# INTER-AMERICAN TROPICAL TUNA COMMISSION

# UPDATED SCIENTIFIC REPORT ON THE STATUS OF DOLPHIN STOCKS IN THE EASTERN PACIFIC OCEAN

## APRIL 2015

In September, 2002, the Southwest Fisheries Science Center issued a NMFS Scientific Report to the Secretary of Commerce that summarized the results of studies that would bear upon the Secretary's decision whether or not to change the U.S. definition of "dolphin-safe" tuna. The IATTC presented the Secretary a IATTC Scientific Report with data and conclusions of its own to respond to those raised in the SWFSC Report.

The NMFS report expressed concerns that "the practice of chasing and encircling dolphins somehow is adversely affecting the ability of these depleted stocks to recover." However, its data showed that these dolphin stocks were slowly increasing, and that, if their recovery was being hindered, the cause was not related to the fishery. The SWFSC report argued that the stocks were not recovering at an "expected" rate, and that a plausible explanation for this was unobserved mortality due to the fishery, In response, the IATTC Report stated that the NMFS Report

> "emphasizes only evidence that there may be an impact from the fishery, and discounts evidence that there is not, and relies on highly-speculative assumptions about what was and is taking place. Moreover, its conclusions are based on a small amount of data, which, as the report itself admits, cannot be used to draw reliable inferences on population levels. The data in the report that suggest that fishing is not having a significant adverse impact were largely ignored. In any case, the SWFSC conclusion that some unobserved mortality is the reason for low population growth rates requires that the unobserved mortality be more than 20 times (2,000 percent) the observed mortality. It is highly unlikely that this could be the case. Further, the results from the abundance surveys undertaken by the SWFSC indicate that the dolphin stocks have been stable or increasing for more than 20 years."

The IATTC Report concluded:

> "The best available scientific evidence supports the conclusion that the purse-seine fishery is not having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean, specifically that the intentional deployment on or encirclement of dolphins with purse seine nets is not having a significant adverse impact on any depleted dolphin stock in the eastern tropical Pacific Ocean. This evidence does not support a finding that the purse-seine fishery is having a significant adverse impact on any dolphin stock in the eastern tropical Pacific Ocean. This statement is based on the information presented in the SWFSC report, and our independent analyses of the status of dolphin stocks and observations of their interactions with the tuna fishery over the last 30 years."

Although little or no weight was given to the IATTC Report by Dr. Hogarth, the decision maker delegated by the Secretary, he did conclude that there was indeed no significant adverse impact and that the "dolphin-safe" definition could be changed to match that of the definition used under the AIDCP (Taking and Importing of Marine Mammals, 68 Fed. Reg. 2010-17; Jan. 15, 2003).

A U.S. Court decision, however, overturned this finding in 2004, arguing that "the best science that was available, while not conclusive, indicated that dolphins were adversely impacted by the fishery" and that the NMFS had failed to complete the necropsy study mandated by the U.S. Congress, a decision that was affirmed on appeal in 2007 (9th U.S. Court of Appeals, 484 F.3d 1123).

Since the NMFS and IATTC Reports were written, new research studies have been conducted, particularly on dolphin abundance and trends and the swimming dynamics of dolphin mothers and calves. This document will describe the research conducted since the 2002 Final Finding and discuss how these new results compare with previous data and conclusions.

**Abundance and Trends**

*1998-2000 NMFS surveys.* From abundance estimates generated from surveys conducted in 1986-1990 and 1998-2000, the NMFS showed that populations of northeastern spotted dolphins and eastern spinner dolphins were increasing slowly, with northeastern offshore spotted (N = 641,153, CV = 0.17) and eastern spinner dolphins (N = 448,608, CV = 0.23%) growing at rates of 1.7% and 1.4% per year, respectively. A more complex two-stage interpretation of the abundance estimates indicated an increase in the two stocks during the late 1980s, but declines or stability during the 1990s. The NMFS interpreted this as a "failure to recover" because the increases were not statistically significant and because it was assumed that these populations should be growing at a maximum rate for delphinids, a rate thought to be 4% (Gerrodette and Forcada, 2005; Reilly *et al.* 2005; Wade *et al.* 2007). Because the growth rate was not 4%, the NMFS argued that there must be significant hidden fishery-related mortality that is hindering the recovery of these populations, and that this hidden mortality was related to fishing effort on tuna associated with dolphins ("dolphin sets").

The IATTC argued that no dolphin population has been known to increase at a rate that high and that the temporal pattern in dolphin sets would exclude the fishery as a cause of the presumed lack of recovery. The IATTC noted that

> "For the period 1979-2000, the largest research survey estimates of abundance of the stocks of north-eastern offshore spotted and eastern spinner dolphins (1988-89) occurred just after the highest estimates of fishery mortality (1985-87) and the greatest numbers of sets on dolphin-associated tuna. During the late 1980s and early 1990s the mortalities of dolphins due to the fishery declined dramatically, and the number of dolphin sets (the presumed cause of any hypothetical unobserved mortality) declined by about 25%, and yet the dolphin populations declined or remained stable. It is difficult to explain how the dolphin populations could flourish when subjected to high mortalities and yet decline as the fishing pressures eased if setting on dolphins were having an adverse impact. The SWFSC abundance data demonstrate that, even if the populations are not currently increasing rapidly, it is not because the fishery is responsible for this."

The SWFSC tested its population dynamics models against three separate hypotheses of actual mortality: 1) that the actual mortality is the observed mortality, 2) that the actual mortality is 150% of the observed mortality, and 3) that the actual mortality is 200% of the observed mortality. Of the three, the hypothesis that fit best with the population models was the actual mortality observed in the fishery. While the preference was slight, the IATTC Report argued that "it clearly demonstrates the speculative leap required to reach the conclusion that SWFSC appears to believe likely, that is, that the actual mortality is more than 20 times [2,000 percent] than observed, or 14,400 offshore spotted dolphins and 11,300 eastern spinner dolphins."

A more-recent study (Wade *et al*. 2007) found little or no difference among models testing the effects of different degrees of mortality, population growth rates, and carrying capacities.

*2003 NMFS survey.* An additional survey was conducted by the NMFS in 2003 and the preliminary estimates calculated for northeastern spotted dolphins (N = 737,000, CV = 0.15) and eastern spinner dolphins (N = 613,000, CV = 0.22) were both higher than previous estimates. The preliminary growth rates were 0.6% for northeastern spotted dolphins and 1.1% for eastern spinner dolphins (Gerrodette *et al*. 2005). The two-stage growth rate model was found to be an invalid interpretation of the data. Again, the growth rates were not statistically different from zero, but the authors stated that "the higher preliminary 2003 estimates are encouraging, it would be premature to conclude that the populations are now beginning to recover."

The authors concluded:

> "Nevertheless, the preliminary estimates have influenced our perceptions of the status of these stocks. Wade *et al*. (2002) found that a model indicating a decline in eastern spinner dolphins was slightly more supported by the data than a model indicating a slight increase in recent years. With the 2003 abundance estimates, such a model would probably not be supported for eastern spinner dolphins, and this causes us to be more optimistic about the status of this stock than previously. Gerrodette and Forcada (2005) suggested that a possible explanation of non-recovery is a delay due to intra- and interspecific effects on dolphin population dynamics. There is uncertainty about the rates at which these stocks should recover, and more sophisticated modeling, using other data in addition to the population estimates (Wade *et al.* 2002, Hoyle and Maunder 2004), is needed to improve our assessments of these stocks. Further monitoring will be necessary to reveal whether the higher, 2003 estimates are statistical noise, or whether the populations of NE offshore spotted and eastern spinner dolphins are beginning to recover."

*2006 NMFS survey.* During the analysis of the 2006 survey results it was discovered that a programming error had resulted in the underestimation of previous calculations of abundances for eastern and whitebelly spinner dolphins and northern common dolphins (Gerrodette *et al.* 2008). The most-recent estimates (2006) of abundance for northeastern offshore spotted dolphins (N = 857,884, CV = 0.23) and eastern spinner dolphins (N = 1,062,879, CV = 0.26) are higher than previous estimates (see also Table 1).

The growth rates were still modest over the 1986-2006 time period, with the northeastern spotted dolphins increasing at a rate of 1.0% and the eastern spinners dolphins increasing at a rate of 1.9%, however authors concluded that more-recent data showed:

> "Over the 8-year period from 1998-2006 when reported dolphin bycatch was at low levels relative to population sizes, all 3 of the officially depleted dolphin stocks (coastal and northeastern offshore spotted and eastern spinner dolphins)

were estimated to be growing at rates considered to be near the 4-8% maximum possible for dolphins …"

However, there was a corresponding decline in the abundance of the western/southern spotted dolphins, possibly indicating that the increase in the northeastern spotted dolphins could be a result of movements across the current geographic stock boundaries (Dizon *et al*. 1994).

**TABLE 1.** Abundance estimates (*N*) and coefficients of variation (CV) based on the 2006 NMFS survey (Gerrodette *et al.* 2008).

| Species and stock | *N* | *CV* |
|---|---|---|
| **Spotted dolphin (*Stenella attenuata*)** | | |
| Northeastern | 857,884 | 0.23 |
| Western/Southern | 439,208 | 0.29 |
| **Spinner dolphin (*Stenella longirostris*)** | | |
| Eastern | 1,062,879 | 0.26 |
| Whitebelly | 734,837 | 0.61 |

The IATTC staff used a logistics model with data from NMFS abundance estimates and IATTC mortality estimates to calculate growth rates, abundance estimates, and minimum abundance estimates that are the basis of Stock Mortality Limits used to manage dolphin populations (IATTC Scientific Advisory Board document SAB-07-05; October 2009; Table 2). The abundance estimate projected to 2010 for northeastern spotted dolphins is 911,177 (CV = 0.15) and for eastern spinner dolphins is 790,613 (CV = 0.18). The growth rate for both stocks is 2.0%.

**TABLE 2.** Abundance estimates (*N*) for 2010, minimum abundance estimates (*Nmin*), and stock mortality limits (SML = 0.1% of *Nmin*) (from IATTC Scientific Advisory Board document SAB-07-05; October 2009).

| Species and stock | *N* | *CV* | *Nmin* | SML |
|---|---|---|---|---|
| **Spotted dolphin** | | | | |
| Northeastern | 911,177 | 0.15 | 793,466 | 793 |
| Western/Southern | 911,830 | 0.08 | 881,256 | 881 |
| **Spinner dolphin** | | | | |
| Eastern | 790,613 | 0.18 | 655,562 | 655 |
| Whitebelly | 711,883 | 0.11 | 666,852 | 666 |

No surveys have been conducted in the eastern tropical Pacific since 2006 due to a lack of shiptime and funding. Lennert-Cody *et al*. (in review) has compiled different alternatives to assess population abundance and trends in the future.

One of the assumptions for line-transect abundance estimation is that animals directly on the trackline are always detected, even in poor sighting conditions. This assumption had been found to be true for large schools of dolphins Barlow (1995). However, a new study by Barlow (in press) based on more data showed that abundance estimates are underestimated by a significant amount even for large schools and even in relatively calm sea states. Although it is not possible currently to predict the recalculated abundance trends, it is likely that recalculated abundances will be significantly higher.


Barlow, J. In press. Inferring trackline detection probabilities, g(0), for cetaceans from apparent densities in different survey conditions. Marine Mammal Science.

Dizon, A. E., W. F. Perrin, and P. A. Akin. 1994. Stocks of dolphins (*Stenella* spp. and *Delphinus delphis*) in the eastern tropical Pacific: A phylogeographic classification. NOAA Technical Report NMFS-119.

Gerrodette, T. and J. Forcada. 2005. Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. Marine Ecology Progress Series 291: 1-21.

Gerrodette, T., G. Watters, and J. Forcada. 2005. Preliminary estimates of 2003 dolphin abundance in the eastern tropical Pacific. SWFSC Admin. Rep. LJ-05-05. 26 p.

Gerrodette, T., G. Watters, W. Perryman, and L. Ballance. 2008. Estimates of 2006 dolphin abundance in the eastern tropical Pacific, with revised estimates from 1986-2003. NOAA Tech. Memo. NMFS-SWFSC-422.

Hoyle, S.D., and M.N. Maunder. 2004. A Bayesian integrated population dynamics model to analyze data for protected species. Animal Biodiversity and Conservation 27.1:247-266.
Lennert-Cody, C.E., M.N. Maunder, P.C. Fiedler, M. Minami, T. Gerrodette, J. Rusin, C. Minte-Vera, M. Scott, S.T. Buckland. In review. Purse-seine vessels as platforms for monitoring the population status of dolphin species in the eastern tropical Pacific Ocean.

Reilly, S.B., M.A. Donahue, T. Gerrodette, K. Forney, P. Wade, L. Balance, J. Forcada, P. Fiedler, A. Dizon, W. Perryman, F.A. Archer, and E.F. Edwards. 2005. Report of the scientific research program under the International Dolphin Conservation Program Act. NOAA Tech. Memo. NMFS-SWFSC-372, 101 p.

Wade, P. R. 2002. 2002. Assessment of the population dynamics of the northeastern offshore spotted and the eastern spinner dolphin populations through 2002. SWFSC Admin. Rep. LJ-02-13, 58 p.

Wade, P.R., G.M. Watters, T. Gerrodette, and S.B. Reilly. 2007. Depletion of spotted and spinner dolphins in the eastern tropical Pacific: modeling hypotheses for their lack of recovery. Marine Ecology Progress Series 343:1-14.


**Observed Mortality**

Both the NMFS and IATTC Reports agreed that recent observed mortality estimates were well below the levels that are considered sustainable. Because of the difference between the observed and expected population growth rates, the NMFS Report speculated that there must be additional mortality occurring that is not reported by observers.

The observed mortality continues to be low, typically about 1000 dolphins per year (IATTC 2009). The IATTC has developed a data-screening procedure to identify unusual dolphin mortality (Lennert-Cody and Berk 2007). This procedure is being applied annually to the data of the IATTC, and on a voluntary basis to data of the national observer programs. IATTC and NMFS staffs also initiated a sampling program to monitor the unloadings of purse-seine vessels of less than 363 tons of carrying capacity and found that any dolphin mortality caused by small purse seiners are unlikely to be substantially affecting trends in dolphin abundance (Lennert-Cody *et al.* 2013).

IATTC. 2009. Annual Report of the Inter-American Tropical Tuna Commission 2007. La Jolla, CA.

Lennert-Cody, C.E., and R.A. Berk. 2007. Statistical learning procedures for monitoring regulatory compliance: an application to fisheries data. Journal of the Royal Statistical Society Series A 170:1–19.

Lennert-Cody, C.E., J.D. Rusin, M.N. Maunder, E.H. Everett, E.D. Lagarcha Delgado, and P.K. Tomlinson. 2013. Studying small purse-seine vessel fishing behavior with tuna catch data: Implications for eastern Pacific Ocean dolphin conservation. Marine Mammal Science 29(4):643-688.

**Potential unobserved mortality**

The NMFS Report discussed possible sources of unreported mortality: the observer's inability to see everything during the set, observer corruption, mortality caused by smaller purse seiners that are not observed, and mortalities that occurred outside the net due to the delayed effects of stress, or the mortality of calves separated from their mothers during the chase.

NMFS population models, however, did not support the notion that additional mortality was occurring, and any additional hidden mortality of orphaned calves was inconsequential and sustainable by the population. The SWFSC Report presented the results of three population dynamics models that assumed: 1) that the actual mortality was the observed mortality, 2) that the actual mortality was 150% of the observed mortality, and 3) that the actual mortality was 200% of the observed mortality. Of the three, the hypothesis that fit best with the population models was the actual mortality observed in the fishery. The IATTC Report noted that this "clearly demonstrated the speculative leap required to reach the conclusion that SWFSC appears to believe likely, that is, that the actual mortality is more than 20 times [2,000 percent] that observed, or 14,400 offshore spotted dolphins and 11,300 eastern spinner dolphins."

*Potential mortality of orphaned calves.* Archer *et al*. (2001; 2004) did report the mortalities of lactating mothers without associated calves, leading to the conclusion that many of these orphaned calves subsequently die. They calculated that mortality could be underestimated by 10-15% for spotted dolphins and 6-10% for spinner dolphins. The IATTC Report calculated an additional potential annual mortality of less than 120 dolphins due to this cause.

Archer, F.T. Gerrodette, A. Dizon, K. Abella, and S. Southern. 2001. Unobserved kill of nursing calves in the tuna purse-seine fishery. Marine Mammal Science 17(3):540-554.

Archer, F.T. Gerrodette, S. Chivers, and A. Jackson. 2004. Annual estimates of the unobserved incidental kill of pantropical spotted dolphin (*Stenella attenuata attenuta*) calves in the tuna purse-seine fishery in the eastern tropical Pacific. Fishery Bulletin 102:233-244.

*Cow-calf separation*. The NMFS Report also speculated that mothers and calves might become separated[1] during the chase, that calf mortality might result. While there was no evidence that mothers abandoned their calves prior to a set, and some evidence against it, it was speculated that this unobserved mortality might be responsible for the difference between the observed annual population growth rates of 1.7% for spotted dolphins and 1.4% for spinner dolphins and the 4% growth rate.

Since 2002, this has been a particularly active area of research. Studies have examined the spatial relationship between mothers and newborn calves, and the potential energetic costs to a mother of swimming in close association with a calf (Weihs 2004; Edwards 2006; Noren *et al*. 2006; 2008; Weihs *et al*. 2006; Noren and Edwards 2007; 2011; Noren 2008; 2013). These studies indicate that newborn calves (less than a month old) would be the most vulnerable to separation from their mother, and calves less than a year old would be at risk. The crucial question of "Would a mother abandon its calf during a chase?" still remains unanswered, however.

Ongoing research by the NMFS has expanded this topic to examine potential fetal mortality caused by fishery operations. Archer *et al*. (2010) also presented a method for estimating the exposure of dolphins to fishing operations.

Archer, F.I., J.V. Redfern, T. Gerrodette, S.J. Chivers, W.F. Perrin. 2010. Estimation of relative exposure of dolphins to fishery activity. Marine Ecology Progress Series 410:245-255.

Edwards, E.F. 2006. Duration of unassisted swimming activity for spotted dolphin (*Stenella attenuata*) calves: Implications for mother-calf separation during tuna purse-seine sets. Fishery Bulletin 104:125-135.

Noren, S. R. 2008. Infant carrying behaviour in dolphins: Costly parental care in an aquatic environment. Functional Ecology 22(2):284–288.

Noren, S.R., G. Biedenbach, and E.F. Edwards. 2006. Ontogeny of swim performance and mechanics in bottlenose dolphins (*Tursiops truncatus*). Journal of Experimental Biology 209:4724-4731.

Noren, S.R. and E.F. Edwards. 2007. Physiological and behavioral development in delphinid calves: Implications for calf separation and mortality due to tuna purse-seine sets. Marine Mammal Science 23(1):15-29.

S.R. Noren, G. Biedenbach, J.V. Redfern, E.F. Edwards. 2008. Hitching a ride: the formation locomotion strategy of dolphin calves. Functional Ecology 22(2):278–283.

Noren, S.R., E.F. Edwards. 2011. Infant position in mother–calf dolphin pairs: A social

[1] Dolphin calves typically swim in their mother's slipstream, allowing the calf to keep pace with relatively little effort. If the calf falls out of this "drafting" position, it is argued, there is a possibility that it could no longer keep up with the mother unless the mother slows down.

interaction with hydrodynamic benefits. Marine Ecology Prog Series 424: 229−236

S.R. Noren. 2013. Altered swimming gait and performance of dolphin mothers: Implications for interactions with tuna purse-seine fisheries. Marine Ecology Progress Series 482:255–263.

Weihs, D. 2004. Hydrodynamic of dolphin drafting. Journal of Biology 3:1-23.

Weihs, D., M. Ringel, and M. Victor. 2006. Aerodynamic interactions between adjacent slender bodies. AIAA Journal 44(3):481-484.

*Physiological stress.* Mammalian stress responses, with a focus on dolphins associated with the tuna purse-seine fishery were reviewed by Curry and Edwards (1998) and updated by St. Aubin (2002a). The NMFS Report summarized the case for physiological stress having a significant adverse impact on dolphin populations:

> "However, in the aggregate, the findings from the available data *support the possibility* that tuna purse-seining activities involving dolphins *may have* a negative impact on *some* individuals. [italics added for emphasis] Some evidence was found for potential stress-related injury or unobserved mortality of dolphins involved in purse seine fishing operations, based on the combined documentation of: (a) moderately elevated stress hormones and enzymes indicative of muscle damage observed in live dolphins examined in the nets; (b) evidence of past (healed) muscle and heart damage in dolphins killed during fishing operations; and (c) fatal heart damage in virtually all fishery-killed dolphins, which most likely was related to elevated catecholomines. The responses observed in the samples of live animals were well within those ranges from which dolphins are expected to recover fully; however, it is possible that some dolphins may experience stronger responses, such as during occasional 'catastrophic' aspects of fishery operations when dolphins may become trapped under a canopy in the net."

The IATTC Report argued:

> "this heavily-qualified conclusion is so laden with uncertainties that a finding of significant adverse impact cannot be based on it. The conclusion is based on a mixture of data and speculation. But the data cited (as opposed to the speculation) do not support a finding of significant adverse impact. On the contrary, all the data mentioned indicate that no significant adverse impact is occurring. The stress hormones and enzymes are at levels from which the dolphins would fully recover from chase and encirclement; the healed heart and muscle lesions are not life-threatening and are commonly seen in dolphins in the wild that are not associated with the purse-seine fishery. Thus they cannot be attributed with any certainty to purse-seine fishery interactions (Cowan and Curry 2002), nor assumed to result in the stress-related mortality of dolphins. The rest of this conclusion is based on speculation."

A study of the lymphoid organs conducted as part of the SWFSC Necropsy Program (Romano *et al.* 2002a) showed no signs of stress or of a compromised immune system. Analyses of the blood collected from dolphins captured during the CHESS studies were largely equivocal

(Forney *et al.* 2002, Romano *et al.* 2002b, St. Aubin 2002b, St. Aubin *et al.* 2013). St. Aubin *et al*. (2013) found that "chase and encirclement of dolphins by a tuna purse seiner results in a measurable stress response typical of odontocetes" but that "there were remarkably few changes in blood parameters in recaptured dolphins." The blood analyses also contradicted the suggestion that capture myopathy was occurring because recaptured dolphins had lower values of the muscle-specific enzyme CK, rather than the higher values that would be encountered if capture myopathy were occurring (Forney *et al*. 2002).

Cowan, D. F., and B. E. Curry. 2002. Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical Pacific tuna fishery. SWFSC Admin. Rep., La Jolla, LJ-02-24C, 31 p.

Curry, B.E., and E.F. Edwards. 1998. Investigation of the Potential Influence of Fishery-Induced Stress on Dolphins in the Eastern Tropical Pacific Ocean: Research Planning. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-254, 71 pp.

Forney, K.A., D.J. St. Aubin, and S.J. Chivers. 2002. Chase Encirclement Stress Studies on dolphins involved in eastern tropical Pacific Ocean purse seine operations during 2001. SWFSC Admin. Rep., La Jolla, LJ-02-32, 27 p.

Romano, T., K. Abella, D. Cowan, and B. Curry. 2002a. Investigation of the morphology and autonomic innervation of the lymphoid organs in the pantropical spotted, spinner, and common dolphins (*Stenella attenuata*, *Stenella longirostris* and *Delphinus delphis*) incidentally entangled and drowned in the tuna purse-seine fishery in the eastern tropical Pacific. SWFSC Admin. Rep., La Jolla, LJ-02-25C, 25 p.

Romano, T., M. Keogh, and K. Danil. 2002b. Investigation of the effects of repeated chase and encirclement on the immune system of spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific. SWFSC Admin. Rep., La Jolla, LJ-02-35C, 37 p.

St. Aubin, D.J. 2002a. Further assessment of the potential for fishery-induced stress on dolphins in the eastern tropical Pacific. SWFSC Admin. Rep., La Jolla, LJ-02-23C, 13 p.

St. Aubin, D.J. 2002b. Hematological and serum chemical constituents in pantropical spotted dolphins (*Stenella attenuata*) following chase and encirclement. SWFSC Admin. Rep., La Jolla, LJ-02-37C, 49 p.

St. Aubin, D.J. K.A. Forney, S.J. Chivers, M.D. Scott, K. Danil, T.A. Romano, R.S. Wells and F.M.D. Gulland. 2013. Hematological, serum, and plasma chemical constituents in pantropical spotted dolphins (*Stenella attenuata*) following chase, encirclement, and tagging. Mar. Mammal. Sci. 29(1):14-35.

*Thermal stress.* One of the CHESS studies examined the thermal stress that may be caused by chasing prior to encirclement (Pabst *et al.* 2002). They measured deep-core temperatures along with surface temperatures and heat flux from the dorsal fins of the dolphins (the dorsal fin functions as a radiator to release excess heat). None of these measurements showed any indications that adverse impacts due to heat stress were occurring.

Data for one spotted dolphin ("the hotter spotter"), however, were puzzling. It had displayed the highest deep-body temperature, yet it had been involved in the shortest chase of the study (12 min from the time the helicopter first flew over the herd to let go of the net), which occurred 1.8 hours prior to the thermal measurements. The most likely explanation was that the temperature reading was an artifact of the research activities, the chasing by swimmers in order to capture and sample the dolphins. This particular dolphin endured the longest chase by the swimmers (24 min) of any of the sampled dolphins. The IATTC argued that the most parsimonious explanation was that the higher temperature of this dolphin was a short-term effect of the research activities (the 24-min chase by the swimmers) immediately prior to the thermal measurements rather than an effect of the fishing operation (the 12-min chase) that was almost two hours prior to the temperature measurements.

NMFS, however concluded that the "hotter spotter" could "represent an anomaly or an indication that this individual may have been more prone to overheating following a prolonged chase." In doing so, the NMFS ignored the field data that showed that the chase was not a prolonged one (in fact the shortest chase of the entire cruise) and that the research activities were a more proximate cause for the higher temperature, and consistently ignored the IATTC's arguments. The effect of the "hotter spotter" was exaggerated even further when, in an Expert Opinion submitted to the NMFS and in a Declaration submitted to the US Ninth Court of Appeals, Dr. Robert Hofman (formerly of the U.S. Marine Mammal Commission) conjectured that as many as 9,500 dolphin mortalities could be occurring due to thermal stress caused by chase and encirclement by the tuna purse-seine fishery.

Since then, technical papers on the research methods used to study thermal regulation in the CHESS study have been published (Meagher *et al*. 2002; Westgate *et al*. 2007; Barbieri *et al.* 2010).

Barbieri, M.M., W.A. McLellan, R.S. Wells, J.E. Blum, S. Hofman, J. Gannon, D.A. Pabst. 2010. Using infrared thermography to assess seasonal trends in dorsal fin surface temperatures of free-swimming bottlenose dolphins (*Tursiops truncatus*) in Sarasota. Bay, Florida. Marine Mammal Science 26(1):53-66.

Meagher, E.M., W.A. McLellan, A.J. Westgate, R.S. Wells, D. Frierson, D.A. Pabst. 2002. Respiration, heart rate and heat flux across the dorsal fin in bottlenose dolphins, *Tursiops truncatus*. Journal Experimental Biology 205:3475–3486.

Pabst, D. A., W. A. McLellan, E.M. Meagher, and A.J. Westgate. 2002. Measuring temperatures and heat flux from dolphins in the eastern tropical Pacific: Is thermal stress associated with chase and capture in the ETP-tuna purse seine fishery? SWFSC Admin. Rep. LJ-02-34C, 54 p.

Westgate A.J., W.A. McLellan, R.S. Wells, M.D. Scott, E.M. Meagher, D.A. Pabst. 2007. A new device to remotely measure heat flux and skin temperature from free-swimming dolphins. Journal of Experimental Marine Biology and Ecology 346:45–59.

**Life History**

A NMFS necropsy study found no or inconclusive evidence that stress was having a significant adverse impact on dolphin populations, but the sample sizes collected for these studies were low. The low sample size was cited as a reason by the U.S. District Court for overturning the Secretary of Commerce's determination that there was no significant adverse impact, ruling that the NMFS had not completed the necropsy study mandated by the U.S. Congress.

Since 2002, additional papers on dolphin life history have been published (Archer and Robertson 2004; Perrin *et al*. 2005; Danil and Chivers 2006, 2007; Cramer *et al.* 2008; Larese and Chivers 2008, 2009). A study by IATTC and NMFS scientists of the movements and diving behavior of spotted dolphins has been published (Scott and Chivers 2009). NMFS has also developed a method to diagnose reproductive status of both male and female dolphins from the blubber attached to most skin biopsy samples (Kellar 2008; Kellar *et al*. 2006; 2009; 2013a; 2013b; Trego *et al*. 2013). Biopsy samples collected between 1999 and 2003 showed a female pregnancy rate of 11.8% for spotted dolphins, a lower rate than the pregnancy rate of 21.8% determined from fishery-killed females collected earlier between 1974 and 1992 (Kellar *et al.* 2013a). A correlation of higher pregnancy rate with estimated fishery exposure was also observed.

NMFS researchers (Cramer *et al.* 2008) have also published a paper that argues on the basis of aerial photogrammetric measurements of dolphin herds that 1) the proportion of calves in northeastern spotted dolphin herds declined from 1987-2003; 2) the proportion of calves in eastern spinner dolphin herds remained stable from 1987-1993, but declined thereafter; 3) the length of disassociation (when the calf presumably becomes independent of the mother) decreased as the number of spotted dolphin sets for that same year increased, suggesting a fishery effect; and 4) a similar correlation was not found for eastern spinner dolphins.

If there is indeed a reduced reproductive output over time, this is difficult to reconcile with the survey results and population model trends (Gerrodette *et al.* 2008; IATTC Scientific Advisory Board document SAB-07-05; October 2009) which show spotted and spinner dolphin populations have been slowly increasing throughout this same time period.

The discrepancy between these studies may be due to the Cramer *et al.*'s data-selection or sampling schemes. The authors excluded 70% of their data, particularly herds greater than 600 dolphins because they "dominated the model fitting." This is a source of bias if, as in some other delphinids, calves are more common in larger groups than smaller ones. For spotted dolphins, over half of the schools they sampled and almost half of the individuals were sampled during the 1992 and 1993 surveys. These surveys were very different than the others, targeting a different species (common dolphins), different habitats than the tropical ones typically inhabited by spotted and spinner dolphins, and covering much smaller areas. Also, they used the total sets on all dolphin stocks as the index of fishery effort, rather than the specific number of sets for each stock. This assumes that the total sets is a reliable proxy of fishing effort for each individual stock, but the proportion of the total sets that involved northeastern spotted dolphin varied significantly for the years they sampled. The total number of sets would greatly overestimate the exposure of dolphins sampled in 1992 and 1993 when only a small fraction of the species range was sampled.

The unpublished age-at-length data for spotted dolphins at the heart of their age of disassociation *vs.* fishing effort analysis conflicts greatly with published life history literature. The authors estimated length for a two-year old is 126 cm is an anomaly. The published life history literature for spotted dolphins (Perrin *et al*. 1976; Hohn and Hammond 1985; Bright and Chivers 1991), other delphinids (Sergeant et al. 1973; Kasuya 1972, 1976; Ross 1977; Kasuya and Brownell 1979; Hohn 1980; Perrin and Henderson 1984; Kasuya *et al*. 1986, 1988), and even the unpublished data they present for spinner dolphins all argue that 126 cm is the length one would expect of a 1-year-old spotted dolphin, and not a 2-year old. By greatly underestimating the length for a 2-year-old, they then would underestimate the number of calves in the sample, and call into question their conclusion that fishing effort correlates with a declining reproductive output of spotted dolphins. Interestingly, their estimate of the length of 2-year old spinner dolphins is not an anomaly, and there is no correlation between fishing effort and reproductive output for spinner dolphins.

The Scientific Advisory Board of the AIDCP has recommended reinstating a dolphin life-history sampling program by observers to look at trends in vital rates. This recommendation was approved by the Meeting of the Parties but funding has not yet been obtained to collect new samples from dolphins taken in the fishery.

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**Ecosystem effects**

To explain why some dolphin populations were not increasing at the rate NMFS expected (4%), the NMFS examined whether a change in the carrying capacity of the ecosystem could have occurred. The NMFS Report concluded that a such a change in the ecosystem was not likely, although there were significant increases in biomass during 1986-2000 for other ETP species, such as pilot whales, Bryde's whales, common dolphins, and yellowfin tuna. The IATTC Report calculated that over 200,000 more pilot whales, over 750,000 more common dolphins, over 7,000 more Bryde's whales, and more than 70% more yellowfin tuna were added to the ecosystem from 1986-2000. The increases of these populations of large predators could increase competition for fish and squid that the spotted and spinner dolphins feed upon, and thus reducing the population growth rates. A NMFS Expert Panel on the Ecosystem agreed that ecosystem variation could have a significant impact on dolphin populations in the eastern Pacific Ocean.

A population modelling study by Wade *et al*. (2007) could find no difference between models implicating fishery effects or environmental changes on dolphin populations.

A series of papers were published on the oceanography of the eastern Pacific (Fiedler and Lavin 2006; Redfern *et al*. 2008). NMFS is currently investigating the biological effects of the late 1970s climate shift on larval fish assemblages and seabird diets. The most-recent abundance estimates by Gerrodette *et al.* (2008) found significant increases in bottlenose dolphins. Because this species is rarely taken by the tuna purse-seine fishery, the authors suggested that this increase may be due to changes in their habitat.

The IATTC has collaborated on a series of papers on multi-species models (*e.g.*, Olson and Watters 2003; Watters *et al.* 2003; Hinke *et al.* 2004; Griffiths *et al.* 2013). Gerrodette *et al.* (2012) described the ecosystem impacts of different purse-seine set types. A study of the tuna-dolphin association has been conducted using tracking, food habits and observer and environmental data (Scott *et al*. 2012). The distribution and encounter rates of cetaceans in Colombian waters have been linked with oceanographic features (Palacios *et al.* 2012). Net-tow samples collected in the late 1960s (EASTROPAC cruises) and museum specimens collected prior to the climate shift will be compared with samples collected during the 1986-1990 and 1998-2006 cruises. Papers have linked climate change to community structure in the ETP (Vilchis *et al*. 2009) and a decadal shift in tuna food habits representing major changes in mid-trophic level prey communities (Olson *et al*. 2014).

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## World Trade Organization

On September, 15, 2011, the World Trade Organization (WTO) ruled on a complaint brought by Mexico against the United States and its "dolphin-safe" policy. The WTO ruled in Mexico's favor that the U.S. policy is "more trade-restrictive than necessary to achieve a legitimate objective, taking into account the risks that non-fulfillment would create." The WTO, however ruled against Mexico's argument that the U.S. policy was not discriminatory. Both the United States and Mexico appealed these rulings. On May 16, 2012, a WTO Appellate Body decision reversed both of these rulings. The Appellate Body now found that the U.S. policies were not more trade restrictive than necessary. The Appellate Body also reversed the Panel on the discrimination issue, ruling that the U.S. Dolphin-Safe policy "is not even-handed in the manner in which it addresses the risks to dolphins arising from different fishing techniques in different areas of the ocean."