**Appendix 1. Small-scale sector fish catch estimates**

The methods used to estimate small-scale sector catch in Cambodia, Malaysia, Thailand, and Vietnam are briefly explained below. This is intended to provide the reader with an overview of the range of approaches, assumptions, and data sources that were used to address the lack of data on small-scale fish catches in Southeast Asia. We have not attempted to reproduce the entire methodology for each country here, as these are already explained in detail in the original reports, which are publicly available at [www.seaaroundus.org](http://www.seaaroundus.org).

*Cambodia*

Small-scale sector catch was estimated using two approaches for two distinct time periods. From 1950-1980 the catch contribution of small-scale fishers was based on fish consumption rates (Eqtn 1), and from 1981-2014, on the fishing effort of small-scale fishers (Eqtn 2). The reader is referred to Teh et al. (2014a)[[1]](#footnote-1) for a full description of the methodology, including parameter values and sources.

SSi = Pi \* Ci (Eqtn 1)

Where SS is small-scale sector catch, P is coastal population, and C is fish consumption rate in year *i*.

SSi = Fi \* CRi \* E i  (Eqtn 2)

Where SS is small-scale sector catch, F is number of fishers, CR is catch per unit effort, and E is fishing effort in year *i*.

*Malaysia*

Small-scale sector catch was based on the fishing effort of unlicensed traditional fishers. Two parameters had to be estimated – the number of unlicensed traditional fishers and the catch rate of traditional fishers. The number of unlicensed fishers was estimated by applying a ratio of unlicensed to licensed fishers, defined by a series of anchor points, in Peninsular Malaysia and Sarawak (Teh and Teh 2014)[[2]](#footnote-2), and then linearly interpolating between the anchor points. In Sabah, the average of three methods to estimate the number of traditional fishers was used (see Teh et al. 2009 for detailed methodology). The catch rate of traditional fishers was likewise defined by a series of anchor points. These anchor points included data extracted from the literature, for example, coastal fishers in Sarawak were documented to have caught an average of 1 ton of fish per year in 1948 (Porritt 1997), and in the mid 2000s an average catch rate of 3.68 t ∙fisher-1 ∙year-1 was applied in Sabah based on a case study by Teh et al. (2005). The reader is referred to Teh et al. (2009, 2011) and Teh and Teh (2014) for the full methodology.

*Thailand*

Small-scale sector catch was estimated using the fishing effort method, where a small-scale catch rate of 3 t ∙fisher-1 ∙year-1 in 2002 was used (Lunn and Dearden 2006). This catch rate was multiplied by 94,229 small-scale fishers (Lymer et al. 2008) fishing 9.5 months per year (Lunn and Dearden 2006). This yielded a total volume of catch from small-scale fishers, which was equivalent to 11% of total reported marine fish caught in 2002. In the mid-2000s, Panjarat (2008) estimated that unreported small-scale catches were equal to 16.5% of total marine fish catches. Using these data as anchor points, we added 11% of total reported catch to account for small-scale sector catch from 1998-2002, then linearly increased this percentage to 16.5% in 2005, and held it constant thereafter. Prior to 1998, 17.4% of reported total catch was added to account for small-scale sector catch. The reader is referred to Derrick et al. (2017) for a full description of the methodology, including parameter values and sources.

*Vietnam*

Small-scale sector catch was estimated by first estimating total reported and unreported marine fisheries catch from all sectors in Vietnam, then allocating a portion of this total catch to the small-scale sector. We raised reported landings by an unreported catch ratio (UR) to estimate total marine fisheries catch. We derived the UR of 1.9 by dividing a published and subsequently revised estimate of Vietnam’s marine fisheries capture in 1999 of 2.5 million t (vanZwieten et al. 2002) by reported landings in 1999 of 1.3 million t.

Allocation of total estimated marine fisheries catch to the small-scale sector was based on the following assumptions. We assumed that the industrial sector developed in earnest after 1986 with the implementation of the *doi moi* economic growth and development policy, therefore from 1950-1986 total fish catches were allocated entirely to the small-scale sector. Starting from 0% in 1986, we linearly increased the proportion of the industrial sector to a first anchor point of 37% of total catch in 1998 (Son and Thuoc 2003), and second anchor point of 60% in 2010. The reader is referred to Teh et al. (2014b)[[3]](#footnote-3) for a full description of the methodology, including parameter values and sources.

**Appendix 2. Fishmeal production parameters**

*Cambodia*

The proportion of “trash fish” out of total marine fisheries caught in Cambodian coastal waters was available from 2000 to 2010[[4]](#footnote-4) (Try and Jensen 2006) (Table A1.1):

|  |  |
| --- | --- |
| Table A1.1 Proportion of trash fish in marine fisheries of Cambodia. | |
| Year | % Trash fish |
| 2000 | 27 |
| 2001 | 26 |
| 2002 | 26 |
| 2003 | 27 |
| 2004 | 30 |
| 2005 | 30 |
| 2006 | 28 |
| 2007 | 32 |
| 2008 | 32 |
| 2009 | 31 |
| 2010 | 34 |

We pulled back the 2000 starting anchor point of 27% to 1965, the year we started accounting for the industrial fishing sector in Cambodia, and carried forward the 2010 anchor point to 2013. A fishmeal factory started operating in the coastal province of Kampot in 1990[[5]](#footnote-5). Before the opening of this factory, we assumed that similar to neighbouring Vietnam, 50% of low value fish was being processed into fishmeal. From 1990 to 2013, we apportioned 75% of low value fish to fishmeal based on marine fish end use analysis presented in (Cashion 2016). We linearly interpolated between the starting anchor point of 50% in 1965 to the second anchor point in 1990.

*Malaysia*

Values for % trawl (% of catch caught by trawl nets) and % LVF*trawl*(% of trawl catch that is LVF) were derived as follows. Anchor points for the proportion of total catch caught by trawl nets (% trawl) were extracted from Annual Fisheries Statistics published by the Department of Fisheries (Department of Fisheries 2016) (Table A1.2). For each of the following years, the proportion of reported landings caught by trawl nets in Peninsula Malaysia was:

|  |  |  |
| --- | --- | --- |
| Table A1.2 Percentage of total fish catch caught by trawl nets | | |
| Year | Trawl catch % | |
| 1965 | | 6.6 |
| 1970 | | 29 |
| 1978 | | 51 |
| 1985 | | 41 |
| 1995 | | 54 |
| 2004 | | 56 |
| 2010 | | 50 |

The % of trawl catch that was comprised of low value fish in 1970, the first year for which data on fish catch composition by gear was available, was 49%. We carried back this percentage to 1964, the year we started accounting for industrial fishing, then linearly interpolated from 1970 to the next anchor points of 84% in 1985, 91% in 1999 and 87% in 2010. The anchor point in 2010 was carried forward to 2013. Low value fish were fish categorised in Annual Fisheries Statistics as ‘Grade III’, ‘Manure fish’ (*Ikan baja*), and/or ‘Mixed fish (*Ikan campur*).

We assumed the proportion of LVF that is used for fishmeal mirrored the quantity of fish catch that was processed into fishmeal and manure fish, as extracted from Annual Fisheries Statistics (Department of Fisheries 2016). The anchor points for this parameter were 47% in 1970; 69% in 1978; 53% in 1988; 57% in 1999; and 54% in 2000.

*Thailand*

Anchor points for the percentage of marine capture fisheries landed by trawl nets *(*% trawl) were 56% in 1982; 59% in 1997; and 67% in 2004 (Lymer et al. 2008). As we were unable to locate data from earlier years, we carried back the 1982 value to 1962, the year we started accounting for industrial fishing in Thailand, and maintained the 2004 proportion of 67% to 2013. All gap years were filled by linearly interpolating between anchor points. In the early years of trawling, around 40% of trawl catches consisted of “trash fish” (Butcher 2004). We applied this value as the starting anchor point of % LVF*trawl* in 1962 to calculate the quantity of low value fish in trawl catches. In 2004, low value fish (categorised as “other food fish” and “trash fish”) made up approximately 64% of total catches landed by pair trawls in Thailand (Lymer et al. 2008). We filled % LVF*trawl* data gaps by linearly interpolating between these two anchor points and maintained the 2004 anchor point to 2013.

Data on the quantity of trash fish used for fishmeal production were available from 1987 to 2004 (Lymer et al. 2008). According to (Butcher 2004), the bulk of “trash fish” from trawlers in the early years of trawling was processed into fishmeal to feed chickens and other animals. We interpreted this statement to mean that at least 75% of low value fish was processed into fishmeal, and made this the starting anchor point. We then linearly interpolated to the next anchor point of 97% in 1987, and carried forward the 2004 value of 93% to 2013.

*Vietnam*

There was little data on catch by gear from Vietnam. In 1997, total fish catch caught by trawl nets averaged 43% across the country (Long 2003), and increased to 75% in 2010 (Sinh and Long 2011).We carried forward the 2010 anchor point to 2013, and pulled back the 1997 anchor point to 1987, the year we started accounting for industrial fishing. Data gaps between anchor points were filled using linear interpolation.

The proportion of low value fish in trawl catches was maintained at 70% from 1994 to 2013 (Edwards et al. 2004). Due to lack of data, we halved this value to derive a starting anchor point of 35% in 1987, based on a statement that trash fish used to comprise only 30-40% of the catch from trawling (Edwards et al. 2004). About half of the total annual trashfish landed in Vietnam is used for fishmeal processing[[6]](#footnote-6). We thus applied 50% as the proportion of low value fish used for fishmeal from 1987 to 2013.

**Appendix 3. Total reported and reconstructed fish catch, 1950-2013**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Table A2. Reported landings and reconstructed catches for Cambodia, Malaysia, Thailand, and Vietnam, 1950-2013. | | | | | |
|  | Reported | Reconstructed catches | | | |
| Year | Landings | Industrial | Artisanal | Subsistence | Discards |
| 1950 | 319,039 | 418 | 236,228 | 471,653 |  |
| 1951 | 318,001 | 311 | 238,579 | 477,082 |  |
| 1952 | 312,732 | 311 | 251,005 | 481,262 |  |
| 1953 | 309,338 | 311 | 249,169 | 485,945 |  |
| 1954 | 389,608 | 311 | 266,834 | 609,637 |  |
| 1955 | 417,766 | 311 | 276,814 | 707,539 |  |
| 1956 | 436,927 | 311 | 285,595 | 738,414 |  |
| 1957 | 465,704 | 232 | 297,785 | 770,456 |  |
| 1958 | 484,567 | 232 | 322,961 | 825,349 |  |
| 1959 | 529,025 | 232 | 340,460 | 906,384 |  |
| 1960 | 636,003 | 243 | 386,767 | 1,061,817 |  |
| 1961 | 737,349 | 308 | 415,174 | 1,079,632 |  |
| 1962 | 869,134 | 28,067 | 464,142 | 1,221,860 | 352 |
| 1963 | 1,007,185 | 67,997 | 545,079 | 1,343,075 | 27,355 |
| 1964 | 1,182,178 | 237,130 | 573,970 | 1,380,341 | 43,082 |
| 1965 | 1,250,031 | 542,500 | 595,876 | 1,361,088 | 232,958 |
| 1966 | 1,353,701 | 684,238 | 627,993 | 1,346,821 | 264,355 |
| 1967 | 1,579,679 | 794,557 | 674,135 | 1,345,179 | 283,547 |
| 1968 | 1,817,119 | 983,100 | 689,117 | 1,336,263 | 338,120 |
| 1969 | 1,964,100 | 1,075,944 | 663,807 | 1,318,919 | 349,942 |
| 1970 | 1,922,775 | 1,259,759 | 632,325 | 1,373,463 | 358,105 |
| 1971 | 2,118,553 | 1,521,743 | 667,207 | 1,381,215 | 377,275 |
| 1972 | 2,242,607 | 1,693,884 | 667,555 | 1,363,426 | 371,347 |
| 1973 | 2,297,124 | 1,769,034 | 691,645 | 1,322,843 | 327,649 |
| 1974 | 1,944,314 | 1,762,167 | 666,615 | 1,215,152 | 281,542 |
| 1975 | 1,853,466 | 1,787,573 | 645,467 | 1,138,141 | 263,204 |
| 1976 | 1,980,201 | 1,996,146 | 706,640 | 1,216,712 | 265,024 |
| 1977 | 2,403,704 | 2,213,697 | 857,389 | 1,349,212 | 334,393 |
| 1978 | 2,350,289 | 2,278,058 | 877,769 | 1,292,258 | 301,292 |
| 1979 | 2,223,560 | 2,225,972 | 848,924 | 1,235,113 | 262,269 |
| 1980 | 2,037,837 | 2,091,354 | 866,716 | 1,170,219 | 226,740 |
| 1981 | 2,232,049 | 2,198,827 | 944,883 | 1,217,145 | 236,521 |
| 1982 | 2,316,737 | 2,228,941 | 975,892 | 1,300,289 | 232,661 |
| 1983 | 2,473,462 | 2,189,221 | 1,069,326 | 1,417,279 | 247,768 |
| 1984 | 2,327,515 | 2,038,697 | 1,024,684 | 1,342,576 | 228,572 |
| 1985 | 2,352,619 | 2,001,222 | 1,077,545 | 1,365,474 | 226,018 |
| 1986 | 2,616,440 | 2,127,169 | 1,154,338 | 1,415,326 | 256,838 |
| 1987 | 2,917,175 | 2,459,533 | 1,204,691 | 1,411,363 | 298,578 |
| 1988 | 2,795,674 | 2,445,886 | 1,145,459 | 1,300,631 | 294,763 |
| 1989 | 2,929,261 | 2,623,228 | 1,207,436 | 1,292,904 | 309,928 |
| 1990 | 3,079,035 | 2,785,121 | 1,204,951 | 1,239,930 | 324,666 |
| 1991 | 3,190,283 | 3,043,822 | 1,231,296 | 1,242,933 | 298,600 |
| 1992 | 3,549,965 | 3,393,935 | 1,349,704 | 1,254,715 | 336,472 |
| 1993 | 3,714,555 | 3,556,463 | 1,382,984 | 1,240,919 | 346,438 |
| 1994 | 3,994,235 | 3,808,979 | 1,495,579 | 1,327,075 | 377,121 |
| 1995 | 4,170,807 | 4,060,280 | 1,552,293 | 1,304,052 | 391,096 |
| 1996 | 4,091,644 | 3,977,566 | 1,575,700 | 1,255,963 | 370,404 |
| 1997 | 3,968,625 | 3,824,041 | 1,610,273 | 1,217,551 | 332,358 |
| 1998 | 3,886,820 | 3,908,939 | 1,642,082 | 1,211,261 | 317,142 |
| 1999 | 4,159,221 | 4,133,215 | 1,823,504 | 1,268,303 | 326,543 |
| 2000 | 4,357,850 | 4,193,772 | 1,925,628 | 1,249,211 | 312,007 |
| 2001 | 4,288,615 | 4,219,263 | 1,719,169 | 1,107,368 | 323,817 |
| 2002 | 4,372,305 | 4,335,290 | 1,615,164 | 1,016,047 | 335,559 |
| 2003 | 4,484,113 | 4,434,978 | 1,739,736 | 987,518 | 350,465 |
| 2004 | 4,484,881 | 4,465,627 | 1,684,063 | 916,727 | 361,167 |
| 2005 | 4,445,012 | 4,378,982 | 1,771,629 | 898,388 | 374,200 |
| 2006 | 4,541,447 | 4,333,756 | 1,990,874 | 914,389 | 388,377 |
| 2007 | 4,412,756 | 4,334,695 | 1,711,088 | 769,823 | 394,648 |
| 2008 | 4,693,271 | 4,442,134 | 1,898,881 | 778,131 | 417,126 |
| 2009 | 4,864,722 | 4,504,318 | 1,831,708 | 728,231 | 432,164 |
| 2010 | 5,000,141 | 4,589,832 | 1,828,980 | 683,224 | 446,168 |
| 2011 | 5,201,762 | 4,774,908 | 1,902,730 | 710,774 | 464,158 |
| 2012 | 5,324,946 | 4,887,983 | 1,947,789 | 727,606 | 475,150 |
| 2013 | 5,650,670 | 5,186,979 | 2,066,934 | 772,113 | 504,215 |

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