Sea Grant
Technical Report



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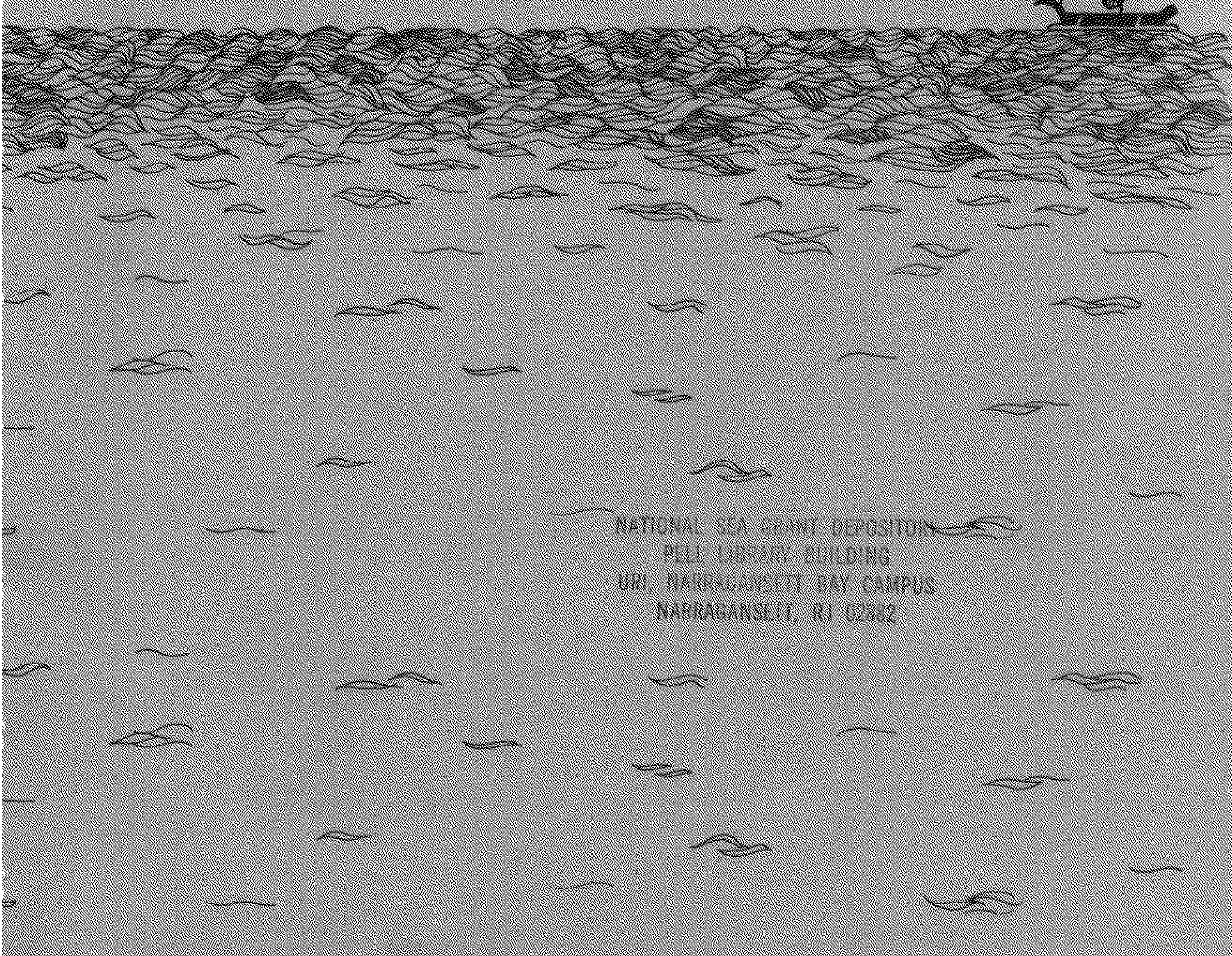
Kim N. Holland

University of Hawaii Sea Grant College Program



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## ABSTRACT

Most pelagic gamefish landed in Hawaii are caught by trolling. Sport trolling, either by commercial charter fishing vessels or by recreational fishing vessels, is the largest trolling sector. Despite this fishery's importance, few data exist regarding its catch per unit of effort (CPUE). A quantitative visual assay of the Kewalo Basin, Honolulu, charter sport fishing fleet was conducted to determine CPUE over a 12-month period. On the average, at least one gamefish was caught on 49.6 percent of every 8-hour day fished. Seasonal fluctuations in CPUE were evident. Species landed in decreasing daily frequency were mahimahi, marlin, aku, ono, and ahi.

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## INTRODUCTION

Whereas the impact of commercial fishing fleets on existing stocks of pelagic fish in U.S. Pacific waters can be determined through various official reporting and assessment programs, the impact of sport fishermen on these species — particularly billfish — is largely unknown. This is particularly true in Hawaii where licenses are not required and where the sport fishing fleet is both heterogeneous and widely dispersed.

Trolling accounts for most of the pelagic fish landed in Hawaii (WPRFMC, 1985), and three trolling groups are recognized: (1) charter sport trollers, (2) commercial trollers, and (3) quasi-commercial/sport trollers. The third group is the largest and also the least monitored because catch reports are not required. Because of the large size of the sport fishing fleet, accurate assessment and prudent management of fish stocks should ideally account for the impact of this sector. There are limited instances of volunteer reporting of total fish caught by sport fishermen operating out of certain Hawaiian harbors, but few data are available regarding CPUE for billfish or other gamefish species. If an accurate estimate of trolling CPUE could be obtained, that information could be combined with future estimates of total fleet size and days fished to yield an estimate of the total impact of sport trolling on the gamefish populations in Hawaiian waters.

In this technical report are catch per unit of effort data for a 12-month period obtained by visually monitoring a fairly wide sample of charter sport fishing vessels. Because the fishing techniques employed by this group are the same as those employed by the other trolling groups, CPUE data from the charter fleet will probably accurately reflect CPUE for trolling as a whole. The data were acquired in a way that did not depend on the active cooperation of the vessel operators in the normal sense of volunteering catch information; consequently, the data are free of the biases which sometimes accompany volunteer reports. Furthermore, the data were not obtained from commercial market or auction records, which can be biased by seasonal focusing of effort on particular species and which yield total figures rather than catch per unit of effort data.

The data presented here indicate the overall catch success rate of the charter fleet operating out of Kewalo Basin, the catch per unit of effort for billfish, and the seasonal fluctuations in landings of marlin and other Hawaiian gamefish species. These data — especially for billfish — are compared with data acquired by other reporting techniques, and possible correlations between fishing success and oceanographic phenomena are discussed.

## METHODS

Data were collected from 30 charter sport fishing vessels using Kewalo Basin on Oahu as their home port. Kewalo Basin is the major port in Honolulu, Hawaii from which commercial sport fishing vessels operate. Data reported here were collected between October 1, 1982 and September 30, 1983.

Catch success was monitored as the vessels returned through the Kewalo Basin channel upon completion of each day or half day of fishing. The assay involved monitoring the type and number of "fish flags" flown by these vessels upon their return to port. The etiquette associated with the successful landing of gamefish species in Hawaii allows the charter captain, upon completion of fishing, to hoist various flags representing which species had been caught by that vessel on that day. In the case of billfish, one flag is flown for each fish landed. This is not true for other gamefish species for which only one flag is flown regardless of the number landed.

The flying of these fish flags allows the boat operator to promote his crew and vessel, thus serving as an advertisement for securing future charters from passers-by and other potential customers. Competition for business is vigorous and consequently the fish flag system is rigorously adhered to by members of the charter fleet. Frequent close checks during the observation period confirmed the accuracy of the assay — that is, boats returning through the channel with flags flying did, indeed, unload those particular species at the dock; and vessels not flying flags did not have any fish on board. Since the fish flag etiquette also dictates that flags be taken down before leaving on the next charter, the flags flown upon return indicate only the most recent day's catch success.

In Hawaiian waters the major marlin species taken (in order of frequency) are Pacific blue marlin *(Makaira nigricans)*, striped marlin *(Tetrapterus audax)*, shortnosed spearfish *(Tetrapterus angustirostris)*, and sailfish *(Istiophorus orientalis)*. Non-billed gamefish taken include ahi (yellowfin tuna, *Thunnus albacares,* and bigeye tuna, *T. obesus*), ono (wahoo, *Acanthocybium solandri*), and mahimahi (dolphin, *Coryphaena hippurus*). Flags are also flown for aku (skipjack tuna, *Katsuwonus pelamis*), although it is not strictly regarded as a gamefish by some fishermen.

Vessels returning to port before 2 p.m. were classified as half-day (4-hour) charters and those returning after 2 p.m. as full-day (8-hour) charters. No attempt was made to keep a catch record of every boat that was fishing every day. The data reported were acquired on a random, "spot-check" basis as the vessels returned to port. However, all returning vessels that were observed on any given day were included in the data.

## RESULTS

Six hundred and seventeen full-day and 67 half-day fishing trips were observed over a period of 12 months. Catch success data for full-day and half-day trips are listed in Table 1 and Table 2, respectively. For non-marlin gamefish, interpretation of these data should be

TABLE 1. CATCH STATISTICS FOR FULL-DAY CHARTERS, 1982-83

| | 1982 | | | 1983 | | | | | | | | | WHOLE YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | |
| Total Observations | 43 | 48 | 14 | 49 | 77 | 24 | 70 | 16 | 95 | 64 | 66 | 51 | 617 |
| Total of All Species | 20 | 28 | 11 | 9 | 29 | 22 | 50 | 10 | 40 | 38 | 30 | 19 | 306 |
| Success Rate (%) | 47 | 58 | 78 | 18 | 38 | 92 | 71 | 62 | 42 | 59 | 45 | 37 | 49.6% |
| Total Marlin | 8 | 8 | 2 | 3 | 5 | 6 | 18 | 2 | 16 | 17 | 6 | 12 | 103 |
| Marlin/Hour | .023 | .020 | .017 | .007 | .008 | .031 | .032 | .015 | .021 | .033 | .011 | .029 | .020 |
| Adjusted Marlin Success (%)* | 14 | 13 | 14 | 6 | 6 | 17 | 21 | 13 | 16 | 22 | 9 | 16 | 13.9% |
| Total Mahi | 13 | 26 | 9 | 7 | 16 | 17 | 27 | 3 | 15 | 8 | 11 | 13 | 165 |
| Mahi Success (%) | 30 | 54 | 64 | 14 | 21 | 71 | 39 | 19 | 16 | 13 | 17 | 25 | 26.74% |
| Total Ono | 17 | 5 | 5 | 0 | 3 | 1 | 2 | 2 | 12 | 20 | 9 | 5 | 71 |
| Ono Sucess (%) | 16 | 10 | 36 | 0 | 4 | 4 | 3 | 13 | 13 | 31 | 14 | 10 | 11.5% |
| Total Ahi | 1 | 2 | 2 | 1 | 5 | 4 | 14 | 2 | 16 | 7 | 8 | 3 | 65 |
| Ahi Success (%) | 2 | 4 | 14 | 2 | 6 | 17 | 20 | 13 | 17 | 11 | 12 | 6 | 10.53% |
| Total Aku | 2 | 1 | 1 | 2 | 4 | 5 | 27 | 7 | 0 | 14 | 14 | 1 | 78 |
| Aku Success (%) | 5 | 2 | 7 | 4 | 5 | 21 | 39 | 44 | 0 | 22 | 21 | 2 | 12.6% |

*Ignores multiple marlin flags, allowing a nominal maximum of one marlin per day. This makes marlin daily success rate comparable with other species for which only one flag is flown regardless of number of fish landed.

TABLE 2. CATCH STATISTICS FOR HALF-DAY CHARTERS, 1982-83

| | 1982 | | | 1983 | | | | | | | | | WHOLE YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | |
| Total Observations | 6 | 10 | 1 | 3 | 4 | 1 | 8 | 2 | 10 | 12 | 5 | 5 | 67 |
| Total of All Species | 2 | 2 | 1 | 0 | 4 | 0 | 6 | 1 | 3 | 5 | 1 | 1 | 26 |
| Success Rate (%) | 33 | 20 | 100 | 0 | 100 | 0 | 75 | 50 | 33 | 42 | 20 | 20 | 39% |
| Total Marlin | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 5 |
| Adjusted Marlin Success (%)* | 0 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 10 | 25 | 0 | 0 | 7.46% |
| Total Mahi | 2 | 2 | 0 | 0 | 3 | 0 | 4 | 0 | 1 | 2 | 0 | 1 | 15 |
| Mahi Success (%) | 33 | 20 | 0 | 0 | 75 | 0 | 50 | 0 | 10 | 17 | 0 | 20 | 22.38% |
| Total Ono | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Ono Success (%) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 20 | 0 | 2.9% |
| Total Ahi | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 0 | 0 | 0 | 7 |
| Ahi Success (%) | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 50 | 30 | 0 | 0 | 0 | 10.4% |
| Total Aku | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 5 |
| Aku Success (%) | 0 | 0 | 100 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 0 | 0 | 7.46% |

*Ignores multiple marlin flags, allowing a nominal maximum of one marlin per day. This makes marlin daily success rate comparable with other species for which only one flag is flown regardless of number of fish landed.

prefaced with the phrase "one or more . . . ." Thus, for full-day charters the year-round chance of catching "one or more mahimahi" is 26.74 percent (Table 1) or approximately 1 fish in 4 days. Comparison of catch success for the various species for full-day charters shows mahimahi at 26.74 percent, marlin at 13.9 percent, aku at 12.6 percent, ono at 11.5 percent, and ahi at 10.53 percent. The overall success rate, that is, the chance of catching "one or more" of any of these species, was 49.6 percent. Thus, on a year-round basis, a Kewalo Basin full-day charter operation has about a one-in-two chance of catching a fish.

Because, in fact, one flag is flown for each marlin caught, a precise catch per unit of effort value for these fish can be calculated. The year-round average for all species of marlin on full-day Kewalo charters was 0.02 marlin/hour (Table 1 and Figure 1). This translates to 1 marlin per 6.25 full days of fishing. There was considerable variation in marlin catch success rate among vessels. For 18 vessels for which 10 or more observations were made, success ranged from 0 marlin/hour to .05 marlin/hour (1 marlin per 2.5 full days fished). The median for this group was .016 marlin/hour (1 marlin per 7 full days fished). Marlin availability was relatively stable year-round when compared with the large monthly fluctuations exhibited by the other gamefish species (Figures 1, 2, and 3). Marlin catch success was slightly higher during the spring and summer than at other times, and there was a distinct low period shared with all other gamefish species in January and February. The nature of the assay does not permit analysis of whether species composition or size distribution of the total marlin catch varied over the year.

Dramatic changes occurred both in overall catch success rate (Figure 4) and in individual species' catch success rates over short periods of time. Also, there were short periods when the catch frequencies for individual species were either well above or well below their yearly averages (Figures 1, 2, and 3). An instance of short-term high catch success for marlin occurred between September 23 and October 2, 1982, when .08 marlin/hour were caught overall (11 fish over 23 full fishing days) at a rate of four times the yearly average. Similarly, between November 26 and December 6, 1982, overall mahimahi catch success was 75 percent (21 fish flags for 28 full days) and in March 1983, 71 percent (17 fish flags for 24 full days). These figures are also well above the year-round mahimahi catch average of 26.74 percent (Table 1) and illustrate the high catch success which occurred both before and after the extremely poor

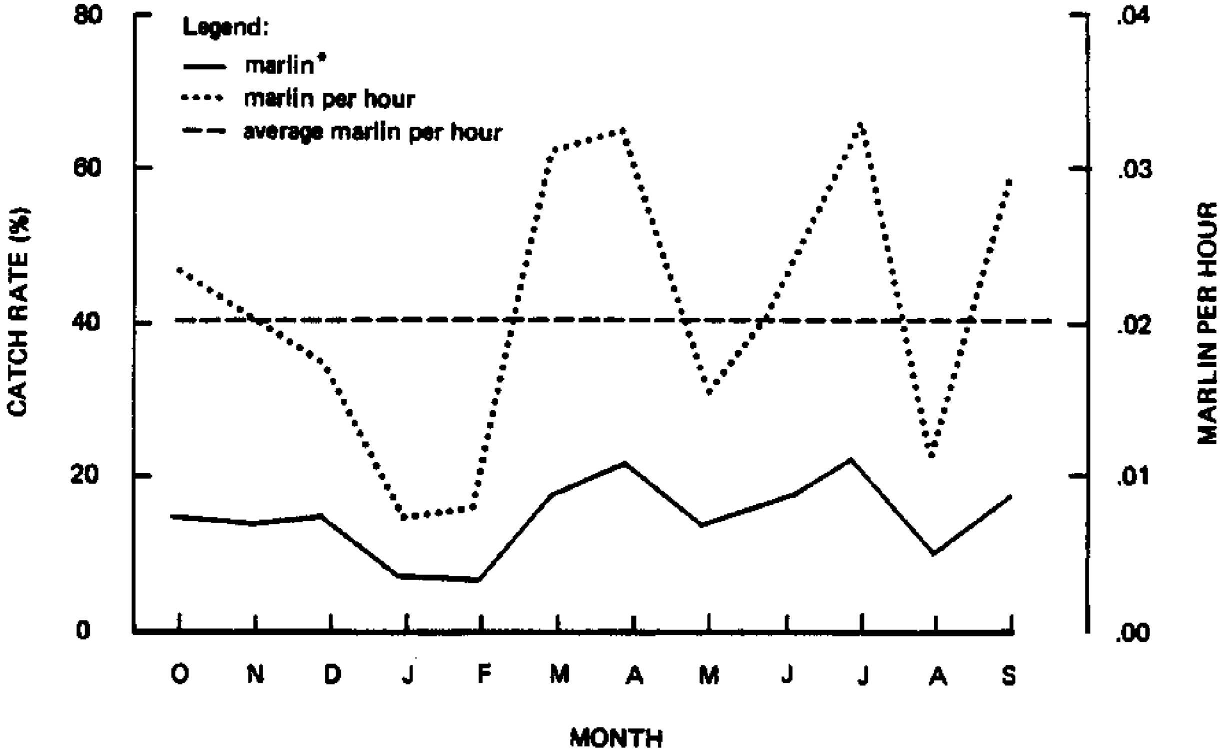


Figure 1. Marlin catch success rate and number of marlin caught per hour, October 1982 through September 1983. For purposes of comparison with other species, the "marlin*" curve was generated by imposing an artificial limit of one marlin flag per boat per day.

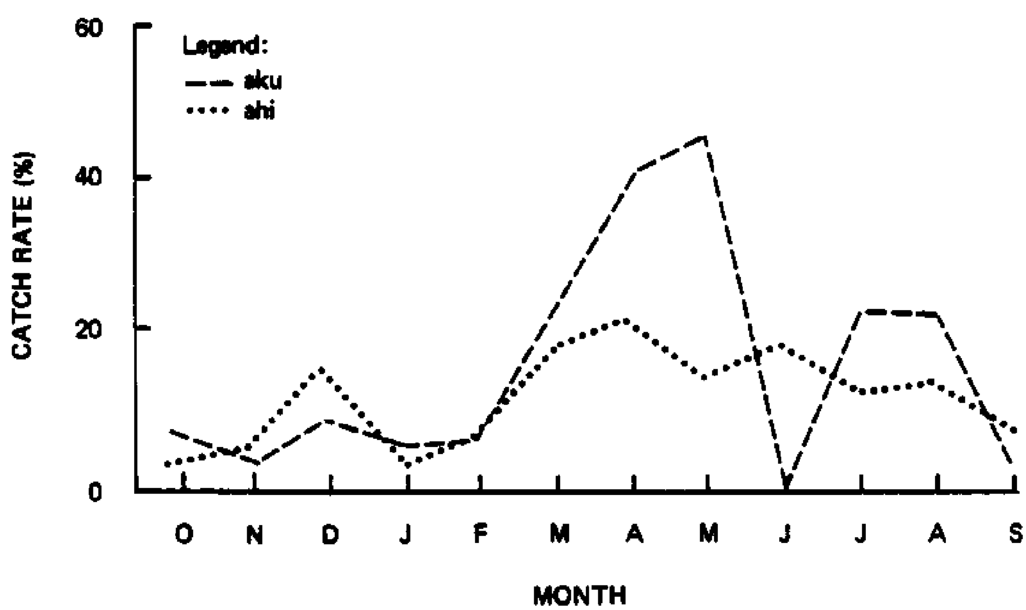


Figure 2. Catch success rate for ahi (yellowfin and bigeye tunas) and aku (skipjack tuna, October 1982 through September 1983

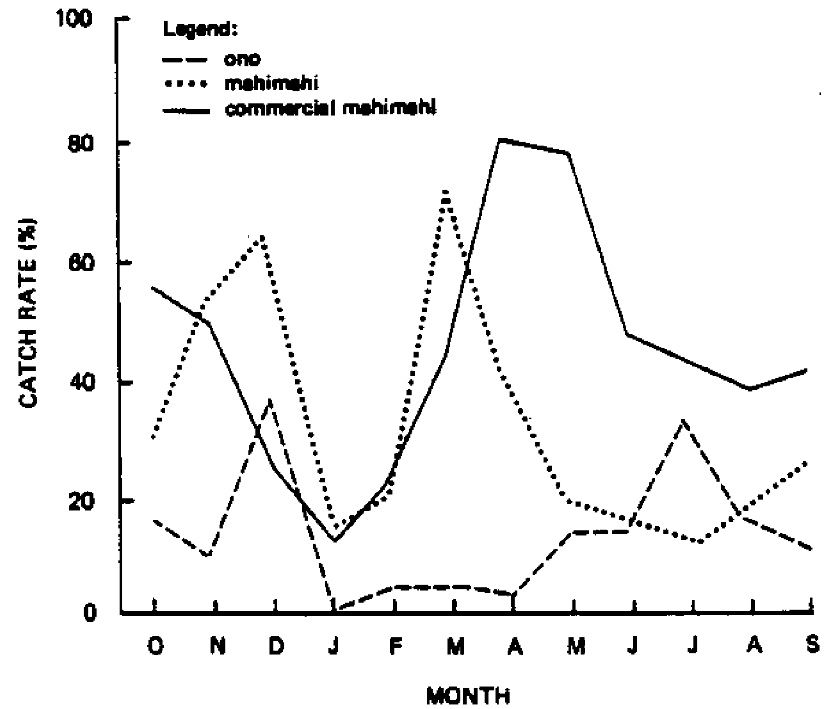


Figure 3. Catch success rate for mahimahi and ono, October 1982 through September 1983. The commercial mahimahi curve represents average total weight landed per month (1949-78), not CPUE.

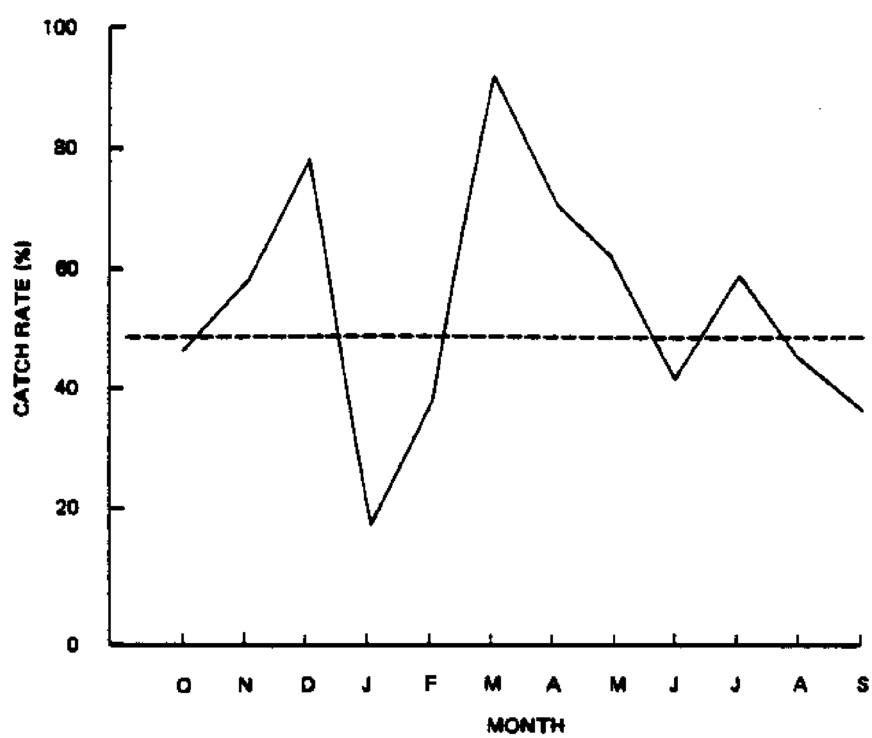


Figure 4. Overall catch success rate for all gamefish species combined. The dashed horizontal line represents the year-round average (49%).

fishing period during January and February (Figure 3), when the catch rate was well below the yearly average. For instance, in January the overall mahimahi catch rate was just 14 percent (7 fish flags for 49 full days), down from 64 percent in December (9 fish flags for 14 full days).

The sharp change in total catch success between the high periods of November-December and March-April and the very low January-February period is one of the most dramatic aspects of these data (Figure 4). Not surprisingly, because mahimahi is the most frequently taken species, any change in mahimahi catch success has a major influence on the overall success rate at these times of the year.

Half-day charters had an overall success rate of 39 percent (Table 2). Catch success rates for mahimahi and ahi on half-day charters (22.38 percent and 10.4 percent, respectively) were similar to the full-day catch success rates. Marlin catch success rate for half days was about 50 percent of that for full days (13.9 percent), and ono catch success rate for half days was markedly lower (2.9 percent) than full-day levels (11.5 percent).

However, these half-day versus full-day data take on a different complexion when translated into hourly rates. For example, full-day and half-day marlin/hour rates were very similar (0.02/hour for a full day; 0.018/hour for half a day), whereas the half-day mahimahi hourly rate ("one or more mahimahi") was 60 percent higher than the full-day rate. The half-day ahi hourly rate was 100 percent better than the full-day hourly rate.

## DISCUSSION AND CONCLUSIONS

It is not possible to firmly determine whether changes in catch success over time are due to changes in the populations of the fish in the area or to changes in the susceptibility of those animals to trolling gear. However, given the opportunistic feeding strategies of these pelagic predators and the diversity of their prey, there appear to be no *a priori* reasons to believe that their feeding behavior (and hence "catchability") would vary greatly with season. Thus, it would seem more likely that changes in fishing success reflect changes in fish populations existing within approximately 25 nautical miles of Honolulu.

The current data only reflect the catch success of the Kewalo Basin-based commercial charter fleet. The "day trip" nature of the fishing limits the size of the fishing area. However, the Kewalo Basin fleet does have access to areas that are generally regarded as good fishing grounds, including the Waianae coast, Molokai Channel, and Penguin Bank. Furthermore, the captains and deckhands are professionals and their vessels are well equipped. Therefore, the results reported here should reflect the impact of the best effort and equipment available.

Limitations of the current assay are that the data only span a 12-month period and that, for non-marlin species, the actual number of fish caught was not known. Also, even though the total number of marlin was known, it was not possible to determine exactly which species were caught, or whether or not species composition or size changed over the year. Pacific blue marlin are the most frequently caught species in Hawaii (Gosline and Brock, 1960), and it is probable that the overall marlin statistics were dominated by the changes in availability of this one species. This is supported by the only other detailed account of sport fishing CPUE in Hawaii (Hida and Shippen, 1984) in which the log of a single vessel, the *Mele Moku* which operates out of Pearl Harbor, has been analyzed for CPUE between 1977 and 1982. Blue marlin constituted 52 percent of the billfish landed (1 per 7.8 days), and the total billfish catch success rate was 1 per 4.13 days (299 billfish in 1,231 days over 6 years). Because the *Mele Moku* fished 7-hour days, its billfish catch rate was .034/hour which, based on 1982-83 rates, would place it in the top 20 percent of the Kewalo Basin fleet.

Another recently published report of charter sport fishing vessels in Hawaii, based on voluntary returns of questionnaires (Samples et al., 1984), indicates a marlin catch success rate around Oahu of 1 fish per 3 days of fishing. It should also be stressed that this figure was derived from estimated averages of number of billfish caught (35) and number of days fished (104) per boat.

The current estimate of marlin catch success (.02/hour or 1 fish per 6.25 days) is considerably lower than Squires' (1983) data for the marlin taken by sport fishermen in Hawaii in 1981. Squires' data, obtained from volunteer reports, indicated that 0.23 marlin/day (1 fish every 4.2 days) was taken statewide in that year. However, his data refer only to Pacific blue marlin. Although blue marlin represent the most frequently taken species (52 percent of total catch in the case of *Mele Moku*), the 33 percent decline between the current data and Squires' data for 1981 would doubtlessly be greater if the latter's data also included other marlin species. However, the differences between the data could be due to differences between voluntary and non-voluntary sampling techniques (both Squires' and Samples et al.'s estimates are higher than the current data), differences in marlin densities statewide as compared with those within reach of the Kewalo fleet, annual fluctuations, or an actual decline in marlin stocks. If there were an actual decline, it would be consistent with the established decline in marlin caught over the last several years by the commercial longline fishery (NMFS-SWFC administrative report, H-83-24, 1983).

Whereas the Kewalo fleet does have access to traditionally good fishing grounds, little is known about the small-scale distribution of marlin. Tagging experiments have shown these animals to be capable of pan-oceanic movements (e.g., from the California coast to Hawaii), but little is known about their short-term behavior or their duration of stay in any particular location. Some marlin tracked in Hawaiian waters have displayed considerable alongshore movements, but the duration of the tracks (less than 1 day) was insufficient to indicate any overall patterns (Yuen et al., 1974). It is possible that the Kewalo fleet catch success rate is lower than the statewide success rate (as measured by the volunteer reports) due to non-uniform distribution of marlin around the state or to localized depletion. Leeward Oahu is an area that is under heavy fishing pressure.

The comparatively constant catch success rate for billfish throughout the year may be due to the successive arrival of different species over the course of the year. Blue marlin are predominant in the summer months. This probably represents the northeastward migration of the main blue marlin population which is located closer to the equator during the rest of the year (Weatherall and Yong, 1983). Both the annual commercial landings (NMFS-SWFC administrative report, H-83-24, 1983) and the catch characteristics of the *Mele Moku* (Hida and Shippen, 1984) show that in the fall and winter the blue marlin catch declines and striped marlin become more common. Shortnosed spearfish make their appearance in late winter and spring. This succession results in a quite constant rate of billfish catch success, with a maximum in the summer months. It is tempting to speculate that the three peaks in catch success (Figure 1) represent the successive arrivals of these species.

There were distinct peaks in the availability of the non-marlin species. In the case of ahi and aku, the well-documented increase due to "season" fish arriving during the summer months was reflected in the broad catch success increase by the sport fishing fleet between March and September (Figure 2). These are usually larger specimens that are thought to be on pan-oceanic migrations (Sund et al., 1981). Less expected, however, was the increase in ahi catch success in December. There is a similar December increase in the commercial catch records for this species (NMFS-SWFC administrative report, H-83-24, 1983). This commercial catch increase could be interpreted as a result of targeting of this species by fishermen at this time due to the high demand for sashimi at Christmas and New Year. However, sport trollers working around leeward Oahu have very limited ability to "target" any particular species.

Thus, the current data suggest a modest actual increase in ahi availability in December.

The complete absence of skipjack (aku) in June (Figure 2) is difficult to explain. Data from the commercial skipjack pole-and-line fishery for this period did not reveal a similar decline. In fact, June's commercial catch was higher than May's (NMFS-SWFC monthly report, August 1983). It should be remembered, however, that pole-and-line vessels travel much farther afield than sport vessels, so the absence of aku in June probably reflected an extremely local (leeward Oahu) phenomenon.

The sharpest peaks of availability were for ono and mahimahi. Ono displayed a sharp peak in December and a broader increase in availability peaking in July. Therefore, the general trend was for higher availability from May through early December, with depressed availability from January through April. A similar profile of catch availability for ono is reflected in the state's commercial landing records (Takenaka et al., 1984), although the December peak is less pronounced.

The most dramatic swings in availability were for the mahimahi, with one very distinct peak in November-December and another in March. On a finer scale, these peaks of availability occurred in late November-early December and late March-early April. The state's commercial catch record (Takenaka et al., 1984) shows a similar bimodal distribution, but with peaks occurring in October-November and April-May (Figure 3). These two distinct peaks in both sets of data and the low availability at other times of the year are suggestive of a band of high stock density moving through the islands first in one direction and then in the other. The timing of these catch success peaks is in close agreement with the average time of movement of the 75° to 76° F isotherm across Oahu (Seckel, 1962). The isotherm moves south of Oahu around early December, and then in late March and April it moves back north where it remains for most of the year. It can be hypothesized that the peaks in mahimahi catch success correspond to higher densities of fish following the movements of these oceanic surface temperature boundaries. In fact, the slight shortening of the inter-peak interval in the current data, as compared with the long-term (29-year) commercial data, may be an indication of the influence of the 1983 "El Nino" on the movement of the mahimahi stock. The absolute poorest fishing success for all species coincided exactly with the coldest ocean temperatures of the year in January, February, and early March. From the fisherman's viewpoint, the offset in the peaks of availability of ono and mahimahi contributes to more consistent overall fishing success. The resultant relatively constant supply of these white-fleshed species also contributes to more stable market prices.

The occasional high abundance of certain species probably accounts for the comparatively high efficiency of the half-day hourly rate. For the relatively constantly available, widely dispersed billfish, hourly rates are essentially the same for whole-day and half-day charters. On the other hand, for mahimahi and ahi which occur in schools and which are seasonally abundant, half-day trips are more efficient overall than half as many full-day trips. This is in spite of the fact that more half-day charters return with no fish at all.

Regardless of whether or not the seasonal availability of the various species is correlated to local oceanographic conditions or to larger-scale migrational drives, the data presented here give, for the first time, a broad-based, objectively acquired description of Hawaiian sport fishing success and catch per unit of effort. The measures of overall catch success and the seasonal changes in availability were not influenced by biases associated with volunteered information or by changes in market demand. Also, the similarities of seasonal availability between these sport fishing data and the commercial landing statistics for the various species further attest to the validity of the "fish flag" assay. This assay could be used to evaluate sport fishing CPUE in other locations where adherence to a fish flag etiquette can be confirmed. Given these current CPUE data for the Kewalo fleet, an objective estimate of the total impact of sport fishing on gamefish in Hawaiian waters can be calculated if data regarding the total number of sport fishing vessels and average number of days fished can be obtained. Hence, this report not only provides an objectively measured estimate of sport fishing CPUE in Hawaii, but it also serves as a point of departure for estimating the total sport fishing impact on gamefish in Hawaiian waters.

## ACKNOWLEDGMENTS

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