

## Annotated Bibliography Complete:

Nine peer-reviewed articles are included; of the 9 articles, 3 are secondary sources, and the remaining 6 are primary. The articles are organized by their subjective importance for the review of captive Killer whale behaviour. More important articles outline specific mechanisms underlying observed behaviours.

## Annotated bibliography: Review Article

### Citation:

Marino, L., Rose, N. A., Visser, I. N., Rally, H., Ferdowsian, H., & Slootsky, V. (2020). The harmful effects of captivity and chronic stress on the well-being of orcas (*Orcinus orca*). *Journal of Veterinary Behavior*, 35, 69–82. <https://doi.org/10.1016/j.jveb.2019.05.005>

### Summary:

This review article aims to review research to illustrate the mechanisms of captivity that impose deleterious effects on the; mortality, stress levels, and morbidity of Killer whales (*Orcinus orca*) held in aquarium environments. Unlike many captive organisms, Killer whales experience greater mortality rates, abnormal behaviours, and increased chronic stress compared to wild populations. Neuroanatomy is presented as a critical factor in understanding Killer whale cognition and behaviour. Killer whale brains were observed to contain anatomy consistent with substantial emotional, social, and cognitive complexity mirroring humans. In conjunction with extensive captivity stressors, these factors are likely mechanisms responsible for poor adaptation to captivity.

Captivity introduces a multitude of stressors affecting Killer whales; the authors suggest the greatest stressor is the lack of control Killer whales have over their environment. This lack of control is exemplified through many factors; artificial pod formation, controlled mating, ambient sounds (music, fireworks, and pool filters), and controlled feeding. These constant stressors lead to abnormal behaviours such as "learned helplessness," never observed in the wild, captive Killer whales will become inactive, anti-social, and wholly disengaged with their surroundings.

Furthermore, spatial limitations affect behavior; tank size standards physically limit the variety of behaviours a resident may express. The standard smooth concrete tanks used for Killer whales lead to boredom-related hyperaggression; captive Killer whales have been observed to partake in self-harming behaviours including, banging their heads on parts of enclosures. Social stressors are also prevalent as Killer whale breeding practices undermine the Killer whale's maternal relationships by selling calves or rearing females more frequently. Premade social groups also create an environment where conflict can not be avoided, and conspecific aggression behaviors are increased and abnormal avoidance behaviours (stranding oneself on land). The authors suggest that further research on stress could be conducted using veterinary records.

## Contribution:

This article progresses the captive Killer whale study field by presenting extensive examples of the mechanisms underlying abnormal behaviour observed in captive subjects. The review also presents information on the physical effects of captivity, which provides a holistic approach to the impacts in captivity. This article supports other literature, specifically by acknowledging the Killer whales' social, emotional, and cognitive complexity. This article provides a valuable overview of the scope of the literature review through the presentation of captive behaviours and the underlying mechanisms.

## Annotated Bibliography: Primary Source

### Citation:

Úbeda, Y., Ortín, S., Robeck, T. R., Llorente, M., & Almunia, J. (2021). Personality of killer whales (*Orcinus orca*) is related to welfare and subjective well-being. *Applied Animal Behaviour Science*, 237, 105297. <https://doi.org/10.1016/j.applanim.2021.105297>

### Summary:

The critical background information presented within the article defines a gap in research on the subjective well-being (SWB), personality traits, and welfare of captive cetaceans (infraorder containing Killer whales).

Previously conducted research relating to the factors of interest had been conducted mainly on primates due to their relatedness to humans. However, previously conducted research also found that cetaceans, such as Killer whales, have a similar emotional and cognitive complexity to the previously studied primates. Therefore, this study aimed to fill the gap in research using similar methods.

Primarily, the aim of the researchers in this article was outlined as 2 main objectives. The first objective was to illustrate that a quantitative, thirty-nine-item welfare questionnaire was a reliable means for observing animal welfare. The study's second objective was to investigate correlations between 3 factors: personality traits, subjective well-being, and welfare. These objectives were investigated using a questionnaire-based methodology. 3 questionnaires were used (1 for each factor) and given to fifty raters from various oceanic parks (SeaWorld. Etc.). Raters were required to have a large amount of contact with the Killer whale subjects; there were twenty-six subjects total.

The significant findings suggested that the researcher-produced welfare questionnaire was an innovative method in assessing the welfare of captive Killer whales. The study exposed that correlations exist between the 3 studied factors. The results uncovered a new way for Killer whales and other cetaceans' welfare to be better monitored in captivity. The correlational findings suggest that abnormal behaviors and nervousness are negatively correlated with SWB. This correlation suggests that whales with good well-being tend to have more common

behaviors, as well as the opposite. Further research could be conducted on Killer whales exhibiting abnormal behaviours to assess their SWB and welfare.

#### Contribution:

This article advances the field of researching captive Killer whale behaviour on two main fronts. Firstly, synthesizing a new method to quantify welfare, SWB, and personality traits will allow for an accurate means of quantifying a Killer whale in captivity. Secondly, the correlations discovered between the 3 factors provide a framework that outlines Killer whales that require increased monitoring or environmental enrichment. This article aligned with previous research done on primates; the authors suggested this may illustrate a convergence. This article is significant to literature reviews as it provides a new methodology for further field research.

#### Annotated Bibliography: Primary Article

##### Citation:

Jett, J., Visser, I. N., Ventre, J., Waltz, J., & Loch, C. (2017). Tooth damage in captive orcas (*Orcinus orca*). *Archives of Oral Biology*, 84, 151–160.  
<https://doi.org/10.1016/j.archoralbio.2017.09.031>

##### Summary:

This article investigated the increased rate of tooth damage in captive Killer whales due to behavioural stereotypies. The researchers define stereotypies as repeated behaviours that seem to have no goal or function. Previous research suggests that advanced forms of dental damage are uncommon in free-ranging Killer whales. All occurrences are likely due to abrasive prey types. However, captive Killer whales often feed on dead, non-abrasive prey (fish, squid, and gelatin); therefore, the authors suggest that the causes of tooth decay are primarily behavioural. The researchers observed the dental imaging of twenty-nine captive Killer whales from various facilities to understand further the mechanisms behind increased tooth damage and the prevalence in captivity.

The study found that all twenty-nine of the observed Killer whales possessed some degree of tooth damage. The researchers suggest that a possible cause for increased tooth damage in captive-born individuals may be due to mimicry and observational learning. The captive-born individuals mimic stereotypies from adult Killer whales who were observed to bite and chew features of their tanks. Jaw popping was also observed. Jaw popping stems from conspecific aggression. It involves Killer whales snapping their mouths shut rapidly, resulting in possibly fractured teeth. The researchers derive that these behaviours are primarily unique to captive Killer whales due to the unique stressors of captivity. Previous literature that stereotypies often occur when captive subjects are under stress from fear, boredom, and frustration. These findings provide another example of abnormal behaviours from captive Killer whales as jaw popping and tooth damage are not prevalent in wild populations. This paper provides a foundation for further

research on the mechanisms of captivity that underlie the presence of dental stereotypies. Additionally, dental records may illustrate Killer whale stress levels.

#### Contribution:

This article advances the study of captive Killer whales as it provides an easily observable, unique behavioural stereotypy. These findings provide further evidence that captivity induces abnormal behaviours in confined animals compared to their free-ranging counterparts. This article largely agrees with previous literature as it emphasizes the existence of stressors unique to captivity that influence the behaviour of Killer whales. This article provides an example of self-harming behaviour giving a new perspective to the cognition of Killer whales which reinforces the key aspects of the literature review, which aims to understand the relationship between Killer whale behaviour and captivity.

#### Annotated Bibliography: Review Article

##### Citation:

Law, G., & Kitchener, A. C. (2017). Environmental enrichment for killer whales *Orcinus orca* at zoological institutions: untried and untested. *International Zoo Yearbook*, 51(1), 232–247. <https://doi.org/10.1111/izy.12152>

##### Summary:

This review aims to present possible enrichment strategies for captive Killer whales; the enrichment strategies aim to improve four categories: health and fitness, social, feeding, and environmental. The researchers outline the intelligence and high degree of complexity of Killer whales to be the sources of requiring enrichment strategies. Killer whale confinement has been largely controversial as they exhibit many abnormal behaviours in captivity; this article aims to elicit "natural" behaviours from captive Killer whale populations.

First, the researchers suggest a satellite communication network between various captive and wild Killer whale populations for social enrichment. The basis of this network is to facilitate a greater degree of socializing/stimuli and provide a new method of vocal learning between Killer whales using different dialects. Second, for feeding enrichment, the researchers suggest complex feeding apparatus that require Killer whales to use various naturally observed feeding strategies such as teamwork, suction feeding (using suction to retrieve food from small spaces), and operant conditioning. The increased usage of these strategies will mimic how wild Killer whale populations tend to feed; this, in turn, allows Killer whales to practice instinctual behaviours and have increased stimulus, mirroring natural populations. Third, for health and fitness enrichment, the researchers suggest recreating natural stimulants through training subjects to hold their breath to mimic diving, wave machines, and introducing kelp for skincare. Finally, for environmental enrichment, the authors suggest changing tanks to include softer material where Killer whales cannot damage their teeth when bored, also allowing for echolocation. All suggested strategies

aim to decrease boredom and enable Killer whales to reproduce natural behaviours, increasing their capacity for captivity. Further research should be conducted by implementing these untested strategies to assess their efficacy and practicality for captive Killer whale populations.

#### Contribution:

This article aims to advance the field of captive Killer whale behavior by addressing the shortcomings of captivity that limit a Killer whale's ability to express natural behaviours. This article gives detailed strategies that may improve the well-being of captive Killer whales by increasing the range of behaviours a subject may express and reducing abnormal behaviours expressed. This article supports previous research as it addresses the limitations of confinement and the boredom associated with captivity. This article was included in the literature review as it provides a means to improve captive Killer whales' behavioral range.

#### Annotated Bibliography: Primary Source

#### Citation:

Sánchez–Hernández, P., Krasheninnikova, A., Almunia, J., & Molina–Borja, M. (2019). Social interaction analysis in captive orcas (*Orcinus orca*). *Zoo Biology*, 38(4), 323–333. <https://doi.org/10.1002/zoo.21502>

#### Summary:

The primary objective of this article is to study and analyze a spectrum of social captive Killer whale behaviours. The behaviours observed included agonistic behaviours (conflict), sexual relationships/behaviours, reconciliation behaviour (post-conflict), and affiliative behaviour (friendly/affectionate). The researchers suggest that studying social behaviours and interactions is a valuable indicator of a Killer whale's well-being. Additionally, confined Killer whales can not escape conflict in confinement. Therefore, the study of social interactions will aid in conflict management. The researchers aimed to quantify and observe these social interactions by observing 6 (3 males and 3 females) captive Killer whales over 3 months using underwater cameras at Loro Parque Zoo

The 3-month observation period led to a newly synthesized social behaviour ethogram for Killer whales. The researchers categorized behaviours into the 3 primarily studied categories agonistic, sexual, and affiliative. Researchers then used this information to quantify relationships between the observed individuals. Quantified behavioral interactions between individuals allowed researchers to determine the compatibility of conspecifics. The compatibility of conspecifics was determined by the frequency of behaviours in each category. Furthermore, relationships with increased frequencies of sexual and affiliative behaviours and low frequencies of agonistic behaviours suggested the conspecifics were compatible; the opposite suggested poor compatibility. Additionally, researchers observed and recorded reconciliation behaviour for the first time in Killer whales, described as affiliative behaviours following a conflict.

These results are significant as the researchers produced a new method in determining conspecific compatibility and well-being. This allows for a greater degree of conflict

management and an increased ability to assess the well-being of a captive social group. The researchers suggest that facilities should utilize these strategies to minimize stress. Stress often leads to increased agonism. Further research should be conducted on the stress reduction of captive Killer whales using compatibility metrics and environmental enrichment.

#### Contribution:

This article advances the field of captive Killer whale behaviour research as it illustrates the social complexity between conspecifics and provides an updated ethogram. The newly synthesized ethogram transcends the scope of the researchers as it will allow for conspecific social behaviour to be quantified and assessed. This article is consistent with previous research as it re-emphasizes the importance of stress reduction and captive pod composition. This article provides a new methodology (compatibility assessment) to the literature review of Killer whale research and a frame of reference for social behaviours in the form of an ethogram.

#### Annotated Bibliography: Review Article

#### Citation:

Anderson, R., Waayers, R., & Knight, A. (2016). Orca behavior and subsequent aggression associated with oceanarium confinement. *Animals*, 6(8), 49.  
<https://doi.org/10.3390/ani6080049>

#### Summary:

The aim of this review article is to assess the broadly observed increases in aggressive behaviours of captive Killer whales. The researchers compile several environmental and physiological factors that may produce aggressive interaction with trainers in aquarium settings. The researchers contextualize the review by establishing that Killer whales have the highest encephalization quota behind human. Encephalization is a measure of brain size to body mass ratio, which is often associated with cognitive complexity. This is supported by firsthand observations and previously conducted research that illustrates Killer whales demonstrating high degrees of behavioural complexity when interacting with trainers.

The researchers found that forty-five percent of captive Killer whales at the time of writing had expressed aggressive behaviours towards humans. The researchers outlined multiple factors in association with the aggressive interactions. Primarily, 1 factor leading to increased aggressive behaviours was Killer whale-human interactions, Killer whales who had unstructured and regular socializing in petting pools become more aggressive later in life. The authors propose that the early socialization with humans was an enriching experience for Killer whales, but once Killer whales began to perform, they traveled globally and no longer experienced petting pools. The researchers hypothesized that Killer whales become cautious of humans and frustrated with the lack of enrichment they received later in life.

The increased prevalence of aggressive incidents of captive Killer whales is still not greatly understood. The Killer whales were extremely complex and exhibited manipulative behaviours that allowed them to make aggressive expressions (lunging, biting, and more). The authors suggest that the Killer whale's ability to form bonds with humans must be further investigated. A better understanding of Killer whale-human friendships should enable the prevention of aggressive interactions. This is due to the underlying mechanism not being completely transparent, but aspects of human-Killer whale relationships lead to increased aggression.

#### Contribution:

This research advances the study of captive Killer whale behaviour because it illustrates a behavioural interaction that is unique to captivity. Rather than conspecific aggression and social structure that has been thoroughly studied in previous works, this presents cases of human-Killer whale interactions. Despite the unique social interaction being studied the article presented a reoccurring mechanism for abnormal behaviours, environmental enrichment, or lack of. Furthermore, this research suggests that human interaction is a form of enrichment and can greatly affect the behaviours of captive Killer whales. This article provides the literature review unique captive behaviours stemming from widely studied mechanisms.

#### Annotated Bibliography: Primary Source

##### Citation:

Graham, M. A., & Noonan, M. (2010). Call types and acoustic features associated with aggressive chase in the killer whale (*Orcinus orca*). *Aquatic Mammals*, 36(1), 9–18.  
<https://doi.org/10.1578/AM.36.1.2010.9>

##### Summary:

The primary objective of this article is to investigate agonistic and aggressive interactions between captive Killer whales. The research was primarily focused on exploring the acoustic communication that accompanied agonistic behaviours. The investigation of Killer whales' agonistic behaviours and interactions is very consequential for the analysis of social interactions. Therefore, this study aims to fill a void in Killer whale research about episodes of agonism better to understand acoustic communication and behavior during these episodes. The researchers believe this is best done in captivity as it allows them to observe the behaviour and call simultaneously.

The researchers used a minimal sample size; two captive Killer whales (1 male and 1 female) from Marineland were observed. The method of observation was a combination of recording Killer whale vocalization and the corresponding behaviour. Observations were conducted by observing Killer whales through submerged windows in the enclosure as well as audio recordings. The researchers focused on agonistic interactions defined by intense chasing, aggressive mouth movements towards genitals, and fluking (lifting tail before diving).

The researchers found that Killer whale vocalizations increased during aggressive interactions, and Killer whales produced distinct tones of various calls. The authors compare the tone changes of calls to the way an emotionally charged human may change tones. Observations also revealed that specific vocalizations were distinctly associated with aggression. The study also revealed that the female was the aggressor in all observed interactions, positively correlating with Killer whales' matriarchal social hierarchy. This paper produces new information describing predisposed causes of aggression between conspecifics and the importance of vocal communication in captive Killer whales. The discovery of distinct tones and calls can allow for the social behaviours of captive Killer whales to be better catalogued. Further research should investigate the causes of conspecific agonism.

#### Contribution:

This article advances the research of captive Killer whale behaviour as it presents observational evidence of conspecific agonism and aggressive vocalization. These findings give further insight into the social dynamics of captive Killer whales and their ancestral social structures. This article agrees with previous research as it illustrates the prevalence of the matriarchal social system in Killer whales. However, this article also presents the first time that maternity may be associated with agonism in the literature review. In conclusion, this article defines agonistic behaviors and provides the literature review with insight into agonistic vocalizations.

#### Annotated Bibliography: Primary Source

##### Citation:

Kremers, D., Lemasson, A., Almunia, J., & Wanker, R. (2012). Vocal sharing and individual acoustic distinctiveness within a group of captive orcas (*Orcinus orca*). *Journal of Comparative Psychology*, 126(4), 433–445. <https://doi.org/10.1037/a0028858>

##### Summary:

The primary objective of this article is to investigate the complex social groupings of captive Killer whales and analyze vocalizations from individuals to distinguish non-shared (distinct) calls from shared (ancestral) calls. Killer whales are vocal learners and have pod-specific dialects. Therefore, the researchers aim to understand if individuals also have distinct acoustic signatures. The research focuses on captivity-unique causes that may create vocal distinctiveness and ancestral causes responsible for shared dialects. Even in captivity, the researchers hypothesize that Killer whales display ancestral vocalizations. The article describes vocal learning as an influential factor leading to pod-specific communication and distinct vocalizations, which may be affected by the captive environment.

The researchers observed the vocalizations of 4 (2 males and 2 females) second-generation captive Killer whales. Collected observations were used to build individual vocal repertoires of



each captive member to assess distinctiveness. The ancestors of these captive Killer whales were Icelandic-Canadian-ranging Killer whales. It was also defined that all captive Killer whales were transported to their current location from various facilities.

The researchers discovered that despite being second-generation captive Killer whales, the vocalizations broadly resembled the ancestral dialects of Icelandic-Canadian-ranging Killer whales. This is significant as it suggests that ancestral behaviours persist in captivity in the form of vocal learning. However, the researchers also suggest that captivity impacts the vocal learning and socialization of Killer whales. The movement of Killer whales between facilities is believed to cause conspecifics to learn individual dialects rather than the ancestral shared dialects. This is likely due to the lack of uniformity in vocalizations within unstable social groupings. The lack of stability causes changes in vocal learning and likely social behaviours. Further research should investigate the behavioural effects of having multiple dialects present.

#### Contribution:

This article furthers the research of captive Killer whale behaviour because it describes vocal learning and sharing between Killer whales and how captivity affects these vocalizations. This article offers insight into the effects of ancestral life-history traits and how unstable social settings cause changes to these behaviours. The production of new behaviours in captivity is a common theme across many studies. However, the benefits or drawbacks of this change are unclear. This article contributes to the literature review as it describes further behavioural changes caused by captivity. However, it also outlines a new mechanism for learning in captivity.

#### Annotated Bibliography: Primary Source

##### Citation:

Úbeda, Y., Ortín, S., St. Leger, J., Llorente, M., & Almunia, J. (2019). Personality in captive killer whales (*Orcinus orca*): A rating approach based on the five-factor model. *Journal of Comparative Psychology*, 133(2), 252–261. <https://doi.org/10.1037/com0000146>

##### Summary:

This article investigated the structure of Killer whale (*Orcinus orca*) personality using a 5-factor model comprised of extraversion, dominance, conscientiousness/agreeableness, and careful factor. Previous research using this personality model exists on humans, primates, and dolphins. However, no previous research has been conducted on Killer whales using this model. The objective of this research was to utilize this model on captive Killer whales and compare the results to previous research on various species.

The study was conducted on twenty-four captive Killer whales using fifty-five raters who had high contact with the subjects. The raters observed Killer whales and rated the presence of thirty-eight personality describing adjectives.

The study results suggested that the Killer whale personality structure is similar to the personality structure of the chimpanzee. The researchers suggest that the tested personality factors are correlated strongly with many of the same factors found in humans and chimpanzees, which illustrates a possible convergence. Additionally, the results also suggest that the personality complexities of the Killer whale may contribute to the social complexity of Killer whales. Based on the personality similarities between Killer whales and chimpanzees, the researchers suggest that this type of personality may contribute to behaviors such as teaching, learning, and social interactions. The significance of this article is based on the determination of personality structure. These findings enable the researchers to draw conclusions from Killer whale behavioural tendencies based on a comparative methodology with abundant research. The comparisons between a Killer whale and chimpanzee personality also establishes a foundation upon which further research may be produced. Further research can further explore the distinct personalities between captive and free-ranging Killer whales to understand the effects of captivity further. Furthermore, the researchers suggest that additional research between closely related species may provide evolutionary insight into observed personalities.

#### Contribution:

This article advances the field of researching captive Killer whale behaviour because establishing personality factors may provide greater insight into the source of behaviours. Additionally, these findings may also further the understanding of the social nature of Killer whales, especially when compared to well-researched and socially complex primates, such as chimpanzees. This article agrees with previously conducted research as it acknowledges the complexity of Killer whales as well as the comparison with primates. This article adds to the literature review an understanding of Killer whale personality which may help understand behavioural expression in captivity.