມ່ນ້ຳຂອງນີ້, ການຄຸ້ມຄອງປາຊະນິດນຶ່ງ ຊະນິດດຽວ ແມ່ນ ເປັນໄປໄດ້ຍາກ. ໃນທາງກົງກັນຂ້າມ, ຈຶ່ງແນະນຳວ່າຄວນວາງແຜນ ຄຸ້ມຄອງທັງລະບົບນິເວດໂດຍລວມ. ລະບົບການເຄື່ອນຍ້າຍຂອງປາທີ່ກ່າວໄວ້ຂ້າງເທິງນັ້ນ ແມ່ນສາມາດໃຊ້ເປັນການເລີ້ມຕົ້ນເທົ່ານັ້ນ, ແຕ່ໃນຂອບເຂດທີ່ກ້ວາງຂຶ້ນຂອງລະບົບນິເວດ ສາມາດກາຍເປັນບັນຫາການຄຸ້ມຄອງຜົນກະທົບຂ້າມຊາຍແດນ ແລະ ສາມາດນຳເຂົ້າປະຕິບັດໄດ້ໃນແຜນການພັດທະນາ ອ່າງ.

ຄວາມສຳຄັນຂອງນິເວດວິທະຍາ ຫລື ລະບົບນິເວດ ເຮັດໃຫ້ມີຄວາມສາມາດຈຳແນກໄດ້ເຖິງປາ ທີ່ມີນິໄສເຄື່ອນຍ້າຍ ໃນແຕ່ລະລະບົບເຄື່ອນຍ້າຍ. ຕ້ອງເອົາໃຈໃສ່ ປົກປັກຮັກສາ ບ່ອນຢູ່ອາໄສ ທີ່ເປັນຈຸດຫລໍ່ແຫລມ, ທີ່ມີການເສື່ອມຕໍ່ ລະຫວ່າງ ທີ່ອາໄສນັ້ນ ກັບ ລະດັບອຸທົກກະສາດປະຈຳປີ ທີ່ມີຄວາມສຳພັນໃນການກໍ່ໃຫ້ເກີດ ທີ່ຢູ່ອາໄສຂຶ້ນໃນເຂດນ້ຳຖ້ວມປະຈຳປີ.

<u>ລະບົບເຄື່ອນຍ້າຍຂອງປາໃນແມ່ນ້ຳຂອງຕອນລຸ່ມ (LMS)</u>

-ທີ່ຢູ່ອາໄສ ລີ້ໄພໃນລະດູແລ້ງ: ວັງເລິກ, ໂດຍສະເພາະໃນເຂດ ກະແຈະ ຫາ ຊຽງແຕງ (ກຳປູເຈຽ) ໃນລຳແມ່ນ້ຳຂອງ.

-ທີ່ຢູ່ອາໄສທີ່ເປັນບ່ອນອະນຸບານແລະແຫລ່ງອາຫານໃນລະດູຝົນ: ເຂດນ້ຳຖ້ວມໃນ ເຂດສັນດອນປາກແມ່ນ້ຳຂອງ (Mekong Delta) ຂອງຫວຽດນາມ, ພາກໃຕ້ ກຳປູເຈຽ ແລະ ທະເລສາບນ້ຳຈືດ (Tonle Sap System) ຂອງກຳປູເຈຽ.

-ບ່ອນປະສົມພັນ ວາງໄຂ່: ເຂດເປັນແກ້ງ ແລະວັງເລິກ ແຕ່ ກະແຈະ ຫາ ນ້ຳຕົກຄອນພະເພັງ, ແລະເຂດແມ່ນ້ຳເຊສານ. ເຂດນ້ຳຖ້ວມໃນພາກໃຕ້ (ເຊັ່ນ: ເຂດປ່ານ້ຳ ຖ້ວມ ອ້ອມ ທະເລສາບນ້ຳຈືດ (Great Lake) ຂອງກຳປູເຈຽ).

-ເສັ້ນທາງເຄື່ອນຍ້າຍຂອງປາ: ໃນລຳແມ່ນ້ຳຂອງ ຈາກເຂດ Mekong Delta ຫາ ນ້ຳຕົກຄອນພະ ເພັງ ລວມທັງ ແມ່ນ້ຳຕົງເລສາບ (ເປັນເສັ້ນທາງຕິດຕໍ່ທາງຍາວ). ລະຫ່ວາງ ເຂດນ້ຳຖ້ວມ ຫາ ລຳນ້ຳ (ເປັນເສັ້ນທາງຕິດຕໍ່ທາງ ຂວາງ). ລະຫ່ວາງ ລຳນ້ຳຂອງ ແລະອ່າງໂຕ່ງເຊສານ (ລວມເອົາ ເຊກອງ ເຊສານ ແລະເຊຣປອກ)

-ອຸທົກກະສາດ: ນ້ຳຖ້ວມປະຈຳປີ ແລະເຂດນ້ຳຖ້ວມ ທີ່ກ້ວາງໃຫຍ່ໃນພາກໃຕ້ຂອງ ກຳປູເຈຽ (ລວມທັງແມ່ນ້ຳຕົງເລສາບ) ແລະ Mekong Delta, ແລະການໄຫລກັບຄືນປະຈຳປີຂອງແມ່ນ້ຳຕົງເລສາບ ແມ່ນມີຄວາມ ສຳຄັນ ຕໍ່ຜົນພະລິດປາ.

<u>ລະບົບເຄື່ອນຍ້າຍຂອງປາໃນແມ່ນ້ຳຂອງຕອນກາງ (MMS)</u>

-ທີ່ຢູ່ອາໄສ ລີ້ໄພໃນລະດູແລ້ງ: ວັງເລິກຕາມລຳແມ່ນ້ຳຂອງ ແລະສາຂາໃຫຍ່ໆຂອງແມ່ນ້ຳຂອງ

-ທີ່ຢູ່ອາໄສທີ່ເປັນບ່ອນອະນຸບານແລະແຫລ່ງອາຫານໃນລະດູຝົນ: ເຂດນ້ຳຖ້ວມ ຕາມລ້ອງແມ່ນ້ຳ ສາຂາຂອງແມ່ນ້ຳຂອງ

-ບ່ອນປະສົມພັນ ວາງໄຂ່: ຕາມແກ້ງ ແລະວັງເລິກຕາມລຳແມ່ນ້ຳຂອງ. ເຂດນ້ຳຖ້ວມຕາມລ້ອງນ້ຳ ສາຂາແມ່ນ້ຳຂອງ.

-ເສັ້ນທາງເຄື່ອນຍ້າຍຂອງປາ: ລະຫ່ວາງ ລຳແມ່ນ້ຳຂອງ (ທີ່ອາຢູ່ໄສໃນລະດູແລ້ງ) ແລະ ສາຂາໃຫຍ່ໆຂອງແມ່ນ້ຳຂອງ (ທີ່ອາຢູ່ໄສໃນລະດູຝົນ)

-ອຸທົກກະສາດ: ລະດັບນ້ຳຖ້ວມ ປະຈຳປີ ທີ່ເກີດມີນ້ຳຂັງ ຕາມເຂດນ້ຳຖ້ວມ ລຽບຕາມສາຂາໃຫ່ໆ ຂອງແມ່ນ້ຳຂອງ

<u>ລະບົບເຄື່ອນຍ້າຍຂອງປາໃນແມ່ນ້ຳຂອງຕອນເໜືອ (UMS)</u>

- ***ທີ່ຢູ່ອາໄສ ລີ້ໄພໃນລະດູແລ້ງ:*** ມີຢູ່ທົ່ວໄປໃນເຂດ ຕອນເໜືອ(UMS), ແຕ່ສ່ວນຫລາຍມີຢູ່ສ່ວນ ໃຕ້ ຈາກ ປາກແມ່ນ້ຳເລີຍ ຫາ ຫລວງພະບາງ.
- ***ທີ່ຢູ່ອາໄສທີ່ເປັນບ່ອນອະນຸບານແລະແຫລ່ງອາຫານໃນລະດູຝົນ:*** ບໍເວນນ້ຳຖ້ວມ ໃນຕອນນີ້ຈະມີຂອບເຂດຈຳກັດ ຢູ່ລຽບຕາມແຄມແມ່ນ້ຳ ແລະເຂດນ້ຳຖ້ວມນ້ອຍໆ ຕາມທີ່ຕ່ຳ ເລາະຕາມລຳນ້ຳ.
- ***ບ່ອນປະສົມພັນ ວາງໄຂ່:*** ບອ່ນປະສົມພັນວາງໄຂ່ ແມ່ນມີຢູ່ທົ່ວໄປ ຕາມລຳແມ່ນ້ຳຂອງ ແລະສ່ວນຫລາຍຈະແມ່ນບ່ອນທີ່ເປັນແກ້ງ ທີ່ຕິດກັບວັງເລິກ
- ***ເສັ້ນທາງເຄື່ອນຍ້າຍຂອງປາ:*** **ແມ່ນ**ເສັ້ນທາງເສື່ອມຕໍ່ລະຫ່ວາງ ທີ່ລີ້ໄພລະດູແລ້ງໃນເຂດໃຕ້ຂອງຕອນເໜືອ ຫາ ບ່ອນປະສົມພັນວາງໄຂ່ໃນເຂດເໜືອສຸດ
- ***ອຸທົກກະສາດ:*** ລະດັບນ້ຳຖ້ວມປະຈຳປີທີ່ ກະຕຸ້ນໃຫ້ປາທຳການເຄື່ອນຍ້າຍ ແລະເຮັດໃຫ້ມີນ້ຳຖ້ງໃນເຂດນ້ຳຖ້ວມ.

ຄຸນສົມບັດຂອງລະບົບນິເວດເຫລົ່ານີ້ ຄວນນຳເຂົ້າໃນຂະບວນການປະເມີນຜົນກະທົບ ໃນໂຄງການພັດທະນາຕ່າງໆ. ການສຶກສາ ປະເມີນຜົນກະທົບເບື້ອງຕົ້ນ ແມ່ນມີປະໂຫຍດຕໍ່ຜົນກະທົບ ທີ່ຈະມີແກ່ຊັບພະຍາກອນ (ເຊັ່ນ: ປາທີ່ມີການເຄື່ອນຍ້າຍ) ທີ່ກ່ຽວກັບການປະມົງ. ເມື່ອກ່າວເຖິງຄຸນຄ່າຂອງປາທີ່ມີນິໄສເຄື່ອນຍ້າຍແລ້ວ ແມ່ນຍາກຈະທຳການປະເມີນ, ເພາະວ່າ ມັນກະຈາຍຢູ່ທົ່ວທຸກແຫລ່ງນ້ຳ ສາຂານ້ຳຂອງ, ຫລາຍຮູບແບບ ແລະ ຫລາຍວິທີການຈັບ ໂດຍໃຊ້ເຄື່ອງມືຫລາຍຮູບແບບ. ເນື່ອງຈາກ ຄວາມສະລັບຊັບຊ້ອນດັ່ງກ່າວຂອງແມ່ນ້ຳຂອງ, ຈື່ງບໍ່ອາດສາມາດເປັນໄປໄດ້ ທີ່ຈະປະເມີນມູນຄ່າທາງດ້ານເສດຖະກິດ ຂອງປາທີ່ທຳການເຄື່ອນຍ້າຍ. ເຖີງຢ່າງໃດກໍ່ຕາມ, ການປະເມີນມູນຄ່າເປັນບາງສ່ວນພ້ອມກັບການປະເມີນຊ່ອງວ່າງຂອງຂໍ້ມູນຂ່າວສານ ທີ່ພຽງພໍສຳຫລັບການວາງແຜນການ. ສຳຄັນໄປກ່ວານັ້ນແມ່ນຂະບວນການເພື່ອການຕັດສິນໃຈ, ຄຸນນະພາບຂອງຂໍ້ມູນ ແລະ ຄວາມຮູ້ທີ່ມາຈາກຫລາຍໆແຫລ່ງຄວນປະກອບເຂົ້າໃຫ້ມີຄວາມສະເໝີພາບທາງດ້ານບໍລິມາດຂອງຂໍ້ມູນ. ຍິ່ງໄປກ່ວານັ້ນ, ມູນຄ່າໂດຍກົງຂອງຊັບພະຍາກອນດ້ານປະມົງ, ການປະກອບສ່ວນຂອງ ລະບົບນິເວດ ຂອງແມ່ນ້ຳຂອງທີ່ມີຄວາມສຳຄັນໃນການຜະລິດທີ່ບໍ່ຈຳກັດປະລິມານ ແລະ ການບໍລິການ.

ເພື່ອຄວາມແນ່ນອນ ທີ່ຈະເຮັດໃຫ້ອ່າງແມ່ນ້ຳຂອງ ເປັນບ່ອນຜະລິດ ແລະ ບໍລິການທີ່ສຳຄັນນີ້ສືບຕໍ່ໄປ, ພວກເຮົາສະເໜີວ່າ ແຜນການພັດທະນາ ແລະ ການປະເມີນດ້ານສິ່ງແວດລ້ອມ ຄວນອີງໃສ່ທ່ວງທ່າຂອງລະບົບນິເວດ ພາຍໃນຂະບວນການຂອງລະບົບນິເວດທີ່ກຳລັງໝູນໄປ, ຄວາມອຸດົມສົມບູນ ແລະ ຄວາມປ່ຽນແປງບໍ່ຢຸດຢັ້ງ ຂອງລະບົບນິເວດຕ້ອງໄດ້ປົກປັກຮັກສາ. ບົດຮຽນຈາກ ຫລາຍໆອ່າງແມ່ນ້ຳຊີ້ບອກໄວ້ວ່າ ວິທີທາງດັ່ງກ່າວມານີ້ ແມ່ນເປັນທາງທີ່ດີ ທີ່ສຸດໃນການນຳໃຊ້ແມ່ນ້ຳໃນແງ່ ເສດຖະກິດ, ສັງຄົມ ແລະ ສິ່ງແວດລ້ອມ.

บทคัดย่อ

ในลุ่มน้ำโขง สัตว์น้ำส่วนใหญ่มีการอพยพย้ายถิ่น สัตว์น้ำเหล่านี้หลายชนิดเดินทางเป็นระยะทางไกลและมักผ่านข้ามพรมแดนระหว่างประเทศในช่วงการอพยพตามฤดูกาล ประชาชนที่อยู่อาศัยทั่วทั้งลุ่มน้ำพึ่งพาสัตว์น้ำที่มีการอพยพย้ายถิ่นเหล่านี้เป็นแหล่งอาหารและการดำรงชีพไม่ทางตรงก็ทางอ้อม โครงการบริหารจัดการทรัพยากรน้ำต่าง ๆ เช่น โครงการเขื่อนผลิตไฟฟ้าพลังน้ำ ส่งผลกระทบเสียหายต่อการอพยพย้ายถิ่นของสัตว์น้ำดังกล่าว ซึ่งส่งผลเสียหายต่อเนื่องถึงความเป็นอยู่ของประชาชนจำนวนมาก

รายงานฉบับนี้ระบุคุณลักษณะหลักของระบบนิเวศแม่น้ำโขงที่มีความสำคัญต่อการบำรุงรักษาสัตว์น้ำที่มีการอพยพย้ายถิ่นตลอดจนแหล่งที่อยู่อาศัยชนิดต่าง ๆ ของสัตว์น้ำเหล่านั้น นอกจากนั้น ยังมีการระบุแนวทางในการผนวกสารสนเทศเกี่ยวกับการอพยพย้ายถิ่นของสัตว์น้ำที่มีอยู่แล้วเข้าในกระบวนการวางแผนงานและการประเมินผลกระทบสิ่งแวดล้อม

ระบบการอพยพย้ายถิ่นของสัตว์น้ำในลุ่มน้ำโขงตอนล่างจำแนกได้เป็นสามระบบที่มีการเชื่อมต่อระหว่างกัน ทุกระบบเกี่ยวข้องกับสัตว์น้ำหลายชนิด ระบบเหล่านี้ ได้แก่ ระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนล่าง (Lower Mekong migration system; LMS), ระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนกลาง (Middle Mekong migration system; MMS) และระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนบน (Upper Mekong migration system; UMS) ระบบการอพยพย้ายถิ่นเหล่านี้มีวิวัฒนาการมาจากการปรับตัวของสัตว์น้ำให้เข้ากับลักษณะทางอุทกวิทยาและลักษณะสัณฐานของแม่น้ำโขงตอนล่าง ตอนกลางและตอนบน

ในระบบนิเวศที่ซับซ้อนและหลากหลายทางชีวภาพเช่นลุ่มน้ำโขง ไม่เหมาะสมที่จะบริหารจัดการสัตว์น้ำเพียงชนิดหนึ่งชนิดใด ในทางตรงกันข้าม การพิจารณาระบบนิเวศทั้งระบบเป็นแนวทางที่สมควรใช้สำหรับการบริหารจัดการและการวางแผน ระบบการอพยพย้ายถิ่นดังกล่าวข้างต้นสามารถใช้เป็นกรอบเบื้องต้น เพราะสามารถใช้เป็นแนวทางในการจำแนกระบบนิเวศออกจากกันซึ่งจะสามารถดำเนินการบริหารจัดการประเด็นข้ามพรมแดนรวมทั้งวางแผนการพัฒนาลุ่มน้ำได้ในขณะเดียวกัน

ลักษณะทางนิเวศวิทยาหรือระบบนิเวศที่สำคัญสำหรับสัตว์น้ำที่มีการอพยพย้ายถิ่นหลายชนิดได้รับการจำแนกในทุกระบบการอพยพย้ายถิ่น สิ่งที่ต้องตระหนัก ได้แก่ การรักษาสภาพที่อยู่อาศัยที่สำคัญและการเชื่อมต่อระหว่างแหล่งที่อยู่อาศัยต่าง ๆ เหล่านั้น รวมถึงรูปแบบการเปลี่ยนแปลงทางอุทกวิทยาในรอบปีที่มีผลต่อการเกิดพื้นที่น้ำท่วมตามฤดูกาล

ระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนล่าง

แหล่งที่อยู่อาศัยในฤดูแล้ง: วังน้ำลึก โดยเฉพาะอย่างยิ่งในลำน้ำโขงตอนระหว่างกรอเจ๊ะ (Kratie) ถึงสตรึงเตรง (Stung Treng)

แหล่งอาศัยหากินและเลี้ยงตัวในช่วงน้ำท่วม: พื้นที่น้ำท่วมในบริเวณสามเหลี่ยมแม่น้ำโขงในประเทศเวียดนามและตอนใต้ของประเทศกัมพูชา และระบบแม่น้ำโตนเลสาป (Tonle Sap River)

แหล่งขยายพันธุ์วางไข่: ระบบแม่น้ำและวังน้ำลึกในกรอเจ๊ะ ถึงน้ำตกโขน (Khone Falls) และในลุ่มน้ำย่อยเซซัน (Sesan) พื้นที่น้ำท่วมทางตอนใต้ (เช่น บริเวณป่าน้ำท่วมที่ติดต่อกับบึงโตนเลสาป)

เส้นทางการอพยพย้ายถิ่น: ลำน้ำโขงสายหลักตลอดระยะตั้งสามเหลี่ยมแม่น้ำโขงถึงน้ำตกโขน รวมถึงแม่น้ำโตนเลสาป (เชื่อมต่อตามแนวยาว) ระหว่างพื้นที่น้ำท่วมกับลำน้ำ (เชื่อมต่อตามแนวขวาง) ระหว่างลำน้ำโขงกับลุ่มน้ำย่อยเซซัน (รวมทั้งแม่น้ำเซกองและแม่น้ำสเรป็อก (Srepok))

อุทกวิทยา: ปรากฏการณ์น้ำท่วมประจำปีทำให้เกิดพื้นที่น้ำท่วมกว้างใหญ่ทางตอนใต้ของประเทศกัมพูชา (รวมทั้งระบบแม่น้ำโตนเลสาป) และสามเหลี่ยมแม่น้ำโขง การไหลย้อนกลับของแม่น้ำโตนเลสาปมีส่วนสำคัญต่อผลผลิตทางการประมง

ระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนกลาง

แหล่งที่อยู่อาศัยในฤดูแล้ง: วังน้ำลึกในลำน้ำโขงและลำน้ำสาขาสายหลักต่าง ๆ

แหล่งอาศัยหากินและเลี้ยงตัวในช่วงน้ำท่วม: พื้นที่น้ำท่วมในระบบนี้มักเชื่อมต่อกับลำน้ำสาขาสายหลักต่าง ๆ

แหล่งขยายพันธุ์วางไข่: ระบบแม่น้ำและวังน้ำลึกในลำน้ำโขง พื้นที่น้ำท่วมที่เชื่อมต่อกับลำน้ำสาขาต่าง ๆ

เส้นทางการอพยพย้ายถิ่น: เชื่อมต่อระหว่างลำน้ำโขง (แหล่งที่อยู่อาศัยในฤดูแล้ง) กับลำน้ำสาขาสายหลักต่าง ๆ (แหล่งที่อยู่อาศัยในช่วงน้ำท่วม)

อุทกวิทยา: ปรากฏการณ์น้ำท่วมประจำปีทำให้เกิดพื้นที่น้ำท่วมตามลำน้ำสาขาสายหลักต่าง ๆ

ระบบการอพยพย้ายถิ่นของสัตว์น้ำในแม่น้ำโขงตอนบน

แหล่งที่อยู่อาศัยในฤดูแล้ง: พบทั่วไปตลอดลำน้ำโขงตอนบน แต่พบมากเป็นพิเศษในช่วงตั้งแต่ปากแม่น้ำเลยถึงเมืองหลวงพระบาง

แหล่งอาศัยหากินและเลี้ยงตัวในช่วงน้ำท่วม: พื้นที่น้ำท่วมที่เป็นขอบเขตของลำน้ำสายหลักและพื้นที่น้ำท่วมขนาดเล็กตามลำน้ำสายหลักต่าง ๆ

แหล่งขยายพันธุ์วางไข่: แหล่งขยายพันธุ์วางไข่มักอยู่ในแม่น้ำตอนที่มีกระแสน้ำไหลเชี่ยวสลับกับวังน้ำลึก

เส้นทางการอพยพย้ายถิ่น: ขอบเขตการอพยพย้ายถิ่นอยู่ระหว่างแหล่งที่อยู่อาศัยในฤดูแล้งตอนท้ายน้ำกับแหล่งขยายพันธุ์วางไข่ตอนเหนือน้ำ

อุทกวิทยา: รูปแบบวงจรน้ำท่วมประจำปีเป็นปัจจัยกระตุ้นการอพยพย้ายถิ่นของสัตว์น้ำและเป็นสาเหตุของน้ำท่วมในพื้นที่น้ำท่วมต่าง ๆ

ลักษณะระบบนิเวศเหล่านี้ สมควรนำมาประกอบการพิจารณาเมื่อมีการประเมินผลกระทบจากกิจกรรมการพัฒนาต่าง ๆ สิ่งที่ต้องทราบก่อนการประเมินผลกระทบ ได้แก่ มูลค่าของทรัพยากรที่ได้รับผลกระทบ (เช่น สัตว์น้ำที่มีการอพยพย้ายถิ่น) จากมุมมองด้านการประมง การประเมินมูลค่าของสัตว์น้ำที่มีการอพยพย้ายถิ่นกระทำได้ยากยิ่งเพราะสัตว์น้ำเหล่านั้นเป็นเป้าหมายการประมงกระจายทั่วทั้งลุ่มน้ำโดยใช้เครื่องมือประมงและวิธีปฏิบัติการที่แตกต่างหลากหลายมาก เมื่อพิจารณาถึงขนาดและความซับซ้อนของการประเมินมูลค่านี้ในแม่น้ำโขง จึงอาจเป็นไปไม่ได้ที่จะประเมินมูลค่าทางเศรษฐกิจของสัตว์น้ำที่มีการอพยพย้ายถิ่นโดยสมบูรณ์

อย่างไรก็ตาม การประเมินมูลค่าเป็นบางส่วนประกอบกับการประเมินสารสนเทศที่ขาดความสมบูรณ์ ก็เพียงพอสำหรับการนำไปประกอบการวางแผนและการประเมินผลได้ในหลายกรณี นอกจากนี้ ยังมีความจำเป็นที่ต้องเน้นการใช้สารสนเทศและองค์ความรู้เชิงคุณภาพจากแหล่งข้อมูลข่าวสารต่าง ๆ อย่างเท่าเทียมกับข้อมูลเชิงปริมาณประกอบในกระบวนการตัดสินใจ อนึ่ง ระบบนิเวศแม่น้ำโขงยังเป็นต้นกำเนิดของสินค้าและบริการจากแม่น้ำที่ไม่สามารถแจงปริมาณได้จำนวนมาก นอกเหนือไปจากทรัพยากรประมงที่มีมูลค่าโดยตรงแล้ว

เพื่อเป็นหลักประกันว่าลุ่มน้ำโขงจะยังคงเป็นแหล่งสินค้าและบริการเหล่านี้ต่อเนื่องตลอดไป จึงเป็นการสมควรที่การวางแผนการพัฒนาและการประเมินด้านสิ่งแวดล้อมตั้งอยู่บนพื้นฐานของวิธี

การพิจารณาทั้งระบบนิเวศซึ่งสามารถดำรงบทบาททางนิเวศวิทยา ความอุดมสมบูรณ์และความสามารถในการฟื้นคืนสภาพของระบบนิเวศไว้ ประสบการณ์จากลุ่มน้ำอื่นทำให้ทราบว่าวิธีการพิจารณาทั้งระบบนิเวศนี้เป็นวิธีการใช้ประโยชน์จากแม่น้ำที่ดีที่สุด ทั้งด้านเศรษฐกิจ สังคม และสิ่งแวดล้อม

DI CƯ CỦA CÁ Ở HẠ LƯU SÔNG MÊ CÔNG
NHỮNG VẤN ĐỀ LIÊN QUAN
TỚI QUI HOẠCH PHÁT TRIỂN VÀ QUẢN LÝ MÔI TRƯỜNG

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Ubolratana Suntonratana và Nguyễn Thanh Tùng

Tóm tắt

Đa số cá ở lưu vực sông Mê công là cá di cư. Rất nhiều loài trong mùa di cư của chúng di chuyển cự ly khá xa, vượt qua biên giới quốc tế. Người dân sống trong lưu vực trực tiếp hoặc gián tiếp phụ thuộc vào cá di cư để lấy thực phẩm và sinh nhai. Các dự án quản lý nước như các đập thuỷ điện có thể gây hại cho sự di cư, từ đó ảnh hưởng xấu đến cuộc sống của một bộ phận lớn dân cư.

Báo cáo này xác định một số đặc tính then chốt của hệ sinh thái sông Mê Công liên quan đến việc bảo vệ cá di cư và nơi cư trú của chúng. Báo cáo này còn thảo luận phương hướng sử dụng thông tin về cá di cư trong việc hợp tác xây dựng kế hoạch và đánh giá môi trường.

Ở hạ lưu sông Mê Công người ta đã xác định được 3 hệ di cư riêng biệt liên quan đến nhiều loài cá, có liên hệ mật thiết với nhau đó là: hệ hạ lưu (LMBS), hệ trung lưu (MMMS) và hệ thượng lưu (UMBS). Những hệ di cư này được hình thành từ việc thích nghi với điều kiện thủy văn và hình thái của các vùng hạ, trung và thượng lưu của sông Mê Công.

Trong hệ sinh thái tổng hợp, đa loài như lưu vực sông Mê Công thì việc chỉ quản lý đơn loài là không khả thi. Trái lại, người ta đề xuất sự tiếp cận cả hệ để quản lý và qui hoạch. Những hệ di cư đã nói ở trên sẽ được sử dụng như mẫu ban đầu, để xác định nó thuộc hệ sinh thái nào, và từ đó có thể vận dụng biện pháp quản lý xuyên biên giới và qui hoạch phát triển lưu vực.

Mỗi hệ di cư được xác định bởi những thuộc tính sinh thái quan trọng của cá di cư. Bảo vệ nơi cư trú có tính nguy cơ, duy trì mối liên hệ giữa chúng và mô hình các yếu tố thủy văn hàng năm đã tạo ra nơi cư trú theo mùa ở vùng ngập là những điều cần được nhấn mạnh.

Hệ thống di cư hạ lưu sông Mê Công (LMS)

Nơi ẩn náu trong mùa khô: Vực sâu chạy dọc theo dòng chính sông Mê Công đặc biệt là ở tỉnh Kra Chiê, Stung Treng .

Nơi kiếm ăn và vỗ béo trong mùa lũ: Vùng ngập ở đồng bằng sông Cửu Long Việt Nam, miền nam Cam Pu Chia và trong hệ thống biển hồ Tông Lê Sáp.

Bãi đẻ: hệ thống thác ghềnh và vực sâu từ Kra Chiê đến thác Khôn và lưu vực sông Sê San. Vùng ngập ở phía nam (như rừng ngập nước khu vực biển hồ Tông Lê Sáp).

Đường di cư: Trên dòng chính từ đồng bằng sông Cửu long đến thác Khôn bao gồm cả sông Tông Lê Sáp (chạy theo hàng dọc); giữa nơi cư trú vùng ngập và các nhánh sông (chạy theo hàng ngang); giữa dòng chính sông Mê Công và tiểu lưu vực sông Sê San (bao gồm cả sông Sê Công và sông Srê Pốc).

Thuỷ văn: lũ hàng năm làm ngập cả vùng rộng lớn phía nam Cam Pu Chia (bao gồm cả hệ thống sông Tông Lê Sáp) và đồng bằng sông Cửu Long và thời gian sông Tông Lê Sáp chảy ngược lại là thời gian rất quan trọng đối với sản lượng cá.

Hệ thống di cư trung lưu sông Mê Công (MMS)

Nơi ẩn náu trong mùa khô: Vực sâu chạy dọc theo dòng chính sông Mê Công và các nhánh chính .

Nơi kiếm ăn và vỗ béo trong mùa lũ: Vùng ngập của hệ thống này phụ thuộc chủ yếu vào các nhánh chính.

Bãi đẻ: hệ thống thác ghềnh và vực sâu dòng chính sông Mê Công. Bãi đẻ trứng vùng ngập liên quan đến các chi lưu.

Đường di cư: Nối giữa dòng chính sông Mê Công (nơi cư trú mùa khô) với các chi lưu (nơi cư trú mùa lũ).

Thuỷ văn: lũ hàng năm gây nên sự ngập khu vực dọc theo chi lưu chính.

Hệ thống di cư thượng lưu sông Mê Công (UMS)

Nơi ẩn náu trong mùa khô: Xuất hiện trong suốt hệ thống UMS nhưng phổ biến là phần hạ lưu từ cửa sông Loei đến Luông Prabang.

Nơi kiếm ăn và vỗ béo trong mùa lũ: nơi cư trú trong vùng ngập bị thu hẹp trong phạm vi vùng ngập của dòng chính cũng như dọc theo vùng ngập của các chi lưu .

Bãi đẻ: nơi đẻ trứng phân bố dọc theo dòng chảy nơi thác ghềnh kế tiếp vực sâu.

Đường di cư: hành lang di cư nối nơi cư trú mùa khô ở hạ lưu với các bãi đẻ ở thượng lưu.

Thuỷ văn: lũ hàng năm gây nên sự ngập và kích thích cá di cư.

Hệ thống sinh thái trên đây cần phải được tính đến khi đánh giá ảnh hưởng của các hoạt động phát triển. Điều kiện tiên quyết để đánh giá ảnh hưởng là đánh giá nguồn tài nguyên bị ảnh hưởng (ở đây là cá di cư) đối với viễn cảnh nghề cá. Tiến hành đánh giá cá di cư như vậy là việc rất khó vì những cá này được khai thác theo những vùng phân bố khác nhau, ngư cụ khác nhau và thao tác khác nhau. Tiến hành đưa ra mức độ và tổng thể khi đánh giá về giá trị kinh tế của cá di cư ở sông Mê Công là không thể được.

Tuy nhiên, đánh giá một phần giá trị đi đôi với đánh giá sự thiếu hụt thông tin trong nhiều trường hợp là thích hợp cho việc dự đoán và xây dựng kế hoạch. Một điều quan trọng cần phải nhấn mạnh là trong quá trình đưa ra quyết định thì thông tin về chất lượng và sự hiểu biết từ nhiều nguồn khác nhau cần phải coi ngang giá trị với thông tin về số lượng. Ngoài ra, đi đôi với giá trị nguồn lợi cá trực tiếp, hệ thống sinh thái sông Mê Công còn cung cấp những của cải quí và dịch vụ khác.

Để đảm bảo cho sông Mê Công có thể tiếp tục cung cấp của cải và dịch vụ đó chúng tôi kiến nghị việc xây dựng phát triển và đánh giá môi trường phải dựa trên cơ sở sự tiếp cận sinh thái, trong đó chức năng sinh thái, sản phẩm và tính mềm dẻo của hệ sinh thái phải được duy trì. Kinh nghiệm từ các hệ thống sông khác cho thấy xuất phát từ quan điểm kinh tế xã hội và môi trường, đây là con đường tốt nhất để khai thác dòng sông.

Introduction 1

1.1 Background

The Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (The Mekong Agreement), which was signed in 1995 by the four countries of the lower Mekong Basin (LMB), Cambodia, Lao PDR, Thailand and Viet Nam, is the legal foundation for the Mekong River Commission (MRC). Through this Agreement the four countries are committed to:

> ***"…cooperate in all fields of sustainable development, utilization, management and conservation of the water and related resources of the Mekong River Basin including, but not limited to irrigation, hydro-power, navigation, flood-control, fisheries, timber floating, recreation and tourism, in a manner to optimize the multiple-use and mutual benefits of all riparians and minimize the harmful effects that might result from natural occurrences and man-made activities" (Article 1 of the Agreement).***

Article 1 of the Agreement thus clearly reflects the fact that the Mekong River ecosystem provides a wide range of benefits and resources, including fisheries. The fishery of the Mekong River Basin is probably one of the largest and most important inland fisheries in the world [1] . The main reasons for this are:

- The river contains an unusually large number of species (probably more than 1,200).
- A large number of people are involved in fisheries activities in the basin.
- Large areas of floodplain remain accessible for fish production.
- The annual flood pulse, which drives fish production on the floodplain, has not been greatly affected, in contrast to most other large rivers.
- In most of the basin, large-scale fish migrations provide the basis for the seasonal fisheries along their migration routes. These migrations have not been affected as in most other large rivers.

The issue of fish migration is of particular interest to the MRC, since many migratory fish stocks constitute transboundary resources, i.e. resources shared between two or more of the riparian countries. Resolving transboundary issues is one of the main reasons for the existence of the MRC and, therefore, one of its core working areas.

Although much is still to be learned about fish migrations in the Mekong, documented knowledge has substantially increased in the past decade. During this period, the Fisheries Programme of the MRC has carried out field surveys and research that have confirmed the importance of the Mekong fisheries and documented some of the ecological processes and functional characteristics that support these fisheries, including the role that fish migrations play in ecosystem functioning and productivity.

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[1] The total annual catch of the lower Mekong River Basin has been estimated at 1.5 – 2 million tonnes, and is particularly important for food security and income generation for the large rural population of the basin.

1.2 The purpose of this report

The intention of this report is to promote the integration of ecological information into future basin planning processes and environmental assessment (EA) procedures for the Mekong Basin. The emphasis is on migratory fishes and the critical habitats and ecosystem attributes that sustain this important resource.

The main targets of the report are the three core programmes of the MRC, the Basin Development Plan (BDP), the Water Utilisation Programme (WUP) and the Environment Programme (EP). Specifically, the report aims to provide inputs to: (1) the basin-wide and sub-catchment planning process of the BDP; (2) the transboundary analysis work carried out under Working Group 2 of the WUP; and (3) the Strategic Environmental Assessment (SEA) process, which is part of the Environmental Assessment guidelines currently being developed under the Environment Programme.

The report will also be of use as a framework for Environmental Impact Assessment purposes for specific development projects within the basin.

The report is mainly based on basin-wide surveys of local ecological knowledge carried out by the assessment component of the MRC Fisheries Programme during 1999 and 2000. Information from other sources is included (and referenced) where appropriate in order to support and complement the surveys of local knowledge.

The methods that were applied during the local knowledge surveys have been described extensively in other publications and will not be described here (Valbo-Jørgensen and Poulsen 2000; Poulsen and Valbo-Jørgensen 1999).

Since the report covers the highest ecological scale (i.e. the entire Lower Mekong Basin), focus on details is limited. We will, for example, not discuss species-specific information, but will instead describe general patterns of large-scale migration systems. Individual species are included as examples only.

Animal migrations 2

Animal migrations represent some of the greatest spectacles of nature. Furthermore, they also play a key role in the culture and livelihoods in many human societies. Many hunting societies, for example, have adjusted their seasonal movements and social structures to the movements of their prime target animals (see for example, Berkes 1999).

Fish migrations in the Mekong River Basin are equally significant to the local people. Many fishing communities along the rivers of the basin have adapted their way of life to the seasonal patterns of fish migrations. A few of the most conspicuous examples are:

- Throughout the basin, villages have adapted to the seasonal migration of groups of small cyprinid fishes belonging to the genus *Henicorhynchus* which takes place at the beginning of the dry season (October-February). These migrations support very large fisheries and the surplus yield creates the foundation for a variety of fish processing activities.
- From December to February, villages near certain sites along the river exploit the seasonal spawning migration of the large cyprinid *Probarbus jullieni* (and also *Probarbus labeamajor*), one of the high-profile 'flagship' species of the Mekong.
- The seasonal spawning migration of the giant Mekong catfish (*Pangasianodon gigas*) has experienced a dramatic decline in recent decades, and today only one site along the entire Mekong River sustains a small traditional fishery for the giant catfish (during the 2001 and 2002 season no fish were caught).

Probarbus jullieni *one of the many migratory fishes of the Mekong*

Many authors have devoted considerable effort trying to define the term migration (see for example, Dingle 1996; McKeown 1984; and others). For the purposes of this report, we share the view of Barthem and Goulding (1997) that a rigid definition does not seem useful. But we find it important to emphasise two issues concerning migration:

- Migration is one type of movement, distinguished from more diffuse types such as foraging for food within a single habitat. It normally involves the "cyclic and predictable movements of a large proportion of animals within the species, or populations of species" (as defined by the International Convention on the Conservation of Migratory Species of Wild Animals, the CMS Convention).
- Migration is an integrated element of the entire life cycle of the animal.

Animals migrate because key habitats essential for their survival are separated in time and space. Often, movements are guided by seasonal changes in living conditions (e.g. escaping winters or seasonal droughts) and/or by seasonal reproductive patterns (e.g. migrating to suitable breeding sites). These movements have evolved with, and thus are finely tuned to, the environment within which they occur. Migratory animals thus depend on a wide range of habitats, and their distribution ranges cover large geographical areas. Since they move regularly between different habitats, they are considered “living threads that tie or link widely scattered ecosystems together” (Glowka 2000). Such links often reach beyond national borders, as is, for example, the case with many of the migrating fishes of the Mekong Basin.

Migratory animals are well adapted to naturally occurring environmental fluctuations and changes, but are particularly vulnerable to the abrupt environmental changes caused by human activities. Therefore, many migratory animals are at risk of becoming endangered (see for instance the IUCN Red list of Endangered Animals, 1996).

2.1 Fish migrations and life cycles

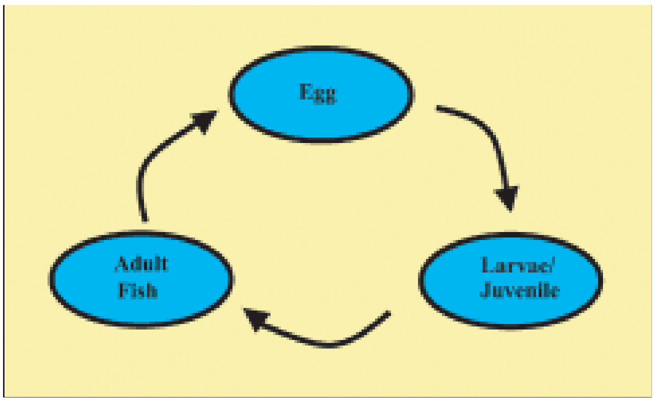
In rivers, fishes have adapted to life in running water and to seasonal changes in habitat availability. The need to migrate is part of this adaptation. Figure 1 illustrates how migrations are integrated into the life cycles of migrating fishes.

Fish movements take place at all stages of life, even the earliest stages. In rivers, movements of fish eggs and larvae, in the form of downstream passive drift are common, and are integrated events of the overall movement patterns of migrating fishes. Often, migration routes and the spatial position of spawning areas are finely tuned to hydrological and environmental circumstances, ensuring that eggs and/or larvae drift back downstream to their rearing habitats with the flowing water.

In an ecological context, fish migrations cannot be described without at the same time describing essential fish habitats and the environment within which these habitats are embedded.

Therefore, impacts of development scenarios on fish migrations are not confined to the blocking of migration routes caused by damming of rivers. Impacts on the environment, and thereby on fish habitats, and changes in hydrological patterns are equally important.

Figure 1 A: Simplified schematic representation of life cycle of fish.



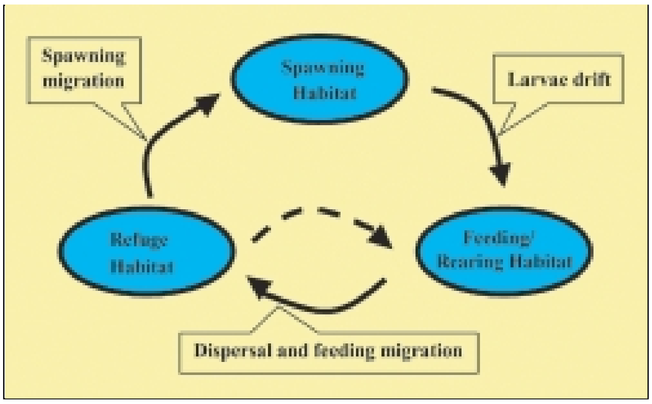


Figure 1 B: Corresponding habitat requirements for the successful completion of lifecycle of fish. Depending on species, arrows may represent short movements (e.g. from lake to adjacent floodplain), or long-distance migration. The broken arrow represents longer-lived species, which may move several times between refuges and feeding habitats.

Fish migration in the Mekong River 3

In a multi-species fisheries environment such as the Mekong system, it is useful to distinguish different species groups based on different life history strategies. The broadest classification of fishes in the Mekong fisheries context is the classification of fishes into black-fishes and white-fishes (Welcomme 1985).

Black-fishes are species that spend most of their life in lakes and swamps on the floodplains adjacent to river channels and venture into flooded areas during the flood season. They are physiologically adapted to withstand adverse environmental conditions, such as low oxygen levels, which enable them to stay in swamps and small floodplain lakes during the dry season. They are normally referred to as non-migratory, although they perform short seasonal movements between permanent and seasonal water bodies. Examples of black-fish species in the Mekong are the climbing perch (*Anabas testudineus*), the clarias catfishes (e.g. *Clarias batrachus*) and the striped snakehead (*Channa striata*).

White-fishes, on the contrary, are fishes that depend on habitats within river channels for the main part of the year. In the Mekong, most white-fish species venture into flooded areas during the monsoon season, returning to their river habitats at the end of the flood season. Important representatives of this group are some of the cyprinids, such as *Cyclocheilichthys enoplos* and *Cirrhinus microlepis,* as well as the river catfishes of the family Pangasiidae.

Figure 1 is representative for both black-fishes and white-fishes. However, for black-fishes, the arrows represent only short movements between 'neighbouring' habitats, whereas for white-fishes, they represent migrations between distant habitats.

Recently, an additional group within this classification has been identified. It is considered an intermediate between black-fishes and white-fishes and therefore has been referred to as grey-fishes (Welcomme 2001). Species of this group undertake only short migrations between floodplains and adjacent rivers and/or between permanent and seasonal water bodies within the floodplain (Chanh *et al.* 2001; Welcomme 2001).

Virtually all fishes of the Mekong are exploited and therefore constitute important fishery resources. All fishes are also vulnerable to impacts from development activities, including transboundary impacts. However, long-distance migratory species (i.e. white-fish species) are particularly vulnerable because they depend on many different habitats, are widely distributed, and require migration corridors between different habitats. For these important fishes, the term 'transboundary' has double meaning: they are transboundary resources that may be affected by transboundary impacts of human activities.

3.1 Important fish habitats in the Mekong Basin

Since the separation of critical fish habitats within the overall ecosystem that constitutes the lower Mekong Basin is the main cause for fishes to migrate, it is useful to identify these habitats before discussing migrations, i.e. the cause (habitats) first, then the response (migrations).

3.1.1 Floodplains

The flood-pulse during the monsoon season is the driving force of the Mekong River ecosystem. As is the case for most tropical floodplain river systems, the seasonal habitats on the floodplains created by the monsoon floods are the main “fish production sites” of the Mekong (Sverdrup-Jensen 2002). These areas are very rich in nutrients, food and shelter during the flood season, and most Mekong fishes depend on these resources for at least certain parts of their early life cycle.

Figure 2: Main floodplain areas of the Lower Mekong Basin.

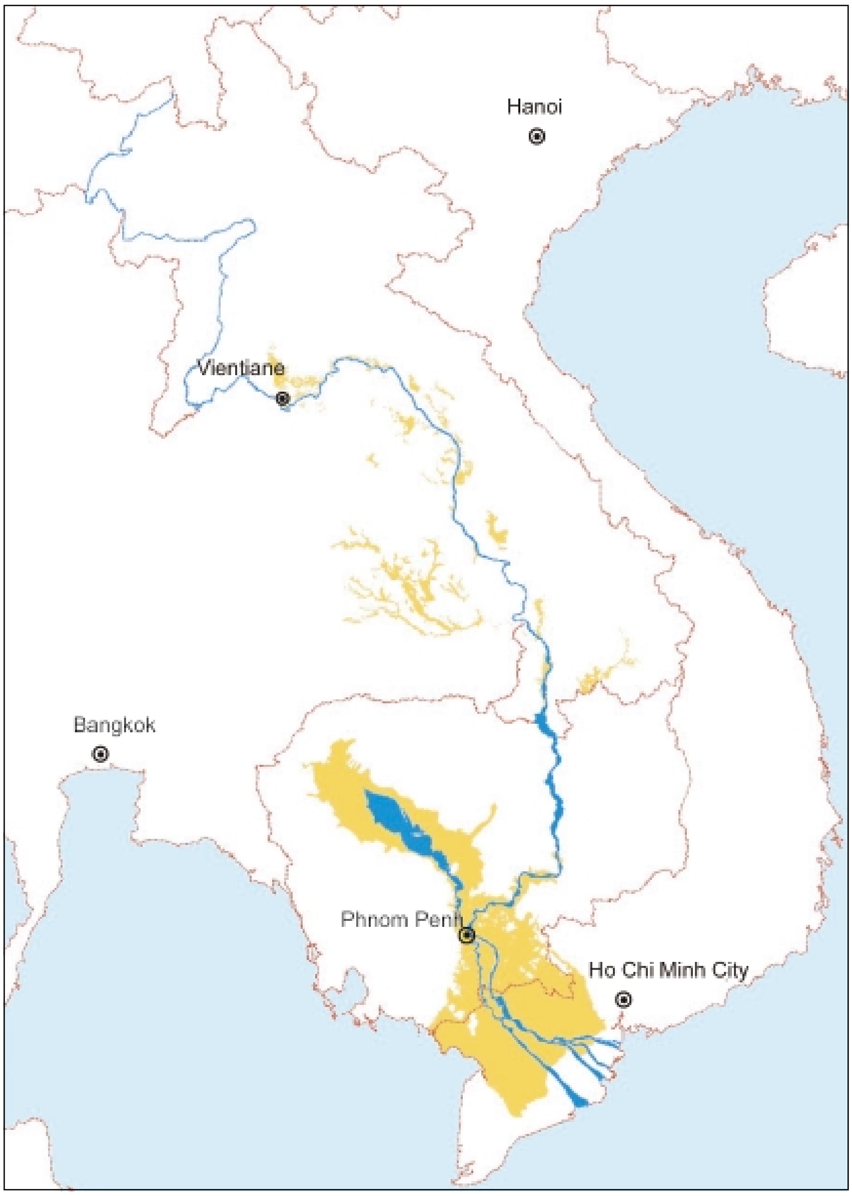


Figure 2 shows a map of the flooded areas of the Lower Mekong River Basin. As can be seen, the main floodplain habitats occur in the lower part in southern Cambodia and the Mekong Delta in Viet Nam. The most important floodplain complex is associated with the Tonle Sap River/Great Lake system in Cambodia. In the upper parts of the basin, in Thailand and Lao PDR, floodplain areas are smaller and are mainly associated with Mekong tributaries. In the upper parts of the basin, i.e. approximately upstream from Vientiane, floodplain habitats become more and more scarce as the river gradually changes to become a typical mountain river with steep riverbanks.

Floodplains are important fish habitats during the monsoon season

The migratory behaviour of many fishes is an adaptation to these hydrological and environmental conditions. The timing of migrations is “tuned” to the flood-pulse, and although different species may have tuned their migrations in different ways, some general patterns can be elucidated. In general, most species spend the dry season “fasting” in refuge habitats. The arrival of the monsoon and its floodwaters is an ecological trigger for both spawning and migration. Spawning at the right time and place will enable offspring to enter floodplain habitats, where they can feed. Some species spawn on the floodplain itself, whereas others migrate upstream to spawn within the river channel and then rely on the river current to bring the offspring to the downstream rearing habitats. Many larger juveniles and adult fish actively migrate from dry-season shelters to the floodplains to feed. Thus, the life cycles of migrating fish species ecologically connect different areas and habitats of rivers. From their point of view, the river basin constitutes one ecological unit interconnecting upstream spawning habitats with downstream rearing habitats.

3.1.2 Dry season refuge habitats

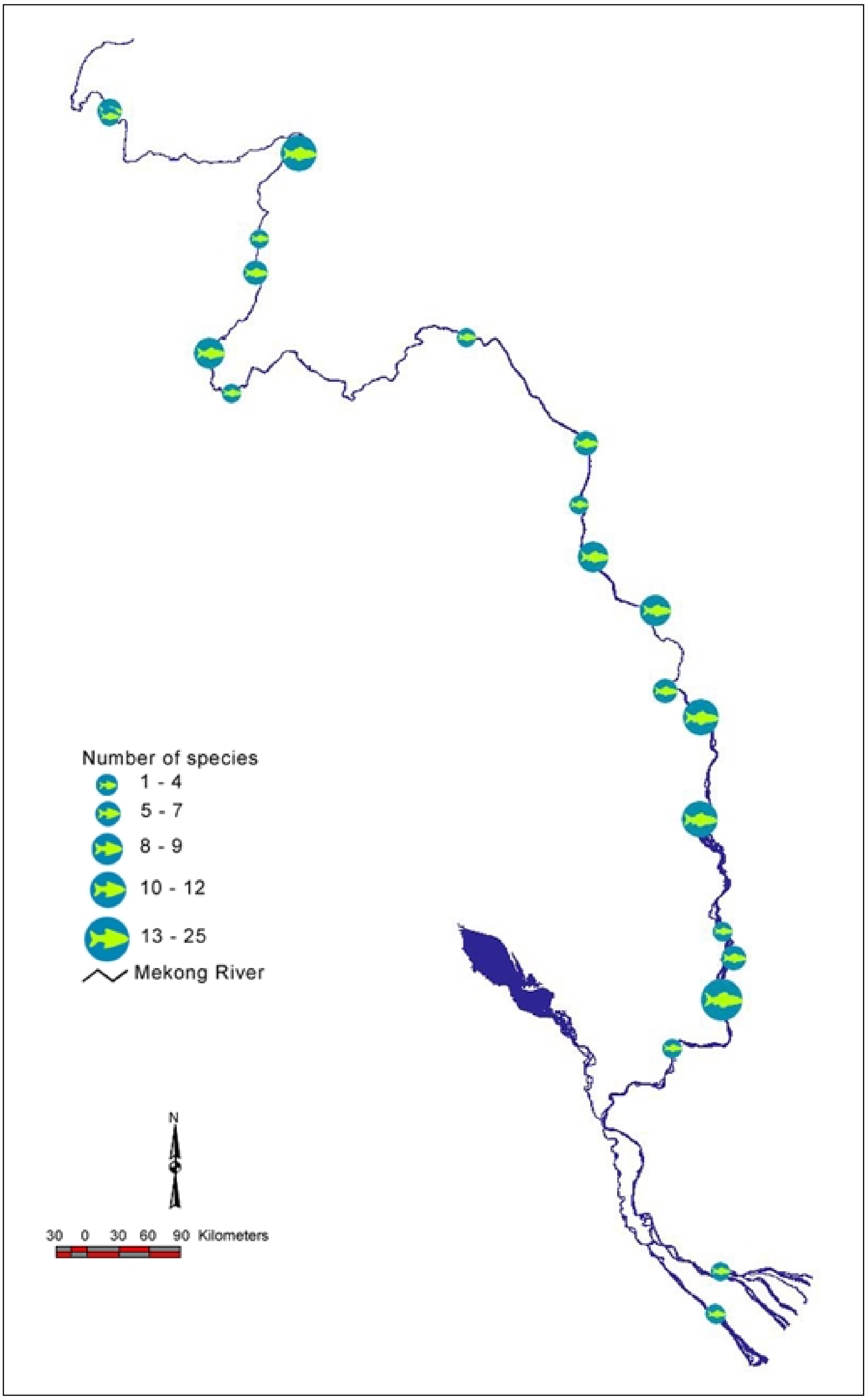
When water recedes from flooded areas at the end of the flood season, fishes have to move out of the seasonal habitats and return to their dry season refuges. In a broad sense, two types of dry season refuge habitats exist:

1) permanent floodplain lakes and swamps
2) river channels

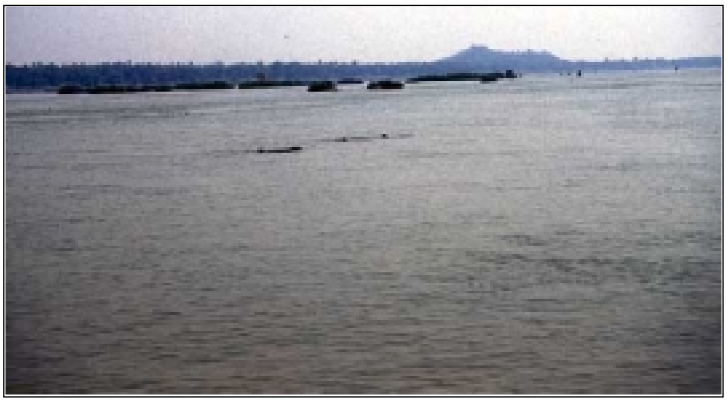
Floodplain lakes are mainly used by the group of black-fish species, whereas river channel refuges are mainly used by whitefishes. In the context of this report, the focus is on refuge habitats associated with river channels, which are mainly used by migrating, transboundary fish stocks belonging to the group of white-fish species.

Within rivers, deep areas are particularly important as dry season refuges. These areas are most often referred to as deep pools. The importance of deep pools in the Mekong River Basin has recently been documented by the MRC Fisheries Programme (Poulsen *et al*. 2002), in which Figure 3 shows the distribution of important deep pool habitats within the Mekong mainstream, based on local ecological knowledge.

Figure 3. Number of species reported using deep pools at each study site in the Mekong mainstream (based on Local Ecological Knowledge. See: Poulsen *et.al*. (2002); Poulsen and Valbo-Jørgensen (1999); Valbo-Jørgensen and Poulsen 2000)



Certain stretches of the Mekong River emerge as important locations for deep pools. In particular, the stretch from Kratie to the Khone Falls in northern Cambodia contains a large number of deep pools that are used by many species during the dry season.



River dolphins surfacing at a deep pool near Kratie

The river stretch immediately upstream from the Khone Falls, as far upstream as Khammouan/ Nakhon Phanom, and the stretch from the Loei River to Louang Prabang also contains many deep pool habitats.

Interestingly, there are also stretches that appear to contain relatively few deep pool habitats. Most notably, there are very few deep pools along the stretch from Kratie in northern Cambodia all the way to the Mekong Delta. Further upstream, within the stretch from Paksan/Beung Khan to Vientiane/ Sri Chiang Mai, deep pool habitats are also scarce.

3.1.3. Spawning habitats for migratory fishes

Although little is known about spawning habitat requirements for most Mekong fishes, spawning habitats are generally believed to be associated with: (1) rapids and pools of the Mekong mainstream and tributaries; and (2) floodplains (e.g. among certain types of vegetation, depending on species).

River channel habitats are, for example, used as spawning habitats by most of the large species of pangasiid catfishes and some large cyprinids such as *Cyclocheilichthys enoplos, Cirrhinus microlepis,* and *Catlocarpio siamensis*. Floodplain habitats are used as spawning habitats, mainly by black-fish species.

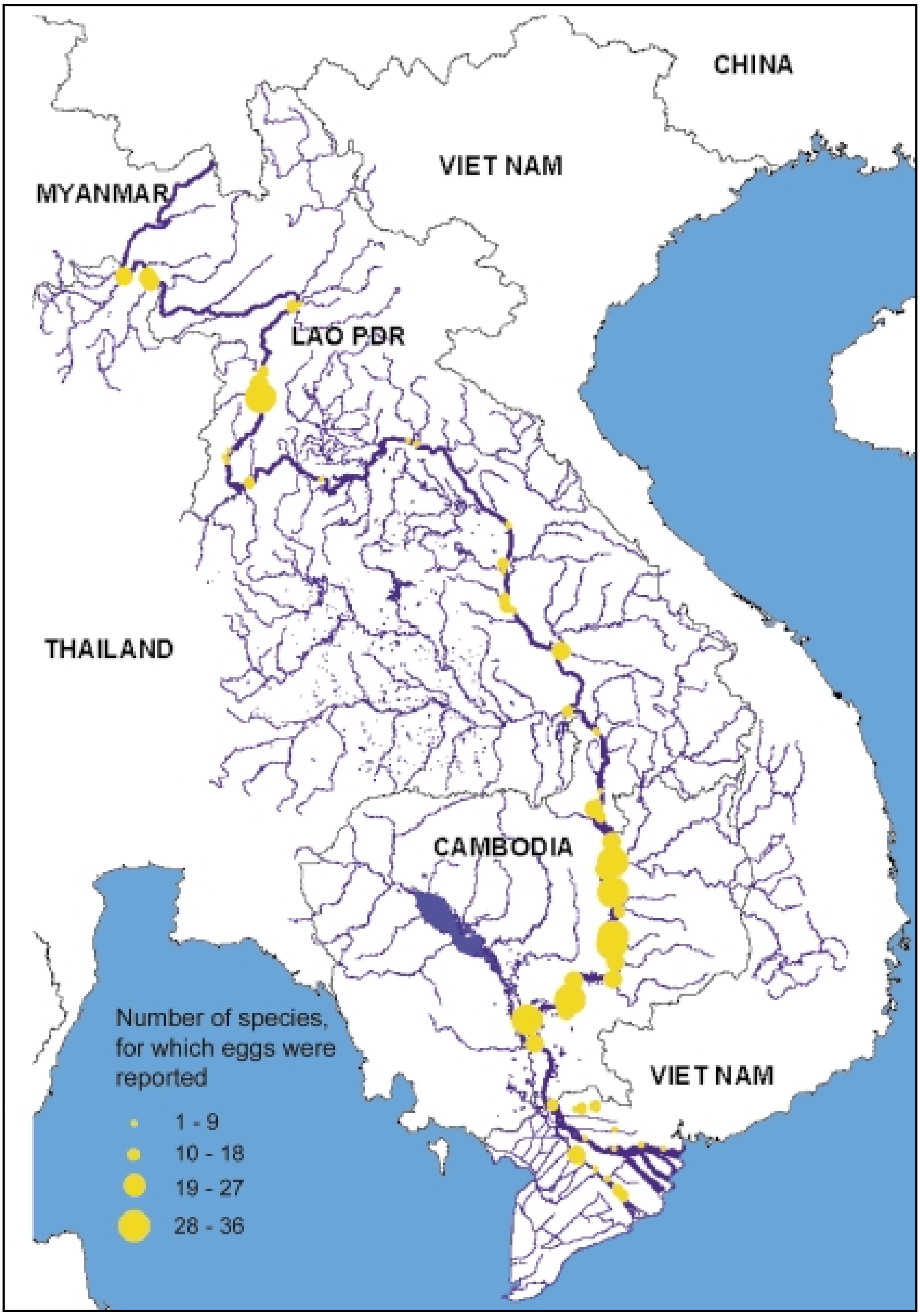
Other species may spawn in river channels in the open-water column and rely on particular hydrological conditions to distribute the offspring (eggs and/or larvae) to downstream rearing habitats.

Information on spawning habitats for migratory species in the river channels of the Mekong Basin is scarce. Only for very few species, such as *Probarbus* spp. and *Chitala* spp., spawning habits are well described because these species have conspicuous spawning behaviour at distinct spawning sites. For most other species, in particular for deep-water mainstream spawners such as the river catfish species, spawning is virtually impossible to observe directly.

Information about spawning can instead be obtained through indirect observations such as observations of ripe eggs in fishes. Figure 4 shows the number of species with eggs that have been observed by fishers (each “pie” in Figure 4 represents the number of species carrying ripe eggs, as observed by fishers). For fishes that spawn in main river channels, spawning is believed to occur in stretches where there are many rapids and deep pools, e.g. (1) the Kratie–Khone Falls stretch; (2) the Khone Falls to Khammouan/Nakhon Phanom stretch; and (3) from the mouth of the Loei River to Bokeo/Chiang Khong.

Figure 4 indicates that the Kratie-Khone Falls stretch and the stretch from the Loei River to Luang Prabang are particularly important for spawning.

Figure 4: Number of species along the Mekong mainstream reported to have eggs in their abdomen (see text for further explanation).

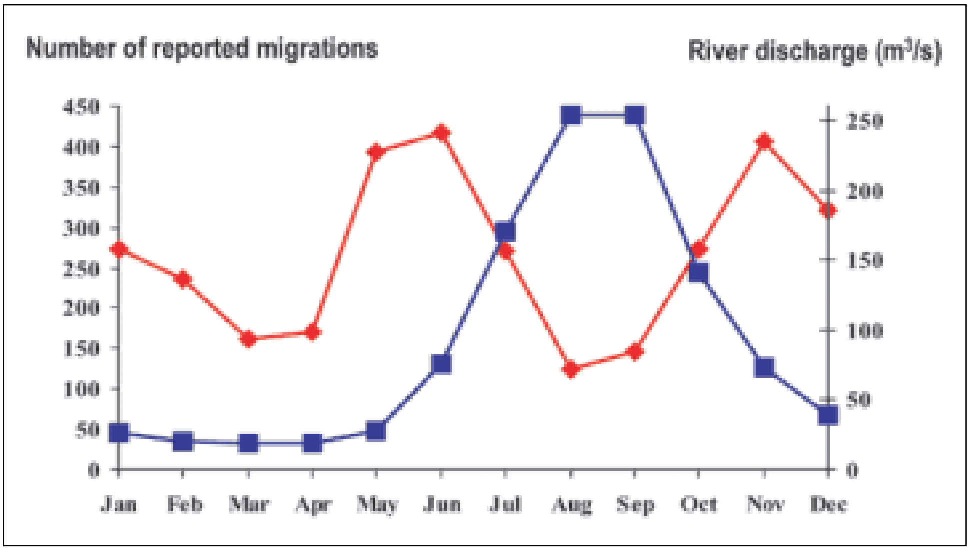


View of the Mekong near Kratie, northern Cambodia. This area is believed to be important for spawning for many migratory fish species.

3.2. Fish migrations and hydrology in the Mekong Basin

There is an intimate link between fish life cycles, fish habitats, and hydrology. Migrating fishes respond to hydrological changes and use hydrological events as gauges for the timing of their migrations. This is illustrated in Figure 5, where peak migration periods are correlated with the annual hydrological cycle. Most species migrate at the start of the annual flood and return at the end of the flood, producing the two peaks shown in Figure 5.

Figure 5: Relationship between migratory activity levels and water discharge in the Lower Mekong Basin (modified from Bouakhamvongsa and Poulsen, 2000) Blue Line: average monthly discharge (m^3/sec) of the Mekong River at Pakse, Southern Lao PDR (data provided by MRC Secretariat). Red Line: Number of migration reports (based on 50 species from 51 sites along the Mekong mainstream).



Also, the spawning season is tuned according to river hydrology, and almost all species spawn at the onset of the monsoon season. Only a few species, such as *Probarbus* spp. and *Hypsibarbus malcolmi*, are exceptions to that rule: they spawn during the dry season.

3.3. Major migration systems of the Mekong

For a complex ecosystem, which involves such a large number of species, it is beyond the scope of this report to discuss individual species. Although different species have developed different life strategies to cope with the environmental circumstances, generalisations can be made, e.g. on migratory patterns. Some of these general patterns will be outlined below (see also Sverdrup-Jensen 2002).

One of the major results of these surveys has been the identification of three main migration systems associated with the lower Mekong River mainstream (Sverdrup-Jensen 2002). These three systems have been termed the Lower Mekong Migration System (LMS), the Middle Mekong Migration System (MMS), and the Upper Mekong Migration System (UMS).

It is important to note that the different migration systems are inter-connected and, for many species, overlapping. Furthermore, their classification as 'systems' is based on the fact that migration patterns are different in each. In general, the migration patterns are determined by the spatial separation between dry season refuge habitats and flood season feeding and rearing habitats within each system. This, again, demonstrates how migration habits are deeply embedded in the environment within which they occur.

3.3.1 The Lower Mekong Migration System (LMS)

This migration system covers the stretch from the Khone Falls downstream to southern Cambodia, including the Tonle Sap system, and the Mekong Delta in Viet Nam (Figure 6). As described above, this migration is driven by the spatial and temporal separation of flood-season feeding and rearing habitats in the south with dry-season refuge habitats in the north. The rise in water levels at the beginning of the flood season triggers many migrating fishes to move from the dry season habitats just below the Khone Falls, e.g. in deep pools along the Kratie-Stung Treng stretch, towards the floodplain habitats in southern Cambodia and the Mekong Delta in Viet Nam. Here they spend the flood season feeding in the fertile floodplain habitats. Some species spawn on, or near the floodplain, whereas others spawn far upstream, i.e. above Kratie, and rely on the water current to bring offspring to the floodplain rearing areas. One of the key factors for the integrity of this system is the Tonle Sap/Great Lake system – a vast and complex system of rivers, lakes and floodplains. As a result of increasing water discharge from the Mekong River at the onset of the flood season, the water current of the Tonle Sap River changes its direction, flowing from the Mekong into the Tonle Sap River and towards the Great Lake. This enables fish larvae and juveniles to enter the Tonle Sap from the Mekong by drifting with the flow. Together with the floodplains of the Mekong Delta in Viet Nam, these floodplains are the main "fish factories" of the lower basin.

An important group of species, which undertakes this type of migration, belongs to the genus *Henicorhynchus*. In terms of fisheries output, these fishes are among the most important of the Lower Mekong. For example, in the Tonle Sap River dai fishery, species of the genus Henicorhynchus account for 40 percent of the total annual catch (Lieng *et al*. 1995, Pengbun and Chanthoeun 2001). Larger species, such as *Catlocarpio siamensis*, *Cirrhinus microlepis*, *Cyclocheilichthys enoplos*, and *Probarbus jullieni*, as well as several members of the family Pangasiidae, also participate in this migration system.

The Sesan tributary system (including the Sekong and Srepok Rivers) deserves special mention here (Figure 7). This important tributary system is intimately linked with the Lower Mekong Migration System, as evidenced by many species such as *Henicorhynchus* sp. and *Probarbus jullieni* extending their migration routes from the Mekong River mainstream into the Sesan tributary system (Chanh Sokheng, personal communication, December 2001). In addition, the Sesan tributary system also appears to contain its own migration system.

Figure 6: A simplified illustration of the Lower Migration System (only the major routes are illustrated). Black arrows represent migrations at the beginning of the dry season; grey arrows represent migration at the beginning of the flood season. See text for further explanation.

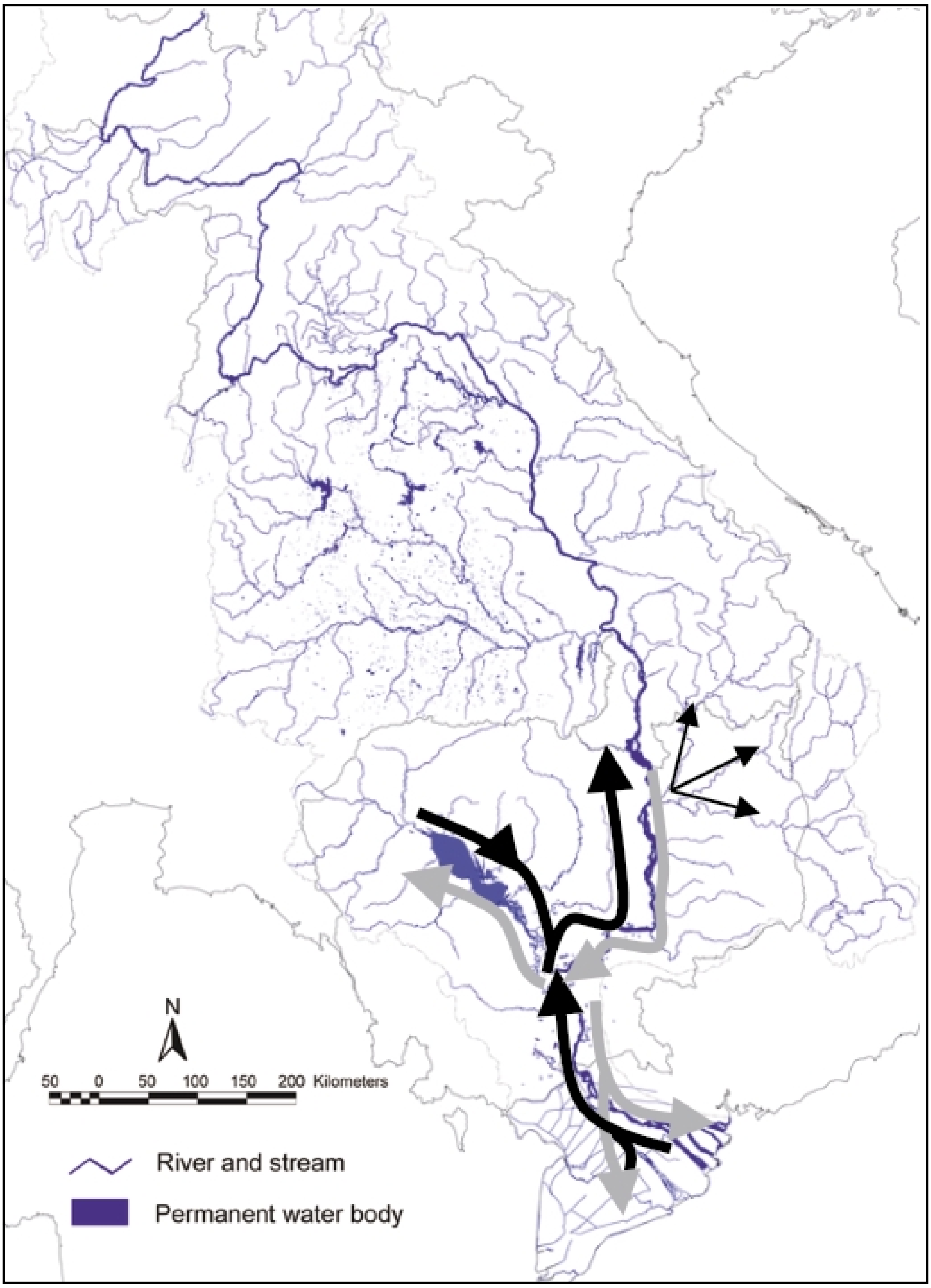
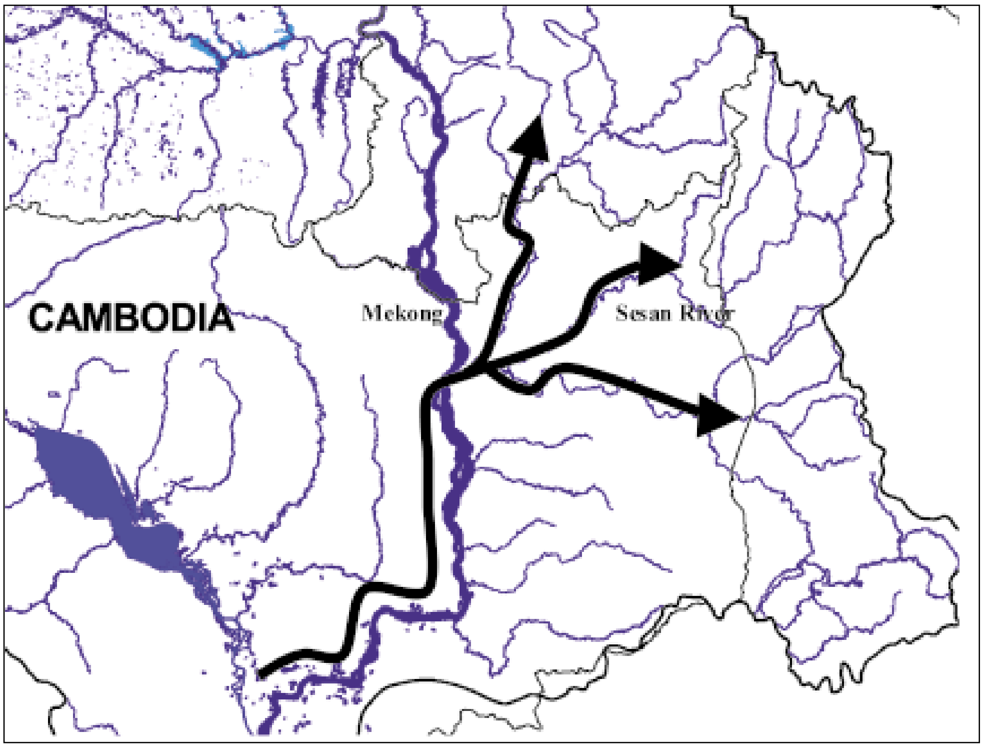


Figure 7: The dry-season migration of *Henicorhynchus* spp. from the Mekong into the Sesan Tributary system



Many of the species (e.g. all the species mentioned above) are believed to spawn within the Mekong mainstream in the upper stretches of the system (from Kratie to the Khone Falls, and beyond) at the beginning of the flood season in May-June. Eggs and larvae subsequently drift downstream with the current to reach the floodplain feeding habitats in southern Cambodia and Viet Nam. The importance of drifting larvae and juveniles has been documented through intensive sampling of larvae fisheries in the Mekong Delta in Viet Nam (Tung *et al*. 2001). During a sampling period of only 45 days in June-July 1999 from two sites (one in the Mekong River and one in the Bassac River in An Giang Province of Viet Nam), 127 species were identified from the larvae and juvenile drift. Fish eggs were not sampled. This illustrates how important hydrology is for the completion of life cycles of fishes in the lower Mekong River.

Fishing for fish larvae in the Mekong Delta (An Giang Province of Viet Nam).

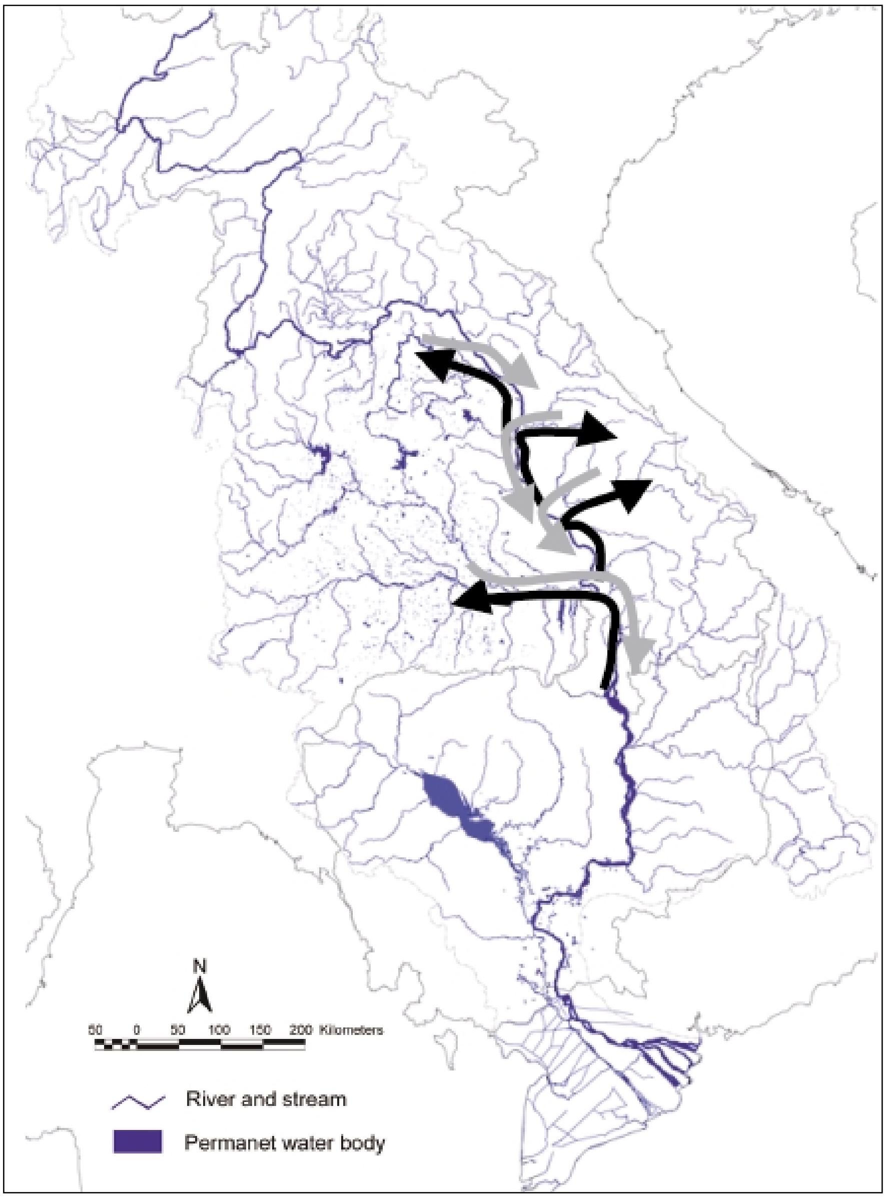
Table 1: The 127 species caught during the larvae sampling of the Mekong and Bassac rivers, in An Giang Province of Viet Nam. M = Mekong; B = Bassac (from Tung, *et. al*., unpublished AMFC report)

Taxa	M	B	Taxa	M	B	Taxa	M	B
OSTEOGLOSSIFORMES			*Rasbora paviei*	■		**Sisoridae**		
Notopteridae			*Rasbora spilocerca*	■		*Glyptothorax laoensis*	■	■
Chitala ornata	■	■	*Rasbora sp.*	■		*Clariidae*		
Notopterus notopterus	■	■	*Sikukia stejnegeri*	■	■	*Clarias batrachus*	■	■
ANGUILLIFORMES			*Systomus binotatus*	■	■	BELONIFORMES		
Ophichthidae			*Thryssocypris tonlesapensis*	■	■	*Hemiramphidae*		
Ophichthus rutidoderma	■		*Thynnichthys thynoides*	■		*Dermogenys pusilla*	■	
Ophichthys sp.	■		*Balitoridae*			SYNBRANCHIFORMES		
Pisodonophis boro	■	■	*Homaloptera sp.*	■	■	*Synbranchidae*		
CLUPEIFORMES			*Cobitidae*			*Monopterus albus*	■	
Clupeidae			*Acanthopsis sp.*	■	■	*Opisternon bengalense*		■
Clupeoides borneensis	■	■	*Acanthopsoides sp*	■	■	*Chaudhuriidae*		
Corica laciniata	■	■	*Botia helodes*	■	■	*Chaudhuria sp.*	■	■
Tenualosa thibaudeaui	■		*Botia modesta*	■	■	*Mastacembelidae*		
CYPRINIFORMES			*Lepidocephalichthys furcatus*	■	■	*Macrognathus siamensis*	■	■
Cyprinidae			*Lepidocephalicthys hasselti*	■	■	*Mastacembelus armatus*	■	■
Albulichthys albuloides	■		*Pangio sp.*	■	■	PERCIFORMES		
Amblypharyngodon chulabhornae	■	■	*Gyrinocheilidae*			*Chandidae*		
Amblyrhynchichthys truncatus	■		*Gyrinocheilus aymonieri*	■		*Parambassis siamensis*	■	
Barbodes altus	■	■	SILURIFORMES			*Parambassis wolffi*	■	■
Barbodes gonionotus	■		*Bagridae*			*Parambassis sp.*	■	
Cirrhinus microlepis	■	■	*Heterobagrus bocourti*	■		*Nandidae*		
Cosmochilus harmandi	■	■	*Leiocassis siamensis*	■	■	*Pristolepis fasciata*	■	■
Crossocheilus reticulates	■	■	*Hemibagrus filamentus*	■	■	*Callionemidae*		
Crossocheilus sp.	■		*Mystus mysticaetus*	■	■	*Callionemus sp.*	■	■
Cyclocheilichthys enoplos	■	■	*Mystus singaringan*	■	■	*Eleotridae*		
Cyclocheilichthys microlepis	■	■	*Mystus sp.*	■		*Eleotris fusca*	■	■
Cyclocheilichthys repasson	■		*Siluridae*			*Eleotris sp.*	■	
Cyclocheilichthys sp.	■	■	*Belodontichthys truncatus*	■		*Oxyeleotris marmorata*	■	■
Cyprinus carpio		■	*Hemisilurus mekongensis*	■		*Gobiidae*		
Dangila sp.	■	■	*Kryptopterus cheveyi*	■		*Brachygobius sp.*	■	■
Epalzeorhynchos munense		■	*Kryptopterus cryptopterus*	■	■	*Gobiopterus sp. 1*	■	■
Esomus metallicus	■	■	*Micronema cf. micronema*	■	■	*Gobiopterus sp. 2*	■	
Garra fasciacauda	■	■	*Micronema sp.*	■		*Pseudogobius sp.*	■	■
Hampala macrolepidota	■		*Ompok eugeneiatus*	■		*Taenioides sp. 1*	■	
Henicorhynchus caudimaculatus	■	■	*Ompok hypophthalmus*	■		*Taenioides sp. 2*	■	
Henicorhynchus sp. 1	■	■	*Ompok krattensis*	■	■	*Stenogobius genivittatus*	■	■
Henicorhynchus sp. 2	■		*Ompok sp.*	■	■	*Stenogobius sp.*	■	■
Hypsibarbus sp.	■		*Wallago attu*	■		*Belontiidae*		
Labeo dyocheilus	■	■	*Schilbeidae*			*Anabas testudineus*	■	■
Lobocheilus sp.	■		*Laides longibarbis*	■		*Trichogaster trichopterus*	■	■
Luciosoma bleekeri	■		*Pangasiidae*			*Trichopsis vittatus*	■	■
Morulius chrysophekadion	■	■	*Pangasianodon hypophthalmus*	■	■	*Channidae*		
Osteochilus lini	■	■	*Pangasius bocourti*	■		*Channa micropeltes*		■
Osteochilus melanopleura	■	■	*Pangasius conchophilus*	■	■	*Channa striata*	■	■
Osteochilus sp.	■		*Pangasius larnaudiei*	■	■	PLEURONECTIFORMES		
Paralaubuca riveroi	■	■	*Pangasius macronema*	■	■	*Soleidae*		
Poropuntius sp.	■	■	*Pangasius polyuranodon*	■	■	*Euryglossa harmandi*	■	■
Probarbus jullieni	■		*Pteropangasius pleurotaenia*	■	■	*Euryglossa panoides*	■	■
Puntioplites proctozysron	■	■	*Ariidae*			*Cynoglossidae*		
Puntius brevis	■		*Hemipimelodus borneensis*	■	■	*Cynoglossus microlepis*	■	■
Puntius spilopterus	■	■	*Akysidae*			*Cynoglossus feldmanni*	■	
Rasbora borapetensis	■	■	*Akysis ephippifer*	■		*Cynoglossus cynoglossus*	■	
Rasbora daniconius	■	■	*Akysis similis*	■	■	TETRAODONTIFORMES		
Rasbora myersi	■	■	*Akysis varius*	■	■	*Tetraodontidae*		
						Tetraodon sp.	■	

3.3.2 The Middle Mekong Migration System (MMS)

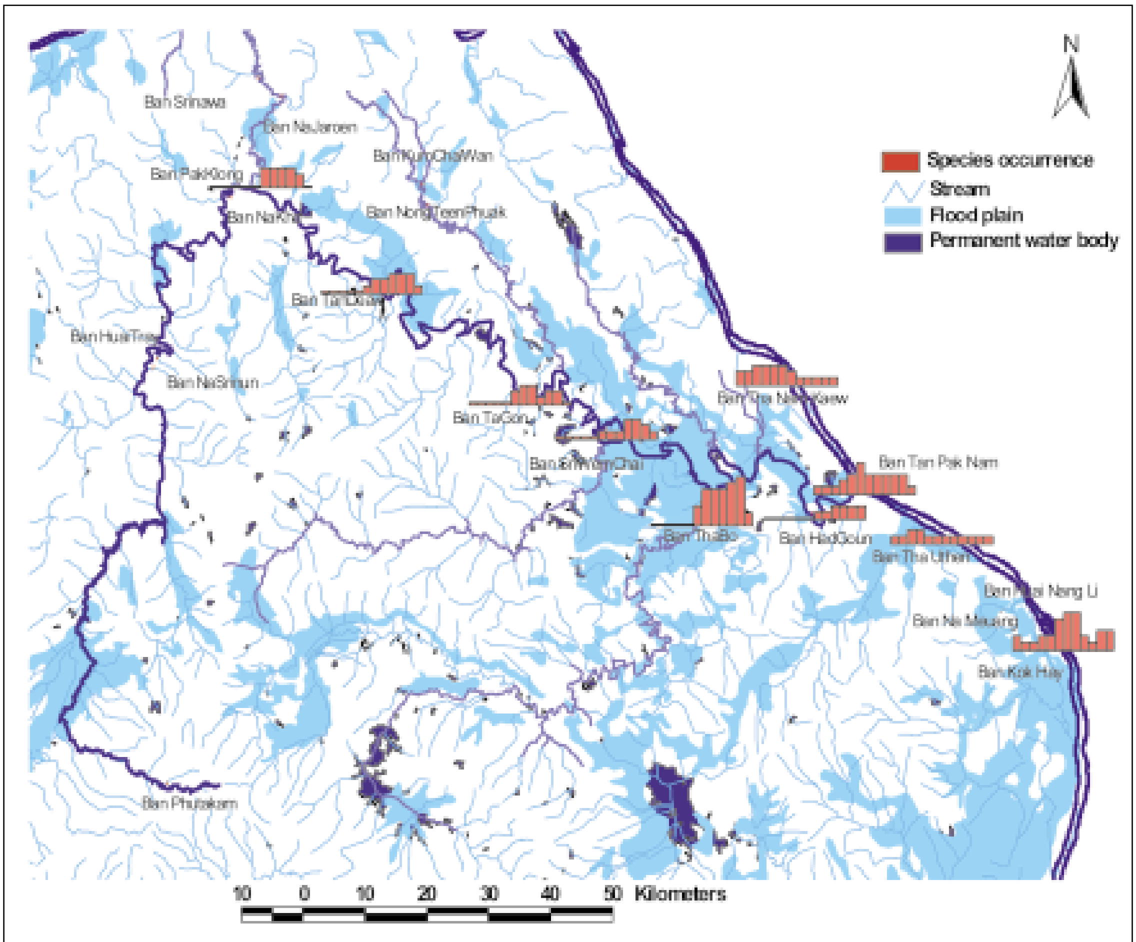
From just above the Khone Falls and upstream to the Loei River, Thailand, the migration patterns are determined by the presence of large tributaries connecting to the Mekong mainstream. Within this section of the river, floodplain habitats are mainly associated with the tributaries (e.g. the Mun River, Songkhram River, Xe Bang Fai River, Hinboun River, and other tributaries), so fishes migrate seasonally along these tributaries from mainstream dry season habitats to floodplain feeding/rearing habitats. At the onset of the flood season, fishes generally move upstream within the Mekong mainstream until they reach the mouth of one of these major tributaries. They swim up the tributary until they can move into floodplain habitats. At the end of the monsoon, fishes move in the opposite direction, from floodplains through the tributary river and, eventually, to the Mekong mainstream, where many fishes spend the dry season in deep pools. An example is given in Figure 8, based on local ecological knowledge.

Figure 8. Simplistic illustration of the Middle Migration System.



This is of course a very simplistic description of the main movements, and there are considerable variations in the general pattern, both between different species and within species. Furthermore, there are complex interconnections to the lower migration system described above, i.e. many of the same species participate in both systems, either as genetically-distinct populations, or at different stages of their life cycle (see later).

Figure 9. Variation in occurrence of a group of 9 Pangasiid species in the Songkhram River and adjacent Mekong, based on Local Ecological Knowledge. See text further for explanation. The species are: *Heligophagus waandersii, Pangasianodon hypophthalmus, Pangasius bocourti, P. conchophilus, P. djambal, P. krempfi, P. larnaudiei, P. polyuranodon, P. sanitwongsei.*



The movement of fish between the Songkhram River and the Mekong mainstream, is illustrated in Figure 9. Each bar chart illustrates reported occurrence by month at each station over the year. The occurrence level for each month was reported as 'high occurrence', 'low occurrence', or 'no occurrence'. It shows that all these species use the Mekong mainstream as a dry season refuge and the Songkhram River floodplain as feeding grounds during the flood season.

Fish trap in the upper Mekong River

It is important to emphasise that the two different migration systems (LMS and MMS) are not "closed" ecological systems, isolated from each other. The two systems are in fact interconnected. Many species are known to migrate over the Khone Falls, both during the flood season and during the dry season, thereby demonstrating that the Falls is not a barrier for fish movements (Baird 1998; Roberts 1993; Roberts and Baird 1995; Roberts and Warren 1994; Singanouvong *et al*. 1996a and 1996b). For some species, the same fish may be part of the lower migration system as a juvenile, and part of the middle migration system as a mature adult. For example, important species such as *Cyclocheilichthys enoplos* and *Cirrhinus microlepis* are mainly reported as juveniles and sub-adults in the Lower Mekong Migration System and as adults in the Middle Mekong Migration System. The same may be true for a number of other species, including the Giant Mekong Catfish. For other species, it may be the case that genetically distinct sub-populations are involved in the different migration systems. However, further research is needed before conclusions can be made on this issue.

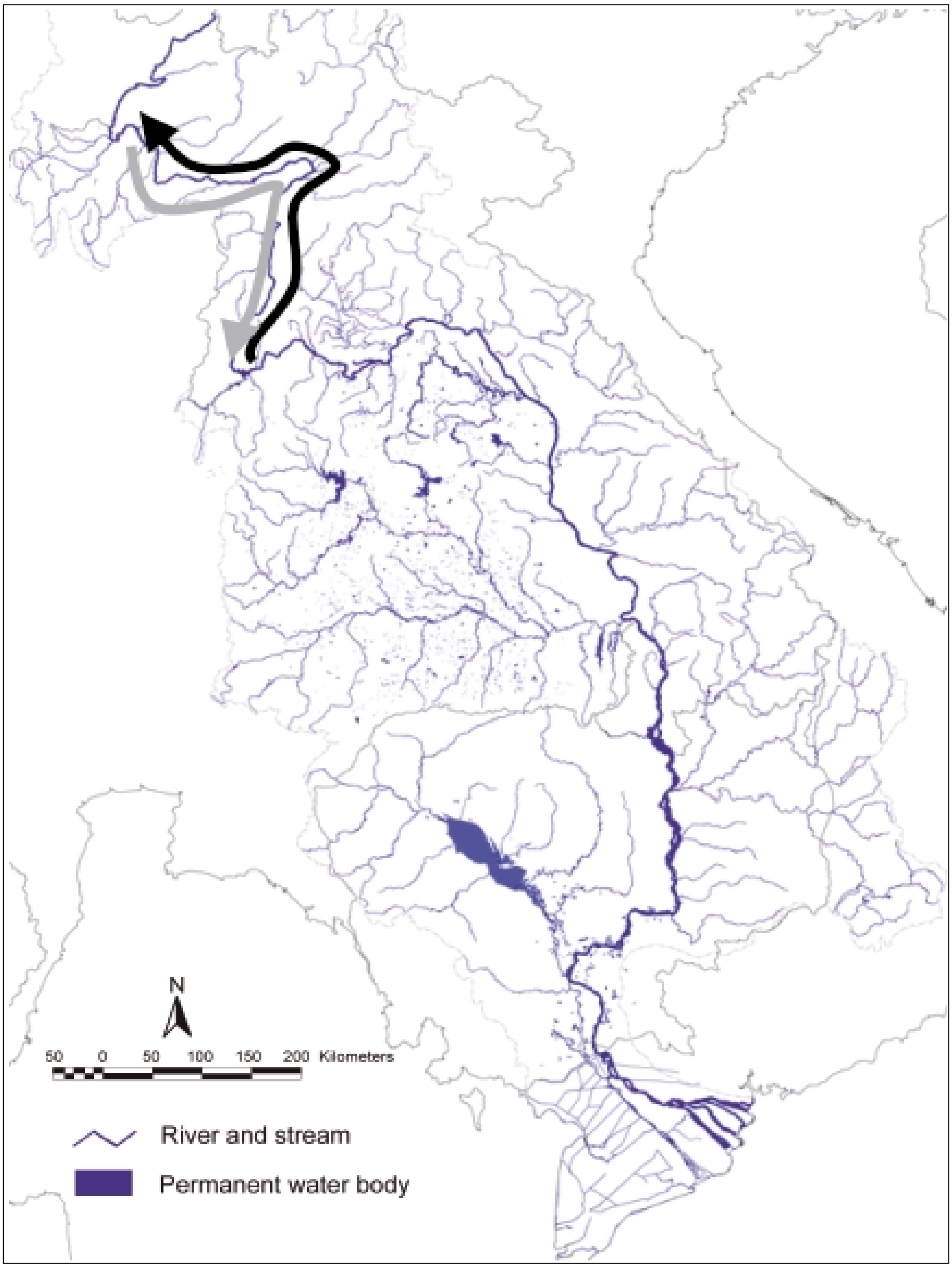
3.3.3 The Upper Mekong Migration System (UMS)

The third migration system occurs in the upper section of the river, approximately from the mouth of the Loei River and upstream towards the border between Lao PDR and China (probably continuing into China, although we have no data to confirm this). This section of the river (Figure 10) is characterised by its relative lack of floodplains and major tributaries (although there are some floodplains associated with tributaries in the far north, i.e. the Nam Ing River, in Thailand). This migration system is dominated by upstream migrations at the onset of the flood season, from dry season refuge habitats in the main river to spawning habitats further upstream. This is also a multi-species migration system, and some of the species participating in the previous migration systems further downstream also participate in this migration, although the total number of species may be lower.

The most conspicuous member of this migration system is the Giant Mekong Catfish, *Pangasianodon gigas*. The *Henicorhynchus* sp., which is so important for the fishery further downstream, is also important along this stretch of the river. For example, a fisherman from Bokeo in northern Lao PDR reported a catch of between 100 and 200 kg per day of this fish during the month of October 2001 (Bouakhamvongsa, in prep.) This may be a genetically distinct stock compared with downstream stocks (although further research is needed to confirm this).

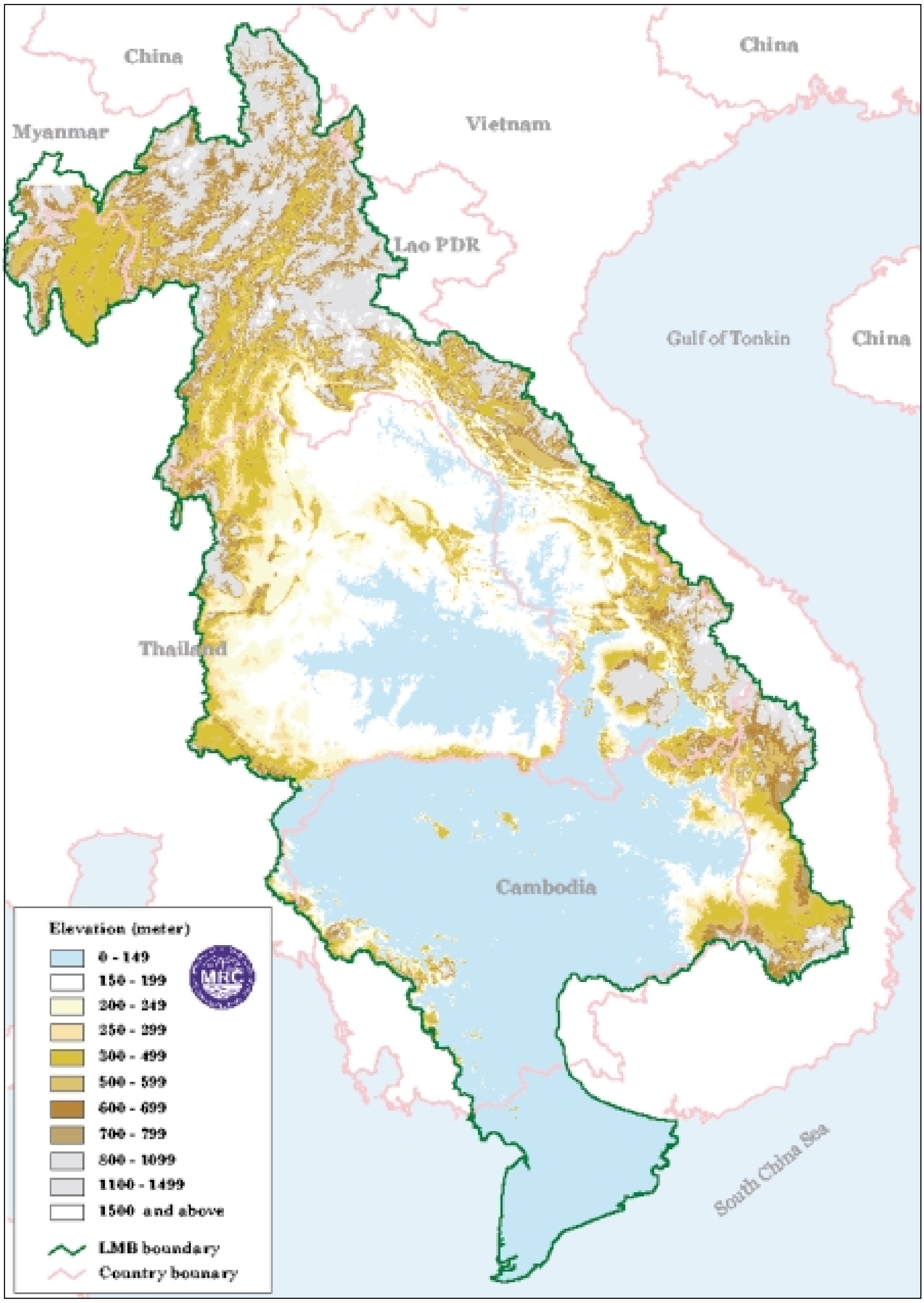
Whereas the LMS and the MMS are inter-connected to a large degree, the UMS appears to be relatively isolated, with little "exchange" between the UMS and the other migration systems. As can be seen from Figure 3, deep pool habitats are rare for a long stretch of the Mekong between the MMS and the UMS. Along the same stretch, observations of mature fishes with eggs are also rare. This indicates that for many migratory species, the stretch from Paksan to the mouth of the Loei River is a functional barrier.

Figure 10. Simplistic illustration of the Upper Migration System.



Interestingly, the geographical extent of these three migration systems corresponds with elevation contours of the lower Mekong Basin (Figure 11). In particular, there is a clear area overlap between the extent of the Lower Mekong Migration System and the extent of the 0-149 m elevation of the Mekong Delta/Cambodian lowlands. A correlation also occurs between the Middle Mekong Migration System and the 150-199 m elevation represented largely by the Korat Plateau. The Upper Mekong Migration System correlates with a plateau of 200-500 m elevation. This demonstrates how fish migration has evolved within the surrounding physical environment.

Figure 11: Elevation map of the Lower Mekong Basin. Note the overlap between the Lower Migration System and the region with the dominant elevation between 0-149 m (the Mekong Plain); between the Middle Migration System and the region with the dominant elevation between 150-199 (the Korat Plateau) and between the Upper Migration System and the region with elevation mainly above 250 m (Northern Highlands).



Managing migratory fishes 4

The two main intervention areas for the sustainable management of the fishery resources of the Mekong are:

- management of habitats and ecosystems (environmental management)
- management of resource use (fisheries management).

Traditionally, fisheries management in the Mekong (and elsewhere) has focussed solely on 'within-the-sector' issues and management activities (e.g. gear restrictions, access restriction, seasonal restrictions). In a complex setting like the Mekong Basin, it is particularly important that fisheries resources are managed within an overall management framework, where environmental management is seen as a pre-requisite for fisheries management (see, for instance Coates, 2001). Fisheries management, in its conventional application, would be of limited use in the Mekong, unless the environment that sustains the fisheries are managed first in a sustainable manner. This requires a multi-disciplinary approach, involving all the different 'users' of the river. The focus of this report, therefore, is on environmental management (i.e. management of habitats and ecosystem attributes), and not on conventional fisheries management.

With regards to the management of migratory, transboundary fish stocks, an additional requirement is that regional, cross-border management initiatives are implemented. This is the area where the MRC is well placed to play a key role. All the three migration systems mentioned previously extend across international borders and thus, by nature, fall under the responsibility of the MRC.

The 1995 Agreement that established the Mekong River Commission, serves as the natural framework under which management guidelines for migratory fishes of the lower Mekong Basin can be designed and implemented. In addition to the 1995 Agreement, another instrument deserves mentioning here: the Convention on Biological Diversity (CBD). The CBD is the most comprehensive international instrument in existence for the management of natural resources. It commits signatory states to "…the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources…". It further makes special reference to the need for states to manage transboundary (i.e. migratory) stocks (e.g. Article 3: "...contracting parties shall ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction". The Convention specifically refers to the cooperation, among contracting parties in research, management and monitoring of biodiversity, including migratory, transboundary elements of biodiversity. The CBD has been signed by all the six riparian countries of the Mekong Basin, including China and Myanmar. However, Cambodia, Lao PDR and Thailand have yet to ratify it.

The main reason for mentioning the CBD in the context of this report is that the two remaining riparian countries, China and Myanmar, which are not members of MRC, are signatories of, and have ratified, the CBD. Therefore, the CBD commits them to the conservation and sustainable use of biodiversity (part of which are fishery resources). Some of the fish migrations extend into China and Myanmar and, in addition, activities undertaken in the two upper countries may impact on downstream fishery resources, including fish migration systems.

Another reason for the relevance of the CBD is that there is a direct link between the high fish diversity and the fisheries productivity of the Mekong (Coates 2001). This link is important to emphasise, because fisheries issues have traditionally been viewed in separation from biodiversity conservation, often even seen as threats to biodiversity conservation. The Mekong fisheries demonstrate the intimate linkages between biodiversity and fisheries: biodiversity conservation can be achieved through the promotion of sustainable use (fisheries), and fisheries productivity can be sustained only through biodiversity conservation.

The fish diversity of the Mekong is reflected in the diversity of fishing gears used to catch them.

4.1. Key issues for the maintenance of ecological functioning of the Mekong ecosystem, with reference to migratory fishes

Based on the ecological information that has been described above, key attributes of importance for the ecological functioning and productivity of the Mekong ecosystem will be listed in the following section. Although the emphasis is on issues related to migratory fishes, the issues are equally relevant for all fish species and indeed for the ecosystem as a whole.

Basically, the most important issue in relation to the ecological functioning of the Mekong River from the point of view of migratory fishes is that critical habitats are maintained in time and space. This includes the maintenance of connectivity between them, i.e. through migration corridors. The importance of the annual hydrological pattern is emphasised, including its role in the creation of seasonal floodplain habitats, as well as its role as a distributor of fish larvae and juveniles through passive drift.

The following key ecological attributes for migratory species are identified, based on the three major migration systems described above along the Mekong mainstream.

The Lower Mekong Migration System (LMS).

General ecological attributes	*Mekong-specific ecological attributes*
Dry season refuge habitats:	Deep pools in the Kratie-Stung Treng stretch of the Mekong mainstream. These habitats are extremely important for recruitment for the entire lower Mekong Basin, including floodplains in southern Cambodia (including the Tonle Sap/ Great Lake System) and the Mekong Delta in Viet Nam.
Flood season feeding and rearing habitats:	Floodplains in the Mekong Delta in Viet Nam, in southern Cambodia, and in the Tonle Sap system. These habitats support the major part of Mekong fisheries.
Spawning habitats:	Rapids and deep pool systems in the Kratie – Khone Falls, and in the Sesan catchment. Floodplain habitats in the south (e.g. flooded forests associated with the Great Lake).
Migration routes:	The Mekong River from Kratie – Stung Treng to southern Cambodia and the Mekong Delta in Viet Nam. Between the Mekong River and the Tonle Sap River (longitudinal connectivity). Between floodplain habitats and river channels (lateral connectivity). Between the Mekong mainstream and the Sesan sub-catchment (including Sekong and Srepok Rivers).
Hydrology:	The annual flood pattern responsible for the inundation of large areas of southern Cambodia (including the Tonle Sap system) and the Mekong Delta is essential for fisheries productivity of the system (see above). The annual reversal of the flow in the Tonle Sap River is essential for ecosystem functioning. If the flow is not reversed (or if reversal is delayed), fish larvae drifting from upstream spawning sites in the Mekong River cannot access the important floodplain habitats of the Tonle Sap System. A delayed flow reversal would also lead to a reduced floodplain area adjacent to the river and lake, and thus, reduced fish production. Changed hydrological parameters, e.g. as a result of water management schemes, result in changed flow patterns, which in turn may change sedimentation patterns along the river. Examples of this already exist in some tributaries where hydropower dams have been constructed, resulting in sedimentation, and thus in disappearance of deep pool habitats.

The Middle Mekong Migration System (MMS)

General ecological attributes	*Mekong-specific ecological attributes*
Dry season refuge habitats:	Deep pool stretches of the Mekong mainstream and within major tributaries. Of particular importance is the stretch from the Khone Falls to Kammouan/Nakhon Phanom. Deep pools immediately downstream from the Khone Falls also are important for this migration system (thereby linking the MMS and the LMS)
Flood-season feeding and rearing habitats:	Floodplains of this system are mainly associated with major tributaries (e.g. the Mun/Chi system, Songkhram River, Xe Bang Fai River, Hinboun River).
Spawning habitats:	Rapids and deep pool systems in the Mekong mainstream (particularly along the stretch from the Khone Falls to Khammouan/Nakhon Phanom). Floodplain habitats associated with tributaries.
Migration routes:	Connections between the Mekong River (dry season habitats) and major tributaries (flood season habitats). Access to floodplain habitats from main river channels must be maintained.
Hydrology:	The annual floods that inundate floodplain areas along major tributaries must be maintained.

The Upper Mekong Migration System (UMS)

General ecological attributes	*Mekong-specific ecological attributes*
Dry season refuge habitats:	Occur throughout the extent of the UMS, but are most common in the downstream stretch from the mouth of the Loei River to Louang Prabang.
Flood season feeding and rearing habitats:	The UMS occurs within a section of the Mekong, which is dominated by mountainous rivers with limited floodplain habitats. Floodplain habitats therefore play a less important role, compared to MMS and LMS. Large catches of *Henicorhynchus* sp. in Bokeo Province of Lao PDR suggest that even the limited areas of available floodplains are important.
Spawning habitats:	Spawning habitats occur mainly in the upper stretches of the system. They are mainly situated in stretches with alternating rapids and deep pools.
Migration routes:	Migration corridors between downstream dry season refuge habitats and upstream spawning habitats should be maintained.
Hydrology:	The annual flood pattern that triggers fish migrations and causes innudation of floodplains.

Khone Falls

The Khone Falls are situated on the border between Cambodia and Lao PDR and thus also demarcate the "border" between the LMS and the MMS. It is important to emphasise that the Khone Falls are not a barrier to migration. The Khone Falls area is probably the most studied site along the whole of the Mekong, and large-scale migrations involving a large number of species have been documented through intensive sampling programmes over the past decade (Baird 1998; Roberts 1993; Singanouvong *et al*. 1996a and 1996b). Thus, the LMS and the MMS are in fact inter-connected.

What makes the LMS and the MMS different from each other is not that they are geographically isolated.The difference is that in the LMS, the dry season refuge habitats are situated **upstream** from the flood season feeding and rearing habitats, whereas in the MMS, they are situated **downstream** from the flood season habitats. Therefore, at the onset of the flood season, in the LMS fishes migrate **downstream** towards flood season habitats, whereas in the MMS, fishes migrate **upstream** towards flood season habitats. As mentioned earlier, in some cases the same fish may participate in both migration systems at different stages of their life cycle.

The UMS may be relatively isolated from the two migration systems further downstream. It thus may represent genetically distinct populations of fishes. If so, these populations should be regarded as separate management units. Further research, particularly on population genetics, is needed to clarify this issue.

Potential impacts of development activities 5

In order to be able to optimise the basin planning process it is necessary to identify and assess potential impacts of different development scenarios on fisheries and the environment that sustain them. In this section some of the potential human impacts on migratory fishes of the Mekong are discussed.

5.1 Human impacts on the Mekong fisheries

Some of the potential impacts of development activities and projects within the Mekong River Basin will be discussed below. Human impacts on rivers have been divided into four categories: (1) supra-catchment (e.g. inter-basin water transfer); (2) land-use change within the basin catchment (e.g. agricultural development, urbanisation, deforestation, land drainage, flood protection); (3) corridor engineering (e.g. dams and weirs, channelisation, dredging, mining); and (4) in-stream impacts (e.g. pollution, navigation, water abstraction, exploitation of native species, introduction of exotic species) (Arthington and Welcomme 1995).

These impacts affect all the fisheries resources of the Mekong, including both black-fish and white-fish. However, the migratory white-fish species are particularly vulnerable, because they depend on large areas, many different habitats, and the un-hindered access to these habitats through the migration corridors linking them. Thus, potential impacts on black-fish species can be regarded as a sub-set of impacts on white-fish species. In the following section, we will try to identify some potential impacts in the context of migratory fishes of the Mekong River.

An assessment of impacts should ideally contain the following processes:

- A **valuation** of migratory fishes as a fishery resource
- An **assessment** of ecosystem attributes and processes that are required in order to sustain the resources
- Based on the two first points, an **assessment** of the **degree** of impacts (i.e. will the resource disappear, or will part of it be able to persist in spite of the impacts?).

In the following section, we will discuss these three points with particular emphasis on the Lower Mekong Migration System.

5.1.1 Valuation

In order to be able to assess impacts of different development scenarios, the potentially-impacted resources must be quantitatively valued. This should also include a valuation of the critical ecosystem attributes that sustain the resources. A large body of literature has emerged in recent years focusing on assessing the value of natural resources and ecosystem services (see for instance: Barbier *et al*. 1996; Secretariat of the Convention on Biological Diversity 2001). Much of this literature emphasises the difficulties associated with assessing the value of ecosystems and their multiple functions, including, particularly, the many intrinsic, non-tangible values associated with, and services provided by the ecosystem. Although such values are important and must be included in the overall basin planning and impact assessment process, they are not considered in this report. Instead, the focus is on the 'direct use' value of migratory fishes, i.e. their direct value as **fisheries resources**.

In this report we focus on the direct-use values of migrating fishes because they are relatively simple to quantify (in theory, at least) compared to the intrinsic, non-tangible ecosystem values. However, we strongly emphasise that these values must not be ignored just because they are difficult, sometimes impossible, to quantify.

The direct-use value is most often expressed as a monetary value ($US) based on the amount of the resource, multiplied by a known unit price. For fisheries, the amount is usually expressed in weight (kg), although for certain specialised fisheries, the number of fish may be applied (e.g. fisheries targeting live juveniles for stocking purposes). Ideally, a more relevant expression of the value of a resource would be to assess the **replacement value**, i.e. the cost of replacing the resource with something of equal value for the livelihood of local communities. This would, for example, include the costs of transporting and storing foods of equivalent nutritional value to the places where people currently eat wild fish. To carry out such an assessment would be a complex undertaking and considered beyond the scope of this report.

The value of fisheries in the Mekong River Basin is more than just the direct-use value.

The total direct-use value of the fishery resources of the Lower Mekong Basin has been estimated at $US 1,478 million (Sverdrup-Jensen 2002). Such an estimate is useful in terms of demonstrating the overall importance of the fisheries. However, for planning and impact assessment purposes, more segregated valuation estimates are needed.

A full economic valuation that would be of use for planning and assessment purposes would require the gathering of a large amount of information at several scales and would also require the disaggregation of estimates both by species and by habitat (Aeron-Thomas 2001). In this regard, migratory species pose a particular challenge, since they cover large geographic areas and depend on a large number of habitats. Therefore, based on existing data, it is not possible to carry out a full valuation. The resources required to carry out a full valuation may in fact be so large (both in terms of time, money and human resources) that it may not be possible to fully valuate the Mekong fisheries, let alone the contribution of migratory species to fisheries. However, a partial valuation based on existing data, together with an assessment of major information gaps would still be useful, and in many cases sufficient for planning and decision-making purposes. In the following section, we will illustrate a process by which a partial valuation of the fisheries of migratory fishes could be undertaken.

In a multi-species environment such as the Mekong, where the coverage of quantitative, species-specific data is limited, the large-scale, multi-species migration systems described above can instead be used as the stratification on which assessments can be based. Thus, the valuation process can be carried out for each of the three migration systems (with due allowance for their inter-connectedness). We will use the Lower Mekong Migration System (LMS) as the example, and in this process we will attempt to:

(1) list all the major fisheries for migratory species within the Lower Mekong Migration System
(2) quantify each of them, where possible
(3) identify the knowledge gaps for these fisheries in terms of quantitative data.

All fisheries targeting migratory species throughout their range and migration routes should be included in a valuation. Even fisheries for which no quantitative data exist should be included as "information gaps". The migratory fishes of the Lower Mekong Migration System support at least the following fisheries during their seasonal movements:

- Floodplain fisheries, of which migratory species constitute a proportion of the total catch (e.g. Tonle Sap River floodplains, Great Lake floodplains and the Mekong-Bassac floodplains in southern Cambodia)
- Great Lake fisheries, of which migratory species constitute a proportion of the total catch
- Fisheries which target migratory fishes when they leave the floodplain (lateral migration)
- The Samrah (brush park) fishery in the upper Tonle Sap River
- Fisheries targeting migratory fisheries in the Tonle Sap (*dai* fisheries)
- Fisheries of the Mekong Delta in Viet Nam
- Fisheries targeting migratory fishes in the Mekong between Phnom Penh and the Khone Falls
- Fisheries at dry season refuges in northern Cambodia
- Khone Falls fisheries – a proportion of which constitutes migratory fishes
- Larvae and juvenile drift fisheries in southern Cambodia and Viet Nam

This illustrates the challenge associated with assessing the value of migratory fishes in terms of their importance in fisheries. And even if this list includes most of the larger fishing operations, it is not complete. Many small-scale fishing activities, which are not included, may in fact catch a significant amount of fish.

In the following section, we will discuss each of the listed types of fisheries in terms of existing quantitative information, species composition and information gaps.

Floodplain fisheries

As stated previously, most fish production in large rivers originates from floodplains. Even most fishes caught in river channels are produced on the floodplains. For example, almost all the species listed from the Tonle Sap River *dai* fishery (e.g. Lieng *et al.* 1995), spend their first important 4-5 months feeding and growing on the floodplains adjacent to the Tonle Sap River.

For the purposes of this report, the aim is then to (1) estimate the fishing yield from floodplain habitats, and (2) to estimate the proportion of migratory (white-fish) species contributing to this yield.

a. Yield from floodplain habitats

Several studies, both from the Mekong and from other river systems, have aimed at quantifying the productivity of floodplains in terms of production (yield) per unit of area (Welcomme 1985; Dubeau *et al.* 2001). One study with this aim was recently carried out in a small floodplain area in Kompong Tralach adjacent to the Tonle Sap River, approximately 45 km north of Phnom Penh (Dubeau *et al.* 2001). The most conservative estimate of per unit area fish yield from this study is within the range of 222-260 kg/ha/year[2] . This corresponds with the estimate of 230 kg/ha/year of Baran *et al.* (in press), cited in Sverdrup-Jensen (2002). However, it is significantly higher than estimates of floodplain yields from Bangladesh (de Graaf *et al.* 2001), which estimated an average floodplain yield over a seven-year period (1992-1999) at 86 kg/ha/year. Only once during this period (in the year with the biggest floods, 1998-99), was the yield estimate within the range found in Kompong Tralach (228 kg/ha/year) (de Graaf *et al.* 2001). The difference may be partly explained by the fact that the inland fisheries of Bangladesh have been exposed to over-exploitation and habitat modification for many years, and floodplain productivity would therefore be expected to be lower compared to the Mekong. If the data from the Kompong Tralach study are used, the per-unit-of-area yield is thus within the range 222-260 kg/ha/year. This can be converted into a monetary value using the initial sale price of $US 0.68 per kg (Sverdrup-Jensen 2002).

b. Migratory species

A large proportion of the floodplain yield originates from the black-fish species, i.e. species that spend their entire life on the floodplain, seeking refuge in permanent lakes in the floodplain area during the dry season. However, many black-fishes are predators, including the abundant *Channa* (snakeheads), and it can be presumed that they feed heavily on whitefishes which have moved into their floodplain habitat. Unfortunately, the lack of detailed information on LMB fish diets precludes a proper analysis of the dependence of many black-fishes on white-fishes as food, and hence an accurate estimation of the extent to which black-fishes represent food-chain-converted white-fish.

A significant proportion of the floodplain catches are white-fish species coming from and returning to river channels. These fishes rely on the **ecological connectivity** between floodplains and river channels.

The direct contribution of migratory species to the floodplain fisheries is hard to estimate because the fisheries are scattered, and based on a large number of people each catching relatively small

[2] The figure is lower than the figure from Dubeau *et al* (2001) because the specialised lot/leased fishery has been subtracted from the data. This fishery will be covered separately in this report because the proportion of migratory fishes are different between the two types of fisheries.

amounts for local consumption. The Kompong Tralach study collected species-specific data as part of the 'log-book' system, although the amounts of each species were not recorded. Based on these data, a measure of abundance can be obtained, i.e. the number of reports for each species reported from the catches during the one-year study (expressed as a percentage of the total number of reports). Such data cannot be used to estimate yield, but provide a relative figure of importance for different species groups.

A total of 64 species, or species groups, were recorded (some records pooled several species together, so the number of species is a lot higher). Although the three black-fish species, which are commonly caught in ricefields (*Anabas testudineus, Channa striata* and *Clarias batrachus*) alone account for 24 percent of the reports, migratory species account for no less than 30 percent of the reports. The most reported white-fish species group is the *Henicorhynchus* group, which account for almost 8 percent of reports. Although these figures cannot be 'converted' into catch, or value estimates, they provide solid indication that migratory fishes are also important in floodplain fisheries.

The floodplain fisheries of the Mekong Delta in Viet Nam are also hugely important and, similarly, a significant proportion consists of migratory white-fish species. Again, however, existing data do not allow a quantitative estimate of this contribution to be made.

Future research should aim at establishing the proportion (by weight) of migratory fishes in catches of floodplain fisheries of the Mekong.

Great Lake fisheries

The Great Lake of Cambodia has its own complex assemblage of fisheries and fisheries concessions (lots). The main gears are fences, arrow-shaped traps and barrages.

Lop trap being set as part of the arrow-shaped trap system, Great Lake, Cambodia

The volume of catches from the fenced fishing lots alone is expected to exceed 100,000 tonnes annually (Sverdrup-Jensen 2002). Based on existing data on species composition from the fishing lots (Van Zalinge *et al*. 2000; Troeung and Phem 1999), the direct contribution of migratory fishes to this yield is estimated to be 48 percent (i.e. excluding white-fishes converted to black-fishes through the food chain).

Migratory fishes from these fisheries thus represent a first-sale value of approximately $US 33,000 (using the price of $US 0.68 per kg).

Fisheries targeting migrations from floodplain to river

Numerous small channels draining the floodplains constitute the escape route for migratory fishes from floodplains and back to river channels, when the water begins to recede at the end of the monsoon season. This provides the foundation for yet another important fishery, the barrage/bag-net fishery. The Kompong Tralach study also included two such fisheries, draining the same floodplain area (Dubeau *et al.* 2001).

The total catch from this fishery encompasses migratory species dependent on connectivity between floodplain and river. The catch is estimated at 128 tonnes over one season (November to February).

An estimate of the total catch from this type of fishery for a large area such as the entire Tonle Sap catchment could be obtained by multiplying this figure with the total number of these fisheries, adjusting for variation in drainage area for each of them. Current data does not enable us to make this calculation.

The Samrah (brush park) fishery in the upper Tonle Sap River

The Samrah fishery is a traditional type of fishery that has been practiced for centuries in Cambodia, particularly in the Tonle Sap River system (Sam 1999). The fishery operates over three to four months in the dry season (January to April).

The total estimated catch from the Samrah fishery in the Tonle Sap River in Konpong Chnnang Province was estimated at 172 tonnes in 1997 and 199 tonnes in 1998 (Sam 1999). Sam (1999) also provided species composition of the catches. An estimated 52 percent of the catch over the two seasons constituted long-distance migratory species. This can be considered as a conservative estimate, since a large proportion of the catch (i.e. 20-25 percent) were identified as ‘other species’ and would certainly also include migratory species.

If we use the average for the two seasons, the monetary value of this catch would then be $US 66,000 (using $US 0.68/kg).

Data from other provinces in Cambodia and from Viet Nam are not available.

The Tonle Sap River* dai *fishery

This is the most well-documented fishery of the lower Mekong Basin (Lieng *et al.* 1995). It specifically targets white-fish species migrating from the Tonle Sap River to the Mekong River at the beginning of, and well into, the dry season (October to March).

Over a five-year period from 1995 to 2000, the total annual catches from the *dai* fisheries varied between 9,000 to 15,500 tonnes (Pengbun and Chanthoeun 2001). Again, using the unit price of $US 0.68/kg, the direct-use value of the *dai* catch ranged between $US 10.54 million and $US 6.12 million.

Fisheries of the Mekong Delta in Viet Nam

The fisheries of the Mekong Delta in Viet Nam are extremely important. They encompass a range of different gears and methods targeting different species groups and operating at both small-scale and large-scale. However, very few segregated data are available. A recent survey estimated the total annual yield from all the fisheries of An Giang Province at almost 195,000 tonnes (RIA2/MRC, in prep.). Approximately 70 percent of this yield constituted migratory (transboundary) species, corresponding to an annual yield of 136,000 tonnes. The direct-use value is thus $US 92.8 million.

Fisheries targeting migratory fishes along the stretch from Phnom Penh to Khone Falls (including the Sesan tributary system)

Migratory fishes are targeted using various types of gears along this stretch. The most important gears are: gillnets, seine nets, various traps, and brush parks. The fish migrations along this stretch are also targeted by migratory fishermen, who follow the fishes for some distance on their upstream journey, particularly from Kratie to Stung Treng and into the Sesan catchment.

In terms of quantity and species composition of the yield from this section of the river, no data are currently available and it is thus not possible to put a monetary value on the yield.

This should therefore be included in the final assessment as an information gap.

Fisheries at dry season refuges in northern Cambodia

These fisheries largely constitute small-scale operations using multiple methods and gear types. They have not been documented in terms of quantity and species composition, and therefore, a quantitative valuation is not possible.

This should therefore be included in the final assessment as an information gap.

Khone Falls fisheries

The Khone Falls fisheries are among the most well documented of the entire basin, both in terms of quantity and species composition. For instance, the annual yield for the 65,000 people living on Khong Island, has been estimated at approximately four tonnes, of which almost 92 percent constituted catches from the Mekong mainstream (Baird *et al.* 1998). The most important species groups reported were the *Henicorhynchus* group. Since a large proportion of the Khone Falls fisheries specifically target migratory fishes, we can assume that most of the yield originates from long-distance migratory white-fishes, which ‘grew up’ on the floodplains in southern Cambodia and the Mekong Delta in Viet Nam.

It is also possible to estimate yield from certain specialised gears targeting migratory species at the Khone Falls.

However, the diversity of fishing operations at the Khone Falls is very high, and for a true and full valuation of the fishery one would have to obtain quantitative data, including species composition, for each operation.

Larvae and juvenile drift fisheries

This specialised fishery targets fish larvae and juveniles of certain catfish species (mainly *Pangasianodon hypophthalmus* and *Pangasius bocourti*). The catch is used in the aquaculture industry in the Mekong Delta in Viet Nam for stocking in cages and ponds (Trong *et al.* 2002). Annual catches of 200-800 million fry have been reported for Viet Nam (Trong *et al*. 2002) and up to 165,000 million in Cambodia (Van Zalinge *et al.* 2002).

The fishery is now banned in both Cambodia and Viet Nam due to its perceived negative impacts on wild fish stocks of many species (Trong *et al.* 2002). Also, it is now possible to hatch both target species in captivity and therefore the demand for wild-caught fry may disappear in the future.

The need to incorporate this fishery into a valuation process may therefore no longer exist. However, this fishery illustrates an important aspect, which should ideally also be included in a full resource valuation: the opportunity value. The development of the larvae fishery was a pre-requisite (and thus provided the opportunity) for the development of the catfish aquaculture industry in Viet Nam. This industry produces about 65,000 tonnes annually (Trong *et al*. 2002). Most of the production is exported, and thus provides a substantial amount of foreign exchange earnings to Viet Nam. The fishery resources, and the rich biodiversity of the Mekong Basin as a whole, potentially hold large and untapped opportunity values in areas such as aquaculture, eco-tourism, recreational fishing, etc.

Floating fish feed factory in An Giang Province, Viet Nam. The feed is produced from dried fish (mostly imported from Cambodia) and used in the cage culture of Pangasiid catfishes in Viet Nam.

5.1.2 Assessing ecosystem attributes and functions

The valuation process above focused on the direct-use value of migratory fishes. In the overall assessment, it is also necessary to include some considerations of the importance (in quantitative terms) of ecosystem attributes, such as critical habitats and migratory connectivity. These attributes were identified in qualitative terms in Section Four. How can their role be (semi)-quantified? In the following section, we will illustrate how this could be done and what it would require in terms of data. Specifically, we will try to quantify the importance of one of the critical habitats for the Lower Migration System: the deep pool refuge habitats along the Kratie-Stung Treng stretch of the Mekong River.

As mentioned above, deep pools in river channels play an important role as dry season refuges for a large number of species and are therefore important for recruitment of fishes at the beginning of the flood season. One could then ask the following question:

> ***How much of the yield from the lower Mekong (expressed in percent) depends on deep pool refuge habitats in northern Cambodia?***

The answer to this question would provide a quantitative measure of the importance of these habitats. But it is much easier to ask this question than it is to answer, particularly when one considers the availability of data. Since the best quantitative data are for the Tonle Sap dai fishery, we will attempt to provide a partial answer to the question, i.e. by answering the following question:

> ***What proportion of the yield from the Tonle Sap* dai *fishery depends on deep pool refuge habitats in northern Cambodia?***

Answer:

Of the 10 most important species in the *dai* fishery of the Tonle Sap over the period 1995 to 2000 (Pengbun and Chanthoeun 2001), six have been reported to use deep pool habitats in northern Cambodia (Poulsen *et al.* 2002)[3] . These six species account for 61 percent of the catch in the *dai* fishery. Three of the remaining four species (*Dangila* spp., *Thynnichthys thynnoides* and *Osteochilus hasselti*), have also been listed as important species in the Khone Falls "tone" trap fishery and are believed to migrate from the Tonle Sap River to the Khone Falls during the dry season (Baird *et al*. 2000). They possibly also utilise deep pool habitats during the dry season. They account for another 14 percent of catches from the *dai* fishery (Pengbun and Chanthoeun 2001). Thus, 75 percent of the total catch from the *dai* fisheries depend on the availability of deep pool habitats in Northern Cambodia (i.e. Kratie to the Khone Falls and the Sesan/Srepok/Sekong catchment). As this estimate is only based on the 10 most important species from the *dai* catches, and also does not take into account any food-chain conversion of the juveniles of deep pool-dependent species, we consider this a conservative estimate.

Ideally, one would have to go through a similar process for all the other major fisheries targeting migratory fishes of the Lower Migration System in order to get a full quantification of the importance of these refuge habitats. Other critical habitats and ecosystem attributes should be assessed through similar processes. It is obvious that existing data do not allow for such a full quantification. And it is questionable whether enough data will ever be available to allow for a full valuation of resources and quantification related to ecosystem attributes. Therefore, planning and decision-making have to be based on existing data, with allowances for information gaps.

5.1.3 Application of valuation data in decision-making and assessments

Any decisions related to planning and development within the context of a large river basin will always have a large element of uncertainty. The many gaps in existing data and information identified in the previous section serve as good illustrations of this.

Even if a full valuation of migratory fishes is not possible, the information above can be used as a guide for planning purposes. It could for instance be applied within the framework of the Basin Development Plan of the MRC, together with information on other uses, and resources, of the river. It could also be incorporated into a future Strategic Environmental Assessment process under the Environment Programme.

In relation to specific development projects, the data can be used in the first screening of a project. One illustrative example is applied to the proposal to build a mainstream hydropower dam at Sambor in northern Cambodia.

[3] Three of the remaining species, *Dangila sp*., *Belodontichthys dinema* and *Thynnichthys thynnoides*, were not included in the deep pool study.

Sambor is a small village situated on the Mekong River between Kratie and Stung Treng. The village has given its name to a nearby system of rapids (the Sambor Rapids). These rapids, and associated deep pools, are important fish habitats, particularly for spawning and refuge purposes.

A small section of the Sambor Rapids, northern Cambodia.

If the Sambor hydropower project were built, its impact on migratory fish stocks would be significant because:

- the dam would change the hydrology and water levels for a significant distance upstream and downstream of the proposed dam site, including the deep pool stretch between Kratie and Stung Treng. This would eventually lead to deep pool refuge habitats filling up with sediment and disappearing.
- the dam would cut, or significantly impair, migration corridors between floodplain habitats in the south and refuge habitats in the north.
- the dam would interfere with the larval drift system, causing increased direct mortality as well as indirect mortality due to the fact that changed hydrological patterns would prevent larvae from reaching their "intended" destination.

Any proposal to build a hydropower project should incorporate the following as potential project costs:

- the value of the migratory fishery resources (including an assessment of information gaps) that will potentially be impacted by the project.
- a description and quantification of all possible impacts on the fishery, including: the blocking of fish migration and larval drift; the trapping of nutrients and sediment needed for production downstream; reductions in oxygen levels downstream; daily water level fluctuations; and effects on people's fishing activities.
- if impacts can be mitigated (e.g. through design modification, management measures and/or the inclusion of fish-ways), the cost of such mitigation measures should be incorporated into the project.

- the degree to which the above mitigation measures would be expected to reduce impacts should be assessed and taken into account (i.e. mitigation measures are rarely, if ever, able to fully eliminate adverse impacts).
- gaps in the available data should be identified, and if these gaps are seen as constraints on decision-making regarding the project proposal, a data collection programme aimed at filling the gaps should be incorporated into the proposal.

It is likely that if these additional costs were included in project proposals, some hydropower projects would be abandoned early in the screening process.

5.1.4 Lessons learned from elsewhere

It is a tremendously difficult task to steer basin-wide development in a sustainable direction. Therefore, it is important to learn as much as possible from experiences in other parts of the world.

The Kissimmee River, United States of America

The Kissimmee River is situated in south-central Florida. During the 1960s and early 1970s, the river was channelised in an effort to claim land for agricultural development. Through this process, 75 percent of the river’s floodplain area and wetland habitats were lost. This led to a significant change in the ecological structure and functioning of the river. Based on the negative impacts of the channelisation project, a restoration project was authorised in 1992 and commenced in 1999: the Kissimmee River Restoration Project. The project will take 15 years to implement and cost $US 400 million. The strategy focuses on reestablishing historic hydrologic conditions and reconnecting the river with its floodplain. Specifically, the following activities will be undertaken:

- Reestablishing historic discharge patterns from Lake Kissimmee
- Acquiring 85,000 acres of floodplain and watershed land in both the upper and lower basin
- Continuous backfilling of 22 miles of canal
- Removal of 2 water control structures
- Recarving of 9 miles of former river channel

For further information on the Kissimmee River project, see the website of the South Florida Water Management District (www.sfwmd.gov).

The Skjern River, Denmark

The Skjern River is a small river in western Denmark. In the 1960s, similar to the Kissimmee River, it was channelised, and its floodplain area drained with the main purpose of agricultural development. However, it soon became apparent that the new agricultural land was not fertile and the negative impacts of the channelisation started to emerge. Therefore, it was decided to restore part of the river to its former river channel and reestablish more than half the historic floodplain area of the river basin. The Skjern River Restauration Project was initiated in 1999 and the river works completed in 2002, at a cost of 254 million Danish Kroner (equivalent to about $US 33 million).

The main lessons from the two projects are:

- The channelisation resulted in **a range** of different negative impacts, such as a decrease in fish stocks, a decrease in other aquatic fauna, an increase in pollution (eutrophication) of aquatic ecosystems, a draining of rivers and a loss of the recreational and aesthetic values of the river basin.
- The planning process leading to the decision to channelise the rivers was based on single-sector priorities and did not take the multiple-use nature of the river basin into account.
- The planning process did not include ecological considerations and, as a consequence, the impacts which emerged after the channelisation projects was not anticipated.
- Most of the features that the restauration projects seek to restore are of similar nature to the ecosystem attributes for the Mekong River mentioned in Section 4 of this report.

These two examples illustrate a general trend in river basin development of the past: river basins were developed with little consideration for their ecological functions. Of large rivers of comparable size with the Mekong, the Mississippi River in North America and the Rhine in Europe have both suffered serious ecological problems (Arthington and Welcomme 1995). A great deal of resources and effort are now being spent to try and restore these rivers to good ecological functioning (see also, Cowx and Welcomme 1998).

It has been generally realised that rivers are more valuable when their original ecology is maintained. It would be an important achievement of the MRC and its member countries, if development could be planned and implemented without compromising the ecological integrity and productivity of the river. If that is possible, the Mekong will never need to be rehabilitated.

5.1.5 Conclusions:

As the previous section showed, there are many gaps in existing knowledge about Mekong fisheries in general, and migratory fishes in particular. Therefore, further data collection aimed at filling some of these gaps should be encouraged. On the other hand, it is also important to emphasise that development activities within the Mekong Basin will not wait until complete knowledge about the ecology of the basin is available, so existing knowledge must be used as the foundation for planning and assessment purposes, as long as the information gaps are acknowledged and taken into account in the decision-making process.

As illustrated previously in this report, we can use existing data to demonstrate, for example, that development projects could significantly decrease the quality of, or access to, dry season refuge habitats along the Kratie-Stung Treng stretch of the river. These impacts, if accounted for in estimating the cost of the project would likely mean that the project would not be economically viable. The same considerations would apply to many other proposed dam projects in the LMB.

Another important issue to emphasise is that for a large and complex ecosystem such as that of the Mekong Basin, decision-making cannot be based solely on quantitative data (e.g. fisheries yield data). Decisions should be taken within the framework of a holistic ecosystem approach where both quantitative data and qualitative information are taken into account on equal terms. In such a framework, fisheries are just one of many ecosystem services that should be considered.

The vision for the Mekong River Basin has been stated by the Mekong River Commission as: *"an economically prosperous, socially just and environmentally sound Mekong River Basin"* (MRC Strategic Plan 2001-2005). It is of course much easier to formulate such a vision than to implement it. One of the major roles of the MRC is to translate this broad vision into a number of more specific and tangible goals. This report may be seen as an attempt to formulate some suggested goals for the river from one point of view, that of the conservation and sustainable use of migratory fishes of the Mekong.

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