

RECOUNT PIRARUCU: A METHOD FOR ASSESSING THE QUALITY OF PIRARUCU COUNTINGS

RECONTAGENS DE PIRARUCU: UM MÉTODO DE AVALIAÇÃO DA QUALIDADE DAS CONTAGENS DE PIRARUCU

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KEYWORDS

Mamirauá SDR;
Pirarucu Management;
Pirarucu Counting.

ABSTRACT

The pirarucu counting method is a simplified stock assessment that has been used as the main parameter for establishing the annual fishing quotas in the management system of the Mamirauá and Amanã Reserves. In spite of the method's directness, considering the recent expansion of managed fisheries, we cannot confirm that the counters thoroughly obey the original methodology. There is a concern of a technical nature, as the results of the counts directly influence the fishing quotas, and the lack of technical supervision or the inadequate application of the method are factors that can compromise the management system as a whole. This study aims to assess the counts that took place in six fishing environments of the Jarauá Sector, Mamirauá Reserve, and in four fishing environments of the area of the Pantaleão Fishing Agreement Complex, Amanã Reserve. We verified the consistency of the information resulting from the count, presented to the technical staff. To do this, we conducted recounts of juvenile and adult pirarucus in the same environments. In the Jarauá Sector we found significant differences in the counting results from Samaumerinha do Tucuxi and Curuçá do Centro. In Comprido do Maciel we found differences regarding the number of counted areas. In the sampled environments from the Pantaleão region we did not find significant differences between the counts. The results highlight the importance of creating assessment mechanisms for the counts, for the purpose of preventing possible alterations in the results that might influence the fishing quotas without a biological reason for justifying such quotas.

PALAVRAS-CHAVES

RDS Mamirauá;
Manejo de pirarucu;
Contagem de Pirarucu

RESUMO

O método de contagens de pirarucu é um levantamento de estoque simplificado que tem sido utilizado como o principal parâmetro para o estabelecimento das cotas anuais de pesca no sistema de manejo das Reservas Mamirauá e Amanã. Apesar da facilidade na aplicação do método, com a recente expansão do manejo, não se pode afirmar que a prática dos contadores obedece criteriosamente à metodologia original. Existe uma preocupação de ordem técnica, pois o resultado das contagens influencia diretamente as cotas de pesca, e a falta de supervisão técnica ou a aplicação inadequada do método são fatores que podem comprometer o sistema de manejo como um todo. Este estudo tem o objetivo avaliar as contagens realizadas em seis ambientes de pesca no Setor Jarauá, Reserva Mamirauá, e em quatro ambientes de pesca na Área do Acordo de Pesca do Complexo do Pantaleão, na Reserva Amanã. Foi verificada a consistência das informações resultantes da contagem, apresentadas à equipe técnica. Para tal, foram realizadas recontagens de pirarucus jovens e adultos naqueles mesmos ambientes. Para o setor Jarauá, foram encontradas diferenças significativas nos resultados das contagens nos ambientes Samaumerinha do Tucuxi e Curuçá do Centro. No ambiente Comprido do Maciel encontramos diferenças entre o número de áreas contadas. Para os ambientes amostrados na região do Pantaleão não foram encontradas diferenças significativas entre as contagens. Os resultados mostram a necessidade da criação de mecanismos de avaliação das contagens, visando impedir possíveis alterações nos resultados que influenciem as cotas de pesca sem uma razão biológica que fundamente tais cotas.

INTRODUCTION

The natural resource management systems of implemented in the Sustainable Development Reserves of Mamirauá - MSDR and Amanã - ASDR were developed from traditional practices, combined with minimum impact techniques and based on scientific research (QUEIROZ; PERALTA 2006). One of the main economic alternatives first begun in MSDR and ASDR, among the best known and most studied so far, is the sustainable management of pirarucu fisheries (*Arapaima gigas*) (VIANA et al., 2007).

Some of the previous studies about the biology and ecology of the species (QUEIROZ; SARDINHA, 1999; QUEIROZ, 2000) have supported the first attempts of sustainable management of pirarucu fisheries, along with the implementation of a simple and efficient stock assessment system (CASTELLO, 2004). After the implementation of management in 1999, several studies have contributed to and confirmed the effectiveness of managed fisheries (ARANTES et al., 2006; ARANTES et al., 2007; CASTELLO, 2007; AMARAL, 2007a; CASTELLO et al., 2009; ARANTES, 2009; LOPES; QUEIROZ, 2009).

Among the many studies done on the subject, the development of the counting methodology stands out as essential for the continuity of this activity. Since 2000, the stock assessments of pirarucus have been performed with the counting method, which is based on knowledge fishers have regarding the species, and on basic aspects of its biology. These fishers have traditionally

used this practice in their fishing environments for assessing the amount of fish existing in their natural environment (CASTELLO, 2004; VIANA et al., 2007).

This practice is very effective mainly due to the respiratory behavior of the species, which is physostomous and presents mixed accessory respiration, and so must emerge to the surface of the water every 5-15 minutes in order to breathe (QUEIROZ; SARDINHA, 1999). Experienced fishers have the ability to identify visually, or through hearing, and to classify individuals into two categories: juvenile (or *bodeco*, individuals between 1 and 1.5 m total length) and adults (or *pirarucu*, individuals over 1.5 m total length). In this way the specimens can be individually counted and differentiated (CASTELLO, 2004).

To validate this method, Castello (2004) conducted comparisons between the counting results and the stock assessments he obtained from experiments involving capture and marking of animals in the same environments where they had been counted. This practice allowed the author to confirm the accuracy of the assessed countings, with a detection threshold of individuals with 1 m total length. Thus, using traditional local knowledge, knowledge of the species biology and comparison with other methods of population estimates, the counting method was developed and recognized by the agency responsible for licensing the activity and authorizing the annual fishing quotas, the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA).

Since then, the pirarucu counts came to be regarded the main tool used by fishers to monitor stocks in the MSDR and ASDR management areas, and to estimate the amount of pirarucus to be captured. Counting went on to become one of the “ground rules” of the pirarucu management system. Since 2001, with the approval of the counting methodology, the quota authorized for capture by IBAMA, which had been issued in kilograms since 1999, is now issued in number of fishes. This change enabled an increase in production with the catch of larger and heavier individuals, which also helps to protect the juvenile stocks and to avoid the risks of overfishing. If a problem should be detected, because the management process would be carefully monitored, the proportion of the quota regarding the counted adult stocks would be readjusted, adapting to new situations that could arise (VIANA et al., 2007).

The relative ease in applying the counting methodology developed by Castelo (2004), and the rapid replenishment of pirarucu in the managed areas, have caused this counting method to quickly spread to other areas, allowing fishers from different parts of Amazonia to use the technique to guide the sustainable catch of pirarucus. Currently, with the great expansion of pirarucu management to other areas of the Amazon river, and to management areas in other states of the federation, such as Pará and Acre, and even to neighboring countries such as Peru, Colombia and Guyana (AMARAL et al., 2007), we are finding a lack of careful technical supervision adequate to monitor all the work in so many different locations.

Concerned with the application of the counting method, which was being expanded to several areas without further technical monitoring, in 2005 and 2007 researchers and technicians from FMP/MISD evaluated the accuracy and precision of the pirarucu counting performed by fishers involved in the community management of the species. To this end, they compared the individual counting and counting by fishing groups from other management areas in lakes of the Mamirauá Reserve with the known density of pirarucu. This density had been obtained from the capture of pirarucus in the same lakes. This set of activities was named Counting Certification, and after the individual comparisons, the counters were either approved or disapproved according to their performance (VIANA et al., 2007; ARANTES et al., 2007).

Despite all these efforts, the counts continue to be performed by the fishers and their results have directly influenced the annual fishing quota authorized by the competent organ. It is known that not all fishers have the same ability to perform precise countings and that they are not always accompanied by technical oversight. Thus, it becomes impossible to know if the fishers involved are appropriately using the counting methodology (CASTELLO et al., 2011), or even if the counting results are being somehow altered, i.e. forged in the interest of the fishers themselves in having their fishing quotas increased. In this case, a lack of direct supervision, or the improper application of the method are factors that may generate incorrect results, provide elevated quotas for inappropriate

reasons, and in extreme cases compromise the pirarucu management system as a whole.

Some mechanisms necessary for monitoring these issues have already been developed, but have not been satisfactorily implemented for several reasons. The regulations for pirarucu fisheries continue to require only that the fishers perform the counting, but this is insufficient for regulating the fishery in light of the possible problems mentioned above (ARANTES et al., 2007; CASTELLO et al., 2011). Therefore, this study proposes a method for evaluating the quality of the pirarucu stock assessment in an inexpensive and replicable way.

MATERIAL AND METHODS

Study site

Among the management systems advised by the Fisheries Management Program of the Mamirauá Institute for Sustainable Development (FMP/MISD), two management areas were selected for investigation of the counting results. These were the Jarauá sector in MSDR, which has performed management since 1999, and the area of the Pantaleão Complex Fishing Agreement, Pantaleão AP, in ASDR, which has conducted managed fisheries since 2008.

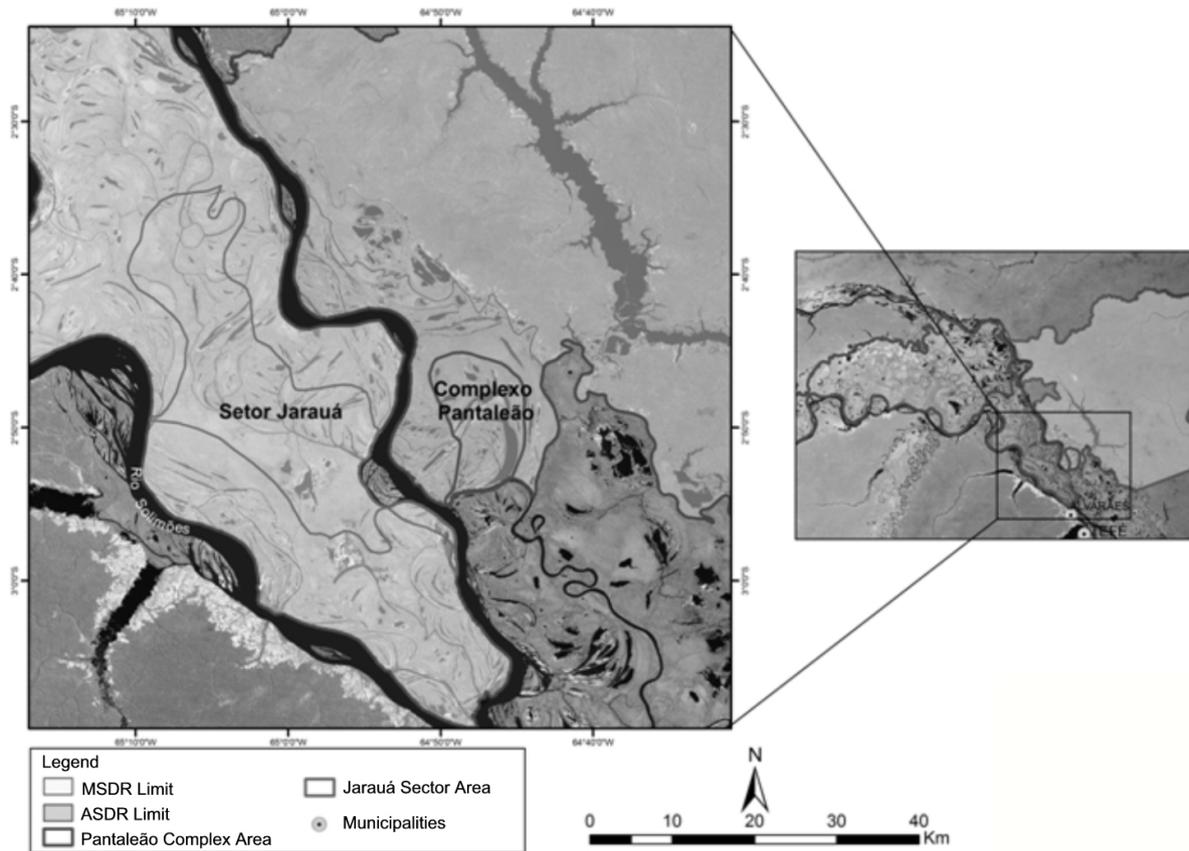


Image 1 - Map of the areas of the Jarauá Sector (MSDR) and the Pantaleão Complex Fishing Agreement (ASDR).

Collection and Analysis

The pirarucu counts were performed by counters in each management area, observing the water level, waiting for all fishing environments to be isolated and no longer have connectivity with other water bodies.

During the counting of the environments by counters from the Jarauá Sector and from the Fishing Agreement of Pantaleão, the fishers responsible for the counting groups filled in the "Counting Forms", following the standard procedure for management of those areas. At the end of the procedure, these fishers sent the counting forms to FMP, with the number of bodecos and pirarucus found in the countings of each environment.

In the year of 2009, during which this work was conducted, two to five days after the count performed by the sector, a previously selected team, composed of experienced counters from other areas, was mobilized to conduct a check. These other fishers then performed a recount of some of the environments counted a few days earlier by local fishers. It is important to note that the counters from Jarauá and Pantaleão AP were not informed about the intention of a verification when the first counts took place.

For the selection of the recount team some criteria were followed by the technicians of FMP/MISD. The most significant were the experience of the fisher in pirarucu fisheries, and provenance of management areas other than those evaluated. In addition, all the recount team members needed to

have achieved a satisfactory performance during the individual evaluation of the certification process for counters, carried out a few years before.

In the present study, the recount of pirarucus was conducted in six fishing environments of the Jarauá Sector: Comprido do Maciel, Poço do Maciel, Samaumerinha do Tucuxi, Curuçá do Centro, Panelão, and Maneco. We also studied four fishing environments of the Pantaleão AP area: Comprido do Pirapucu, Redondo do Pirapucu, Miratinim, and Jacareúba. These 10 fishing environments were selected by criteria that took into account the ease of access for the activity to be carried out quickly, a size sufficient to allow more than one counter to be used in the counting activity, and the absence of any fishing activities in the area between count and recount.

In the environments selected for recount, the team carefully followed the counting methodology defined in Castello (2004), and had no access to the results from counting performed days earlier by local counters in the surveyed areas. In addition, during this period the subpopulations of the lakes remained isolated, and there was no exchange of animals, meeting the presuppositions of closed population in accordance with the methodology developed by Castello (2004).

In each studied area, a local representative accompanied the entire work, and advised on the distribution of the counters in each environment, as well as on the number of countings performed therein during the previous counting. Thus it was possible to replicate the same sampling effort on both countings.

Initially, we verified with FMP how many fishers who participated in the counting of each environment took part in the certification, as this would increase the reliability of the data.

The result of the recount was compared to that of the initial count. We compared the numbers of bodecos, pirarucus and the total number of fishes from this species counted in each evaluated fishing environment, for each sector. We considered counting differences up to 30% as admissible, because, according to Arantes (2007), individual variations in the surveys of pirarucu countings by fishers presented percentage errors below 30%.

We compared the total values found in the counts and recounts in each fishing environment of both sampled areas, Jarauá Sector and Fishing Agreement of Pantaleão. In order to test the normality of the counting results from each environment by area, we used the Komolgorov-Smirnov test. Student's t test ($p \leq 0.05$) was used when the data presented normal distribution, and Levene's test was used for the calculation of variances. When the data did not present normal distribution, we used Mann Whitney's U Test ($p \leq 0.05$), and for the application of all tests we used the STATISTICA 8.0 software.

Considering that the methodology for the conduction of counting (CASTELO, 2004) assumes that each area, or subdivision of the fishing environment, subject to counting should have a maximum of 2 hectares, and should be evaluated by one counter at a time, it is considered that this is a critical rule for applying the method. Therefore, we also analyzed comparisons between the number of counted areas in each of the fishing environments examined in this study.

RESULTS

All 10 fishing environments pre-selected for recount in the Pantaleão AP area and in the Jarauá sector were analyzed. The counting performed in the Jarauá sector involved 14 counters. Of these, nine were certified counters. In the Pantaleão AP area, nine counters took part on the countings. Of these, four participated in the certification process held earlier.

Jarauá Sector

POÇO DO MACIEL

When comparing the values found by counters from the Jarauá sector and by external counters, we found that the number of counted areas, bodecos, pirarucus and total individuals presented no differences above the threshold of 30%.

SAMAUMERINHA DO TUCUXI

In Samaumerinha do Tucuxi lake, the comparisons of the values found by counters from the sector and by external counters revealed differences superior to 30% regarding the number of bodecos, pirarucus and total individuals.

COMPRIDO DO MACIEL

In the environment of Comprido do Maciel, large differences between the number of counted areas, or subunits of the fishing environment were found in the comparison of counts. When we compared the results regarding the number of bodecos, pirarucus and total individuals, we found differences superior to 30% between the values obtained in the countings performed by sector members and by external counters.

PANELÃO

For this fishing environment the difference in number of counted areas was only one. And when we compared the values for the number of bodecos, pirarucus and total individuals the differences were within the 30% range of tolerance.

CURUÇÁ DO CENTRO

For this environment, there was no difference between the values for the number of counted areas and of bodecos. However, we found a difference superior to 30% in the number of pirarucus and total individuals.

MANECO

In Maneco lake the difference between values found by sector counters and external counters regarding the number of bodecos, pirarucus and total individuals was superior to 30%.

Regarding counting as a methodology for stock assessment, we compared the total number of individuals counted in the 6 fishing environments of the Jarauá sector and found significant differences between counts performed by sector counters and external counters, when applying the t Test ($p=0.044$, $F=7.55$) (Figure 1).

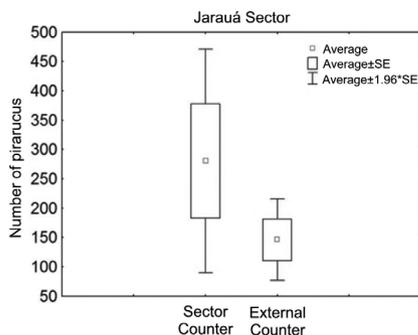


Figure 1 – Chart illustrating the average and standard error of the number of pirarucus counted by sector counters and external counters in fishing environments of the Jarauá Sector.

Area of the Pantaleão Complex Fishing Agreement

MIRATINIM

We compared the values found in countings by AP counters and by counters from outside the Miratinim lake, and found no differences superior to 30% regarding the number of counted areas, bodecos, pirarucus and total individuals.

JACAREÚBA

In Jacareúba lake, we found no differences between the values found by AP counters and by external counters regarding the number of bodecos, pirarucus and total individuals. There was a difference of only one area (plus) in the count by external counters.

REDONDO DO PIRARUCU

In Redondo do Pirarucu lake we found differences superior to 30% for bodecos, pirarucus and total number of individuals. In contrast to all other differences found in the other fishing environments of this study, the differences observed in this fishing environment indicate that the highest values were found during the recount, conducted by external counters, and not in the counting by the AP counters, as expected.

COMPRIDO DO PIRARUCU

Finally, when comparing the values found by AP counters and external counters regarding the number of counted areas, bodecos, pirarucus and total individuals, we found no differences.

When the U Test was applied, to compare the total number of individuals counted in the

four environments of the Fishing Agreement of Pantaleão, there were no significant differences between counting performed by sector counters and by external counters ($U = 7, p = 0.77$) (Figure 2).

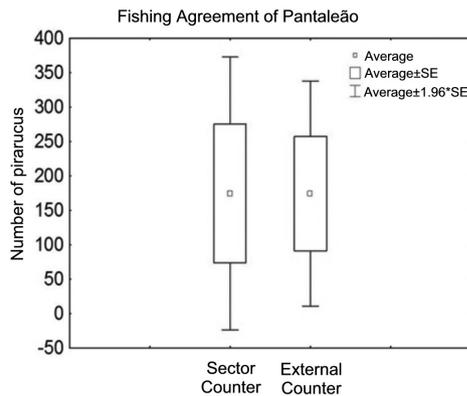


Figure 2 - Chart illustrating the average and standard error of the number of pirarucus counted by sector counters and external counters in fishing environments of the Pantaleão Fishing Agreement.

DISCUSSION

The counts in the Jarauá Sector involved 14 counters, and 9 counters in the Pantaleão Fishing Agreement. Although not all were certified counters, we know that tendencies towards under or overestimation of counting can be minimized or partially canceled when evaluated as a group (ARANTES et al., 2007).

Given that the counting method developed by Castello (2004) demonstrated the ability of fishers in counting pirarucus effectively, and that the majority of fishers involved in the countings during this study were approved in the certification process held years earlier, we consider that the fishers involved know the method and can apply it skillfully.

However, after 10 years of involvement in fishery management of this species, and considering that the counting is still the only criterion for the issuance of annual fishing quotas, we consider that there is a possibility that the procedures are not always correctly developed. As in other managed fishery systems, the beneficiaries always seek to increase their share of benefits, especially when they have access to the means to do so (HILBORN; WALTERS, 1992). People who have access to the Counting Forms, the counters or the board members of fishery organizations can alter the counting results for self-benefit. Another possibility is that skilled and experienced counters can lose their skills over time.

These possibilities could explain the results found in this study, concerning the significant differences obtained from the total counts in the Jarauá sector; and in the fishing environments of Samaumerinha do Tucuxi, Curuçá do Centro, and Maneco, where differences between the countings by external counters and by local counters were superior to 30%, and even differences in the number of counted areas in the environment of Comprido do Maciel were found.

All this suggests that there could be, at any given time, intentional fraud in the counting system. This, in turn, can be detected by means of periodic verifications such as the one described in this work, so that all participants in the management system be aware that there are control mechanisms beyond those which are commonly known. For this reason, we suggest the inclusion of this method for assessing the countings performed by fishers in the standardization of management, aiming at

controlling the quality of the stock assessments. At present, activities seeking to validate of this method are being put into practice, and soon more direct proposals can be formulated by environmental, licensing and control authorities, for the purpose of improving the standardization of this management.

Considering that the system of community management of pirarucus involves organizing communities into associations of producers who also have the role of controlling management through the principle of social control, certain precepts should be carefully observed for the maintenance and correct functioning of this system. They deal with the establishment of rules of use agreed upon by all, and that are in accordance and compliant with current laws. But they also include some participatory activities that are critical to the involvement and mobilization of social actors who benefit from the management. These actions are mainly the creation of forms of social control, such as participatory supervision of fishing areas and environments by the fishers themselves, annual monitoring of the pirarucu stocks (counting) by members of the fishers groups, and tracking of the equitable distribution of benefits among the members of fishery associations or organizations. Another principle that helps in maintaining and operating the system is the establishment of conservative annual fishing quotas, using the precautionary principle in order to ensure, additional protection for the stocks (VIANA et al., 2007). Failure to comply with any of these precepts could jeopardize the system's outcome.

Thus, it is important to develop creation of new indicators for determining the annual fishing quota. If some factors, deliberate or not, may compromise the conduction of countings or even directly influence the quality of information obtained from these countings, there is a high probability that the annual fishing quota issued is inadequate. Arantes and collaborators (2006) identified the pressure of poaching on the resource, the difficulties faced in the conduction of counting by fishers due to fluctuations in the water level, as well as the unavailability of experienced fishers to carry out such countings as important factors that influence the quality of the results. In this work we suggest that intentional factors are also among the difficulties faced in performing the counts.

Alteration of the declared information, aiming to overestimate the stock and increase the quota, and counting groups that do not carefully follow the established method (CASTELO, 2004), can be placed in this category.

It is always important to consider that other indicators beyond stock assessments, could also be involved in the establishment of annual quotas. Amaral (2009) argues that the relation between the authorized quota and the number of pirarucus caught by the fishers can provide a fishing effectiveness indicator, as it portrays both the availability of the resource, complementing the counting, and the organization of the fishers for producing and selling fish. When the establishment of quotas is carried out solely by counting the stock, the generation of this information is so critical that it becomes more vulnerable to fraudulent manipulation.

With counting being currently such a relevant action for the promotion of pirarucu management in Amazonia, the development of forms of assessment and control of the activity, such as the one presented in this study, is of great use. This is especially true when it is a case of a methodology of simple application and diffusion, such as the recount, which involves only the performance of a second count by experienced external counters in some of the fishing environments counted by local counters. Thus, this assessment methodology can be propagated to those areas where the sustainable fishery of pirarucus is being introduced, and where no form of assessing the counts has ever been employed.

CONCLUSIONS

Despite the well-known and recognized ability of pirarucu counters, counting in the Jarauá sector showed overestimation of the number of individuals found in some lakes. The satisfactory results achieved with the recounts enable this instrument to be used in the assessment of the quality of the countings. However, in order to completely validate this technology it is necessary to analyze the values found during the recount in face of the capture and marking of all pirarucus present in the fishing environments, as performed during the original creation of the method, thus making the recount system equally replicable in other locations. However, we reiterate the need for creating additional resources for the establishment of annual fishing quotas, so as to reduce the role of counting and prevent these problems from being so recurrent or so intense that they may compromise the pirarucu stocks with withdrawals beyond the recuperation capacity of the local stock.

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REFERENCES

- AMARAL, E. S. R.; ARANTES, C. C.; BARBOSA, S. Difusão do método de contagem de pirarucu (*Arapaima gigas*) na Amazônia e propostas para sua regulamentação. In: SEMINÁRIO ANUAL DE PESQUISA/INSTITUTO DE DESENVOLVIMENTO SUSTENTÁVEL MAMIRAUÁ, 4, Tefé, 2007. **Resumo**. Tefé: IDSM, 2007.
- AMARAL, E. R. S. **O Manejo Comunitário de Pirarucu (Arapaima Gigas) como Alternativa Econômica para os pescadores das Reservas Amaná e Mamirauá, Brasil**. Dissertação (Mestrado) - Universidade Federal do Pará, Belém, 2009.
- ARANTES, C. C.; SERQUEIRA, D. G.; CASTELLO, L. Densidades de pirarucu (*Arapaima gigas*, Teleostei, Osteoglossidae) nas Reservas de Desenvolvimento Sustentável Mamirauá e Amaná, Amazonas, Brasil. **Uakari**, v. 2, p. 37- 43, 2006.

- ARANTES, C. C.; CASTELLO, L.; SERQUEIRA, D. G. Variações entre contagens de *Arapaima gigas* (Schinz, 1822) (Osteoglossomorpha, Osteoglossidae) feitas por pescadores individualmente em Mamirauá, Brasil. **Pan-American Journal of Aquatic Sciences**, v. 2, p. 263-269, 2007.
- ARANTES, C. C. **Ecologia do pirarucu *Arapaima gigas* (Schinz, 1822) na várzea da Reserva de Desenvolvimento Sustentável Mamirauá, Amazonas, Brasil**. 2009, 72 f. II. Dissertação (Mestrado) - Programa de Pós Graduação em Zoologia, Universidade Estadual de Santa Cruz, Ilhéus, 2009.
- AYRES, M.; AYRES Jr., M.; AYRES, D. L.; SANTOS, A. A. S. **Bioestat 5.0: aplicações estatísticas nas áreas das ciências biológicas e médicas**. Belém: IDSM, 2007. 364 p.
- CASTELLO, L. A method to count pirarucu: fishers, assessment and management. **North American Journal of Fisheries Management**, v. 24, p. 379-389, 2004.
- CASTELLO, L.; PINEDO-VASQUEZ, M.; VIANA, J. P. Participatory conservation and local knowledge in the Amazon várzea: The pirarucu management scheme in Mamirauá. In: PINEDO-VASQUEZ, M. A.; RUFFINO, M.; PADOCH, C. J.; BRONDÍZIO, E. S. (Ed.). **The Amazon varzea: The decade past and the decade ahead**. R. Springer-Verlag, 2011. 466 p., p. 261-176.
- HILBORN, R.; WALTERS, C. J. **Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty**. Chapman & Hall, 1992.
- LOPES, K.; QUEIROZ, H. L. Avaliação do conhecimento tradicional dos pescadores da RDSM. **Uakari**, v. 5, n. 2, p. 59-66, 2009.
- QUEIROZ, H. L.; SARDINHA, A. D. A preservação e o uso sustentado dos pirarucus (*Arapaima gigas*, Osteoglossidae) em Mamirauá. In: QUEIROZ, H. L.; CRAMPTON, W. G. R. (Org.). **Estratégias para manejo dos recursos pesqueiros em Mamirauá**. Brasília: SCM, IPAAM, CNPq, 1999. 210 p.
- QUEIROZ, H. L. **Natural history and conservation of pirarucu, *Arapaima gigas*, at the Amazonian Várzea: red giants in muddy waters**. Tese (Doutorado) - University of St Andrews, Reino Unido, 2000.
- QUEIROZ, H. L.; PERALTA, N. Reserva de desenvolvimento sustentável: manejo integrado dos recursos naturais e gestão participativa. In: GARAY, I.; BECKER, B. K. (Org.). **Dimensões humanas da biodiversidade: o desafio das relações sociedade-natureza no século XXI**. Petrópolis: Vozes, 2006. p. 447-483.
- RAMALHO, E. E.; MACEDO, J.; VIEIRA, T. M.; VALSECCHI, J.; CALVIMONTES, J.; MARMONTEL, M.; QUEIROZ, H. L. Ciclo hidrológico nos ambientes de várzea da Reserva de Desenvolvimento Sustentável Mamirauá – Médio Rio Solimões, Período de 1990 a 2008. **Uakari** v. 5, n. 1, p. 61-87, 2009.

VIANA, J. P.; CASTELLO, L.; DAMASCENO, J. M. B.; AMARAL, E. S. R.; ESTUPINÁN, G. M. B.; ARANTES, C.; BATISTA, G. S.; GARCEZ, D. S.; BARBAODA, S. Manejo Comunitário do Pirarucu *Arapaima gigas* na Reserva de Desenvolvimento Sustentável Mamirauá - Amazonas, Brasil. In: ÁREAS aquáticas protegidas como Instrumento de Gestão Pesqueira. Brasília: Ministério do Meio Ambiente e IBAMA, 2007. p. 239-261.