## 附录1　文献检索语言与数据库(网站)

Appendix 1　Literature retrieval languages and databases (websites)

| 语言 Language | 数据库(网站) Database (Website) |
|---|---|
| 英语 English | Web of Science (www.webofknowledge.com) |
| | Scopus (https://www.scopus.com) |
| | Indianjournals (http://www.indianjournals.com/) |
| 汉语 Chinese | 中国知网China National Knowledge Infrastructure (https://www.cnki.net/) |
| 西班牙/葡萄牙语 Spanish/Portuguese | SciELO (https://scielo.org/en) |
| 日语 Japanese | J-Stage (https://www.jstage.jst.go.jp) |
| 俄语 Russian | Elibrary (https://elibrary.ru/defaultx.asp) |

**数据库：Web of Science**

时间范围：1950.01.01–2024.12.31

检索规则：

TS = ("vertebra* pest*" OR *bird* OR avian* OR waterfowl* OR "avian predator*" OR wigeon* OR duck* OR stork* OR crane* OR falcon* OR owl* OR eagle* OR osprey* OR murre* OR raptor* OR shikra* OR ibis* OR boob* OR cormorant* OR pelican* OR grebe* OR egret* OR heron* OR loon* OR mergus OR darter* OR petrel* OR eider* OR garganey* OR spoonbill OR gadwall OR shoveler OR goldeneye* OR mallard* OR pochard* OR scaup* OR scoter* OR shelduck* OR smew* OR teal* OR tern OR gannet* OR skimmer* OR gull* OR shearwater OR swamphen* OR moorhen OR coot* OR rail OR jacana* OR avocet* OR curlew* OR dowitcher OR kingfisher* OR oystercatcher* OR phalarope OR sanderling OR sandpiper OR snipe* OR plover* OR stint* OR lapwing*)

AND TS = (*ffect* OR conflict* OR consum* OR depreda* OR disturb* OR explo* OR fed OR feed* OR fora* OR hunt* OR impact* OR interact* OR kill* OR pest* OR predat* OR prey* OR reduc* OR risk* OR use*)

AND TS = (*fish* OR gastropod* OR sipuncula* OR echinoderm* OR mussel* OR turtle* OR "black drum*" OR "marine shrimp*" OR "sea food*" OR "red drum*" OR "sea cucumber*" OR "sea gut*" OR "sea spider*" OR "sea urchin*" OR "sea bream*" OR "sea weed*" OR "sea bass*" OR "shi drum*" OR amberjack* OR anchov* OR anemone* OR arkshell* OR beluga* OR bivalve* OR bonito* OR broiler* OR bullfrog* OR carp* OR catla* OR caviar* OR clam* OR cobia* OR cockle* OR pollock* OR haddock* OR hake* OR cod* OR crab* OR croaker* OR dentex* OR dorado* OR eel* OR frog* OR gob* OR grouper* OR flounder* OR halibut* OR largemouth* OR leatherjacket* OR lobster* OR minnow* OR mojarra* OR moll* OR moray* OR mullet* OR octopu* OR oyster* OR pearl* OR pecten* OR perch* OR sturgeon* OR ossetra OR pompano* OR prawn* OR salmon* OR sardin*

OR scallop* OR

sevruga* OR shell* OR shrimp* OR silversid* OR smelt* OR snail* OR snakehead* OR snapper* OR sole* OR spinefoot* OR squid* OR stingray* OR surubim* OR tambaqui* OR tarpon* OR tilapia* OR trout* OR tuna*)

AND TS = (aquacultur* OR maricultur* OR aquafarm* OR aquarium OR "flow through system*" OR

intertidal OR "marine ranch*" OR "ocean ranch*" OR "saline and alkaline soil" OR "open ocean" OR

river* OR pond* OR cage* OR coastal* OR estuar* OR raft* OR farm* OR hatchery* OR lake* OR mangrove* OR marsh* OR mudflat* OR reservoir*)

AND TS = (batch* OR biomass OR catch* OR earn* OR cost* OR count* OR harvest* OR head* OR loss* OR mortalit* OR number* OR output* OR population* OR produc* OR profit* OR quantit* OR revenue* OR stock* OR trade* OR valu* OR yield* OR "encounter* rat*" OR abundance* OR "deter* rat*" OR "visit* rat*" OR scar*)

AND TS = ("acoustic* devic*" OR "human patrol*" OR "straw man*" OR "supplement* feed*" OR "surface* cover*" OR "visual* deterr*" OR bait* OR barri* OR control* OR cull* OR deterr* OR treat* OR device* OR fenc* OR guard* OR increas* OR interven* OR measure* OR manage* OR mitigat* OR net* OR optimiz* OR poison* OR polic* OR protect* OR repel* OR scare* OR shoot* OR sound* OR voic* OR vocal* OR trap* OR sprinkl* OR laser* OR strawman*)

NOT TS = ("shelf life" OR "signal* pathway*" OR antibacterial OR antibody OR acid* OR carbon OR cell* OR chemical OR chick* OR child* OR chromosome OR DNA OR embryos OR gene* OR geno* OR hormone OR immune OR immunity OR micro* OR molecular OR morphology OR muscle OR pathology OR peeled OR phenotyp* OR physiology OR primer OR protein OR RNA OR toxicity OR toxicology OR transcriptome OR triploid)

Exclusion: Patent

**Scopus**

时间范围：1950.01.01–2024.12.31.

检索规则：

(TITLE-ABS-KEY ( "vertebra* pest*" OR *bird* OR avian* OR waterfowl* OR "avian predator*" OR wigeon* OR duck* OR stork* OR crane* OR falcon* OR owl* OR eagle* OR osprey* OR murre* OR raptor* OR shikra* OR ibis* OR boob* OR cormorant* OR pelican* OR grebe* OR egret* OR heron* OR loon* OR mergus OR darter* OR petrel* OR eider* OR garganey* OR spoonbill OR gadwall OR shoveler OR goldeneye* OR mallard* OR pochard* OR scaup* OR scoter* OR shelduck* OR smew* OR teal* OR tern OR gannet* OR skimmer* OR gull* OR shearwater OR swamphen* OR moorhen OR coot* OR rail OR jacana* OR avocet* OR

curlew* OR dowitcher OR kingfisher* OR oystercatcher* OR phalarope OR sanderling OR sandpiper OR snipe* OR plover* OR stint* OR lapwing* ) AND TITLE-ABS-KEY ( *ffect* OR conflict* OR consum* OR depreda* OR disturb* OR explo* OR fed OR feed* OR fora* OR hunt* OR impact* OR interact* OR kill* OR pest* OR predat* OR prey* OR reduc* OR risk* OR use* ) AND TITLE-ABS-KEY ( *fish* OR gastropod* OR sipuncula* OR echinoderm* OR mussel* OR turtle* OR "black drum*" OR "marine shrimp*" OR "sea food*" OR "red drum*" OR "sea cucumber*" OR "sea gut*" OR "sea spider*" OR "sea urchin*" OR "sea bream*" OR "sea weed*" OR "sea bass*" OR "shi drum*" OR amberjack* OR anchov* OR anemone* OR arkshell* OR beluga* OR bivalve* OR bonito* OR broiler* OR bullfrog* OR carp* OR catla* OR caviar* OR clam* OR cobia* OR cockle* OR pollock* OR haddock* OR hake* OR cod* OR crab* OR croaker* OR dentex* OR dorado* OR eel* OR frog* OR gob* OR grouper* OR flounder* OR halibut* OR largemouth* OR leatherjacket* OR lobster* OR minnow* OR mojarra* OR moll* OR moray* OR mullet* OR octopu* OR oyster* OR pearl* OR pecten* OR perch* OR sturgeon* OR ossetra OR pompano* OR prawn* OR salmon* OR sardin* OR scallop* OR sevruga* OR shell* OR shrimp* OR silversid* OR smelt* OR snail* OR snakehead* OR snapper* OR sole* OR spinefoot* OR squid* OR stingray* OR surubim* OR tambaqui* OR tarpon* OR tilapia* OR trout* OR tuna* ) AND TITLE-ABS-KEY ( aquacultur* OR maricultur* OR aquafarm* OR aquarium OR "flow through system*" OR intertidal OR "marine ranch*" OR "ocean ranch*" OR "saline and alkaline soil" OR "open ocean" OR river* OR pond* OR cage* OR coastal* OR estuar* OR raft* OR farm* OR hatchery* OR lake* OR mangrove* OR marsh* OR mudflat* OR reservoir* ) AND TITLE-ABS-KEY ( batch* OR biomass OR catch* OR earn* OR cost* OR count* OR harvest* OR head* OR loss* OR mortalit* OR number* OR output* OR population* OR produc* OR profit* OR quantit* OR revenue* OR stock* OR trade* OR valu* OR yield* OR "encounter* rat*" OR abundance* OR "deter* rat*" OR "visit* rat*" OR scar* ) AND TITLE-ABS-KEY ( "acoustic* devic*" OR "human patrol*" OR "straw man*" OR "supplement* feed*" OR "surface* cover*" OR "visual* deterr*" OR bait* OR barri* OR control* OR cull* OR deterr* OR treat* OR device* OR fenc* OR guard* OR increas* OR interven* OR measure* OR manage* OR mitigat* OR net* OR optimiz* OR poison* OR polic* OR protect* OR repel* OR scare* OR shoot* OR sound* OR voic* OR vocal* OR trap* OR sprinkl* OR laser* OR strawman* ) AND NOT TITLE-ABS-KEY ( "shelf life" OR "signal* pathway*" OR antibacterial OR antibody OR acid* OR carbon OR cell* OR chemical OR chick* OR child* OR chromosome OR dna OR embryos OR gene* OR geno* OR hormone OR immune OR immunity OR micro* OR molecular OR morphology OR muscle OR pathology OR peeled OR phenotyp* OR physiology OR primer OR protein OR rna OR toxicity OR toxicology OR transcriptome OR triploid ) ) AND PUBYEAR > 1950 AND PUBYEAR < 2026

**中国知网 CNKI**

时间范围：1950.01.01–2024.12.31

检索规则：

SU%=("水产"+"海产"+塘+鱼+虾+蛏+蚌+"牡蛎"+贝+"海参"+螺+蛤) *鸟 NOT SU%=(画+诗)

补充检索关键词：“鸟害”

**SciELO**

时间范围：1950.01.01–2024.12.31.

检索规则：

subject: (pájaro* OR aves OR “ave* acuática*” OR “ave* de presa” OR “pato* silb*” OR pato* OR cigüeña* OR grulla* OR halc* OR búho* OR águila* OR “águila* pescadora*” OR arao* OR rapaz OR rapaces OR ibis OR piquero* OR Alcatra* OR cormor* OR pelícano* OR zampull* OR garceta* OR garza* OR colimbo* OR serreta* OR anhinga* OR petrel* OR eider* OR “carreta* carretona*” OR espátula* OR “ánade* friso*” OR “pato* cuchara” OR “porr* americano*” OR “ánade* real*” OR “porr* azul*” OR negrón OR negrones OR “tarro* blanco*” OR cerceta* OR charr* OR rayadora* OR gaviota* OR pardela* OR calamón OR calamones OR “polla* de agua” OR focha* OR rascón OR rascones OR jacana* OR avoceta* OR zarapito* OR “mart* pescador*” OR ostrero* OR falaropo* OR “correlimos tridáctilo*” OR andarríos OR agachadiza* OR chorlito* OR correlimos OR avefría*) AND subject: (efecto* OR conflicto* OR consumo OR depredac* OR perturbac* OR explotac* OR alimentac* OR forrajeo OR caza OR impacto* OR interacci* OR matar OR plaga* OR predaci* OR presa* OR reducci* OR riesgo* OR uso*) AND subject: (pez OR peces OR pescado OR gasterópodo* OR sipúnculo* OR equinodermo* OR mejillón OR mejillones OR Tortuga* OR "corvina* Negra*" OR "camar* marino" OR marisco OR "corvina* roja*" OR "pepino* de mar" OR OR "araña* de mar" OR "erizo* de mar" OR "dorada*" OR "alga* marina*" OR lubina* OR “pez limón” OR anchoa* OR anémona* OR “concha* de arca” OR beluga OR bivalve* OR bonito OR verrugato OR corvallo OR maigre OR “rana* toro” OR carpa* O catla* OR caviar OR almeja* OR cobia* OR berberecho* OR abadejo* OR eglefino* OR merluza* OR bacalao* OR cangrejo* OR corvina* OR dentón OR dorado* OR dorada* OR anguila* OR rana* OR gobio* OR mero* OR platija* OR fletán OR langosta* OR ciprínido* OR mojarra* OR morena* OR mújol* OR pulpo* OR ostra* OR perla* OR pecten* OR perca* OR esturi* OR osetra* OR pompano* OR palometa* OR langostino* OR salmón OR salmones OR sardina* OR vieira* OR sevruga* OR concha* OR camarón OR camarones OR pejerrey* OR eperlano* OR caracol* OR ”cabeza* de serpiente” OR pargo* OR lenguado* OR calamar* OR raya* OR surubí OR tambaquí OR cachama* OR sábalo* OR tilapia* OR trucha* OR atún OR atunes) AND subject:(piscifactoría* OR acuicultura OR maricultura OR acuacultura OR acuario* OR "sistema de flujo continuo" OR intermareal OR "granja* marina*" OR "suelo salino y alcalino" OR océano* OR río* OR estanque* OR jaula* OR costero* OR estuario* OR balsa* OR granja* OR criadero* OR lago* OR mangler* OR pantano* OR lodazal* OR embalse*) AND subject: (lote* OR biomasa OR captura* OR ganancia* OR costo* OR conteo* OR cosecha OR cabeza* OR pérdida* OR mortalidad OR número* OR producción OR población OR beneficio* OR cantidad* OR ingresos OR existencias OR comercio OR valor* OR rendimiento* OR “control de plagas” OR abundancia OR disuasión OR rata* OR cicatri*) AND NOT subject: ("dispositivo* acústico*" OR patrulla* OR espantapájaros OR suplemento* OR “cobertura superficial” OR “disuasión visual" OR cebo* OR barrera* OR control* OR sacrificio* OR interven* OR "dispositivo* visual*" OR cercado* OR guardia* OR aument* OR medida* OR gestion* OR mitig* OR red* OR optimi* OR envenen* OR policía OR protecc* OR repel* OR asust* OR dispar* OR Sonido* OR voz OR vocal OR trampa* OR rociar OR láser)

*其他语言数据库根据统一的检索规则进行检索，未获得有效文献。

*Rule 1: Avian*

*TS=("vertebra* pest*" OR *bird* OR avian* OR waterfowl* OR "avian predator*" OR wigeon* OR duck* OR stork* OR crane* OR falcon* OR owl* OR eagle* OR osprey* OR murre* OR raptor* OR shikra* OR ibis* OR boob* OR cormorant* OR pelican* OR grebe* OR egret* OR heron* OR loon* OR mergus OR darter* OR petrel* OR eider* OR garganey* OR spoonbill OR gadwall OR shoveler OR goldeneye* OR mallard* OR pochard* OR scaup* OR scoter* OR shelduck* OR smew* OR teal* OR tern OR gannet* OR skimmer* OR gull* OR shearwater OR swamphen* OR moorhen OR coot* OR rail OR jacana* OR avocet* OR curlew* OR dowitcher OR kingfisher* OR oystercatcher* OR phalarope OR sanderling OR sandpiper OR snipe* OR plover* OR stint* OR lapwing*)*

*Rule 2: Effects*

*TS=(*ffect* OR conflict* OR consum* OR depreda* OR disturb* OR explo* OR fed OR feed* OR fora* OR*

*hunt* OR impact* OR interact* OR kill* OR pest* OR predat* OR prey* OR reduc* OR risk* OR use*)*

*Rule 3: Aquaculture site/modal*

*TS=(*fish* OR gastropod* OR sipuncula* OR echinoderm* OR mussel* OR turtle* OR "black drum*" OR "marine shrimp*" OR "sea food*" OR "red drum*" OR "sea cucumber*" OR "sea gut*" OR "sea spider*" OR "sea urchin*" OR "sea bream*" OR "sea weed*" OR "sea bass*" OR "shi drum*" OR amberjack* OR anchov* OR anemone* OR arkshell* OR beluga* OR bivalve* OR bonito* OR broiler* OR bullfrog* OR carp* OR catla* OR caviar* OR clam* OR cobia* OR cockle* OR pollock* OR haddock* OR hake* OR cod* OR crab* OR croaker* OR dentex* OR dorado* OR eel* OR frog* OR gob* OR grouper* OR flounder* OR halibut* OR largemouth* OR leatherjacket* OR lobster* OR minnow* OR mojarra* OR moll* OR moray* OR mullet* OR octopu* OR oyster* OR pearl* OR pecten* OR perch* OR sturgeon* OR ossetra OR pompano* OR prawn* OR salmon* OR sardin* OR scallop* OR sevruga* OR shell* OR shrimp* OR silversid* OR smelt* OR snail* OR snakehead* OR snapper* OR sole* OR spinefoot* OR squid* OR stingray* OR surubim* OR tambaqui* OR tarpon* OR tilapia* OR trout* OR tuna*)*

*Rule 4: Yield/encounter*

*TS=(aquacultur* OR maricultur* OR aquafarm* OR aquarium OR "flow through system*" OR intertidal OR "marine ranch*" OR "ocean ranch*" OR "saline and alkaline soil" OR "open ocean" OR river* OR pond* OR cage* OR coastal* OR estuar* OR raft* OR farm* OR hatchery* OR lake* OR mangrove* OR marsh* OR mudflat* OR reservoir*)*

*Rule 5: Measure*

*TS=(batch* OR biomass OR catch* OR earn* OR cost* OR count* OR harvest* OR head* OR loss* OR mortalit* OR number* OR output* OR population* OR produc* OR profit* OR quantit* OR revenue* OR stock* OR trade* OR valu* OR yield* OR "encounter* rat*" OR abundance* OR "deter* rat*" OR "visit* rat*" OR scar*)*

*Rule 6: Exclusion*

*TS=("acoustic* devic*" OR "human patrol*" OR "straw man*" OR "supplement* feed*" OR "surface* cover*" OR "visual* deterr*" OR bait* OR barri* OR control* OR cull* OR deterr* OR treat* OR device* OR fenc* OR guard* OR increas* OR interven* OR measure* OR manage* OR mitigat* OR net* OR optimiz* OR poison* OR polic* OR protect* OR repel* OR scare* OR shoot* OR sound* OR voic* OR vocal* OR trap* OR sprinkl* OR laser* OR strawman*)*

*补充检索Google Scholar以主题相关的短句进行多次检索，获得相关非重复有效文献8篇。

尚晓彤, 黄程, 杨立, 牟希东, 李添明, 刘阳 (2026) 全球尺度水产养殖系统减少鸟类致损措施成效评估. 生物多样性, 34, 25453. doi: 10.17520/biods.2025453. https://www.biodiversity-science.net/CN/10.17520/biods.2025453.

## 附录**2** 养殖水产种类

## Appendix 2 Aquaculture animal species

| 类型 Types | 种类 Species | 频次 Frequency |
|---|---|---|
| 鱼类 Fish | 鲶鱼 Catfish *Ictalurus punctatus* | 33 |
| 鱼类 Fish | 罗非鱼 Tilapia *Tilapia nilotica* | 20 |
| 鱼类 Fish | 虹鳟鱼 Rainbow Trout *Oncorhynchus mykiss* | 17 |
| 鱼类 Fish | 鲤鱼 Carp *Cyprinus carpio* | 7 |
| 鱼类 Fish | 褐鳟 Brown trout *Salmo trutta* | 4 |
| 鱼类 Fish | 美国红鱼 Red drum *Sciaenops ocellatus* | 3 |
| 鱼类 Fish | 拟鲤 Roach *Rutilus rutilus* | 3 |
| 鱼类 Fish | 河鲈 Perch *Perca fluviatilis* | 3 |
| 鱼类 Fish | 革胡子鲶 African catfish *Clarias gariepinus* | 3 |
| 鱼类 Fish | 阳光鲈鱼 Sunshine bass (雌性白鲈 *Morone chrysops* × 雄性条纹鲈 *M. saxatilis*) | 2 |
| 鱼类 Fish | 丁鳜 Tench *Tinca tinca* | 2 |
| 鱼类 Fish | 圆腹雅罗鱼 Ide *Leuciscus idus* | 1 |
| 鱼类 Fish | 西鲑 Crucian carp *Carassius carassius* | 1 |
| 鱼类 Fish | 梭鲈 Pikeperch *Sander lucioperca* | 1 |
| 鱼类 Fish | 食蚊鱼 Mosquito fish *Gambusia affinis* | 1 |
| 鱼类 Fish | 神仙鱼(燕鱼) Freshwater Angelfish *Genus Pterophyllum* | 1 |
| 鱼类 Fish | 小斑柄竺鲷 Southern Cardinalfish *Vincentia conspersa* | 1 |
| 鱼类 Fish | 古比鱼 Guppy *Poecilia reticulata* | 1 |
| 鱼类 Fish | 金灰色鲻鱼 Golden Grey Mullet *Liza aurata* | 1 |
| 鱼类 Fish | 金体美鳊 Golden Shiner *Notemigonus crysoleucas* | 1 |
| 鱼类 Fish | 红眼鱼 Rudd *Scardinius erythrophthalmus* | 1 |
| 鱼类 Fish | 黑莲灯鱼 Black Neon Tetra *Hyphessobrycon herbertaxelrodi* | 1 |
| 鱼类 Fish | 海鳟 Sea trout *Salmo trutta* | 1 |
| 鱼类 Fish | 粉红丝足鲈 Pink Gourami *Helostoma temminckii* | 1 |
| 鱼类 Fish | 慈鲷鱼 Cichlid Cichlidae | 1 |
| 鱼类 Fish | 草鱼 Grass carp *Ctenopharyngodon idella* | 1 |
| 鱼类 Fish | 薄唇鲻 Thinlip Mullet *Liza ramada* | 1 |
| 鱼类 Fish | 白斑狗鱼 Pike *Esox lucius* | 1 |
| 软体动物 Mollusks | 蓝贻贝 Blue mussel *Mytilus edulis* | 14 |
| 软体动物 Mollusks | 牡蛎 Oyster Ostreidae | 8 |
| 软体动物 Mollusks | 硬蛤 Northern quahogs (hard clams) *Mercenaria mercenaria* | 1 |
| 甲壳类 Crustaceans | 澳大利亚淡水小龙虾 Yabby *Cherax destructor* | 3 |
| 甲壳类 Crustaceans | 蓝蟹 Blue crab *Callinectes sapidus* | 2 |
| 甲壳类 Crustaceans | 中华绒螯蟹 Chinese Mitten Crab *Eriocheir sinensis* | 1 |

尚晓彤, 黄程, 杨立, 牟希东, 李添明, 刘阳 (2026) 全球尺度水产养殖系统减少鸟类致损措施成效评估. 生物多样性, 34, 25453. doi: 10.17520/biods.2025453. https://www.biodiversity-science.net/CN/10.17520/biods.2025453.

## 附录3　冲突鸟类名录

## Appendix 3　List of conflict-birds

| 目 Order | 科 Family | 种 Species | 频率 Frequency |
|---|---|---|---|
| 鹰形目 Accipitriformes | 鹰科Accipitridae | 鹗Osprey *Pandion haliaetus* | 34 |
| 鹰形目 Accipitriformes | 鹰科Accipitridae | 黑鸢 Black Kite *Milvus migrans* | 2 |
| 雁形目 Anseriformes | 鸭科Anatidae | 鹊鸭Common Goldeneye *Bucephala clangula* | 7 |
| 雁形目 Anseriformes | 鸭科Anatidae | 欧绒鸭Common Eider *Somateria mollissima* | 5 |
| 雁形目 Anseriformes | 鸭科Anatidae | 棕胁秋沙鸭Hooded Merganser *Lophodytes cucullatus* | 3 |
| 雁形目 Anseriformes | 鸭科Anatidae | 加拿大黑雁Canada Goose *Branta canadensis* | 1 |
| 雁形目 Anseriformes | 鸭科Anatidae | 斑背潜鸭Greater Scaup *Aythya marila* | 1 |
| 雁形目 Anseriformes | 鸭科Anatidae | 长尾鸭Long-Tailed Duck *Clangula hyemalis* | 1 |
| 雁形目 Anseriformes | 鸭科Anatidae | 绿头鸭Mallard *Anas platyrhynchos* | 1 |
| 雁形目 Anseriformes | 鸭科Anatidae | 蓝翅鸭Blue-winged Teal *Spatula discors* | 1 |
| 鹈形目 Pelecaniformes | 锤头鹳科 Scopidae | 锤头鹳Hamerkop *Scopus umbretta* | 7 |
| 鹈形目 Pelecaniformes | 鹈鹕科 Pelecanidae | 褐鹈鹕Brown Pelican *Pelecanus occidentalis* | 3 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 大蓝鹭Great Blue Heron *Ardea Herodias* | 17 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 夜鹭Black-crowned Night Heron *Nycticorax nycticorax* | 14 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 大白鹭Great Egret *Ardea alba* | 5 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 雪鹭Snowy Egret *Egretta thula* | 4 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 黑头鹭Black-headed heron *Ardea melanocephala* | 2 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 苍鹭Grey heron *Ardea cinerea* | 2 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 小蓝鹭Little Blue Heron *Egretta caerulea* | 1 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 白鹭Little Egret *Egretta garzetta* | 1 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 绿鹭Striated Heron *Butorides striata* | 2 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 三色鹭Tricolored Heron *Egretta tricolor* | 1 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 西牛背鹭Western Cattle Egret *Bubulcus ibis* | 1 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 池鹭Chinese Pond Heron *Ardeola bacchus* | 1 |
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 大麻鳽Great Bittern *Botaurus stellaris* | 1 |

| 目 Order | 科 Family | 种 Species | 频率 Frequency |
|---|---|---|---|
| 鹈形目 Pelecaniformes | 鹭科Ardeidae | 鹭科鸟类 Herons Ardeidae spp. | 1 |
| 鹈形目 Pelecaniformes | 鹮科 Threskiornithidae | 鹮科鸟类 Ibises Threskiornithidae spp. | 1 |
| 雀形目 Passeriformes | 拟鹂科Icteridae | 褐头牛鹂Brown-headed Cowbird *Molothrus ater* | 1 |
| 雀形目 Passeriformes | 椋鸟科Sturnidae | 紫翅椋鸟Common Starling *Sturnus vulgaris* | 1 |
| 潜鸟目 Gaviiformes | 潜鸟科Gaviidae | 普通潜鸟Common Loon *Gavia immer* | 1 |
| 鸊鹈目 Podicipediformes | 鸊鹈科 Podicipedidae | 小鸊鹈 Little Grebe *Tachybaptus ruficollis* | 1 |
| 鲣鸟目 Suliformes | 鸬鹚科 Phalacrocoracidae | 角鸬鹚Double-crested Cormorant *Nannopterum auritum* | 22 |
| 鲣鸟目 Suliformes | 鸬鹚科 Phalacrocoracidae | 长尾鸬鹚Reed Cormorant *Microcarbo africanus* | 9 |
| 鲣鸟目 Suliformes | 鸬鹚科 Phalacrocoracidae | 鸬鹚属Cormorant *Phalacrocorax* spp. | 7 |
| 鲣鸟目 Suliformes | 鸬鹚科 Phalacrocoracidae | 普通鸬鹚Great Cormorant *Phalacrocorax carbo* | 2 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 银鸥European Herring Gull *Larus argentatus* | 3 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 笑鸥Laughing Gull *Leucophaeus atricilla* | 3 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 伯氏鸥Bonaparte’s Gull *Chroicocephalus philadelphia* | 3 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 普通燕鸥Common Tern *Sterna hirundo* | 2 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 大黑背鸥Great Black-backed Gull *Larus marinus* | 1 |
| 鸻形目 Charadriiformes | 鸥科Laridae | 渔鸥Pallas’s Gull I*chthyaetus ichthyaetus* | 1 |
| 鸻形目 Charadriiformes | 蛎鹬科 Haematopodidae | 蛎鹬Eurasian Oystercatcher *Haematopus ostralegus* | 5 |
| 鸻形目 Charadriiformes | 鸻科 Charadriidae | 鸻科 Plovers Charadriidae spp. | 2 |
| 鸻形目 Charadriiformes | 籽鹬科 Thinocoridae | 籽鹬科Seedsnipes Thinocoridae spp. | 2 |
| 鸻形目 Charadriiformes | 丘鹬科 Scolopacidae | 丘鹬科Sandpipers Scolopacidae spp. | 2 |
| 鸻形目 Charadriiformes | 蛎鹬科 Haematopodidae | 蛎鹬科Oystercatchers Haematopodidae spp. | 2 |
| 鸻形目 Charadriiformes | 鹮嘴鹬科 Ibidorhynchidae | 鹮嘴鹬科Ibisbill Ibidorhynchidae spp. | 2 |

| 目 Order | 科 Family | 种 Species | 频率 Frequency |
|---|---|---|---|
| 鸻形目 Charadriiformes | 反嘴鹬科 Recurvirostridae | 反嘴鹬科Stilts Recurvirostridae spp. | 4 |
| 鸻形目 Charadriiformes | 彩鹬科 Rostratulidae | 彩鹬科Painted-snipes Rostratulidae spp. | 2 |
| 鹤形目 Gruiformes | 秧鸡科Rallidae | 黑水鸡Common Moorhen *Gallinula chloropus* | 2 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 斑鱼狗Pied kingfisher *Ceryle rudis* | 4 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 冠翠鸟Malachite kingfisher *Corythornis cristatus* | 3 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 大鱼狗Giant kingfisher *Megaceryle maxima* | 2 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 非洲林翡翠Woodland Kingfisher *Halcyon senegalensis* | 2 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 翠鸟属Kingfisher *Alcedo* spp. | 1 |
| 佛法僧目 Coraciiformes | 翠鸟科 Alcedinidae | 普通翠鸟Common Kingfisher *Alcedo atthis* | 1 |

尚晓彤, 黄程, 杨立, 牟希东, 李添明, 刘阳 (2026) 全球尺度水产养殖系统减少鸟类致损措施成效评估. 生物多样性, 34, 25453. doi: 10.17520/biods.2025453. https://www.biodiversity-science.net/CN/10.17520/biods.2025453.

## 附录4

表S4-1 水产养殖系统视觉干扰防鸟措施有效性评估案例

Table S4-1 Case study on the effectiveness of visual bird control measures in aquaculture systems

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 增加水体浑浊度<br>Increase the turbidity of water bodies | 21 | 38% | 肯尼亚 Kenya 14 | 使用农家肥和商业磷酸二在整个鱼类生长期间分次施肥, 增加水体浑浊度。<br>Use farmyard manure and commercial phosphorus fertilizers in multiple applications throughout the fish growth period to increase water turbidity. | Otieno & Shidavi, 2022, 2024 |
| | | | 加纳 Ghana 4 | 在水体浑浊的河口湿地和水体较为清澈的人工水库淡水水体中对照实验。<br>Please conduct a comparative experiment in turbid estuarine wetlands and clearer artificial freshwater reservoirs. | Holbech et al., 2018 |
| | | | 美国 USA 2 | 鱼类投放后立即加入水体着色剂Aquashade®以干扰鸟类视觉。<br>Immediately after releasing the fish, add the water dye Aquashade® to interfere with the birds' vision. | Jenkins & Smith, 1998 |
| | | | 法国 France 1 | 加入天然沉积物(20%黏土), 确保在水深10cm处看不清赛氏盘。<br>Add natural sediment (20% clay) to ensure that the Secchi disk is not visible at a water depth of 10 cm. | Cezilly, 1992 |
| 激光Laser | 5 | 60% | 美国 USA 5 | 使用激光在日落前后照射鸟群。<br>Use lasers to shine on bird flocks before and after sunset. | Blackwell et al., 2002; Glahn, et al., 2000a |
| 闪光灯Flash light | 3 | 66.7% | 美国 USA 3 | 使用灯塔和光束在日落后旋转闪光。<br>Use lighthouses and beams that rotate and flash after sunset. | Woolley & Hopper, 1997 |
| 猛禽风筝Raptor-like kite | 1 | 100% | 美国 USA 1 | 用风筝模拟捕食者(如猛禽)的形象, 吓退鸟类。<br>Use kites to simulate the image of predators (such as raptors) to scare away birds. | Cunningham et al., 2024 |
| 反光带Reflective tape | 1 | 0% | 美国 USA 1 | 红色反光聚酯薄膜带系在埋入池塘周边的金属桩上, 风动时反射阳光产生闪烁。<br>Red reflective polyester film strips are tied to metal posts buried around the pond; they reflect sunlight and create flashes when moved by the wind. | Baird et al., 1993 |

表S4-2 水产养殖系统物理阻碍防鸟措施有效性评估案例

Table S4-2 Case study on the effectiveness of physical barrier bird control measures in aquaculture systems

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 降落阻碍物<br>Landing deterrents | 4 | 100% | 美国 USA 3 | (1)三角形降落阻碍通过其棱角和不规则形状阻止鸟类降落。(2)尖刺条塑料制成的扎带铺设在浮筒表面阻碍鸟类站立。(3)扎带是长28厘米的黑色防鸟装置，将多条扎带密集排列固定在浮筒上，干扰鸟类降落和站立。(1) The triangular landing obstruction prevents birds from landing through its edges and irregular shape. (2) Lay plastic tie strips with sharp points on the surface of floating rafts to prevent birds from standing. (3) The cable ties are 28-cm-long black bird deterrent devices. Multiple cable ties are densely arranged and fixed on the buoy to interfere with birds' landing and standing. | Cunningham et al., 2024 |
| | | | 加拿大 Canada 1 | “AntiCormo” 装置要是通过尖刺结构使鸟类无法舒适站立。<br>The “AntiCormo” device prevents birds from comfortably perching by using a spiked structure. | Comeau et al., 2009 |
| 罩网<br>Cover net | 15 | 73.3% | 美国 USA 6 | 在养殖塘上安装罩网(尼龙、钢丝、塑料等材质)阻碍鸟类取食。<br>Install overhead nets (made of nylon, steel wire, plastic, etc.) on aquaculture ponds to obstruct birds from preying. | Avery et al., 1999; Glahn, Dorr, et al., 2000b; Glahn et al., 1999; Glahn & Dorr, 2002; Woolley & Hopper, 1997 |
| | | | 肯尼亚 Kenya 5 | | Otieno & Shidavi, 2022 |
| | | | 澳大利亚 Australia 1 | | Farrell & Leonard, 2001 |
| | | | 丹麦 Denmark 1 | | Dieperink, 1995 |
| | | | 德国 Germany 1 | | Schmidt, 1998 |

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 电围栏<br>Electric fencing | 2 | 100% | 美国USA 2 | 鸟类身体同时接触塘边的电围栏和水体/地面时, 形成闭合电路, 受到高压低电流脉冲电击, 不致命但极具威慑力。<br>When birds' bodies simultaneously contact both the electric fence around the pond and the water/ground, a closed circuit is formed, and they receive high-voltage, low-current pulse shocks, which are non-lethal but highly deterrent. | Mott & Flynt, 1995 |
| 防鸟绳<br>Bird-scaring lines | 5 | 80% | 美国USA 3 | 塑料线构成9.1×9.1米网格形成起落障碍来防鸟。<br>Plastic lines form a 9.1×9.1 meter grid to create landing obstacles to prevent birds. | Baird et al., 1993; Micheli, 1997 |
| | | | 澳大利亚<br>Australia 1 | 单丝线悬挂于池面上方0.5米作为障碍干扰鸟类进入养殖塘捕食。<br>Hang monofilament lines 0.5 meters above the pond surface as an obstacle to interfere with birds entering the aquaculture pond. | Farrell & Leonard, 2001; |
| | | | 中国China 1 | 尼龙线布设在蟹塘上防鸟。<br>Nylon lines are arranged over the crab pond to prevent birds. | 吴旭干等, 2014; |
| 网笼<br>Net cages | 2 | 100% | 喀麦隆Cameroon 2 | 封闭式网箱排除包括鸟类在内的所有捕食者。<br>Enclosed net cages exclude all predators, including birds. | Yong-Sulem et al., 2007 |
| 塑料膜覆盖<br>Plastic film covering | 1 | 0% | 美国USA 1 | 托盘的顶部覆盖一块 1 毫米厚的黑色塑料, 以防止海鸥(银鸥、大鸥)的捕食。<br>Cover the top of trays with a 1mm thick black plastic sheet to prevent seagulls (e.g., silver gulls, large gulls) from preying. | Beal et al., 2009 |
| 可降解网套包裹<br>Biodegradable mesh sleeves | 1 | 0% | 加拿大Canada 1 | 双层网套, 外层是一层可生物降解的保护性套筒, 网眼尺寸小于内层, 旨在限制贻贝移动至网套外部。<br>Double-layered netting: the outer layer is a biodegradable protective sleeve, with smaller mesh than the inner layer, designed to limit mussel migration outside the netting. | Dionne et al., 2006 |
| 普通围栏<br>Standard fencing | 1 | 100% | 喀麦隆Cameroon 1 | 当地尼龙袋剪裁缝合制成, 高度1.0 米, 埋入堤岸 10 厘米, 木桩固定。<br>Local nylon bags are cut and sewn to make a height of 1.0 meter, buried 10 cm into the embankment, and fixed with wooden stakes. | Yong-Sulem et al., 2007 |

表S4-3 水产养殖系统养殖管理防鸟措施有效性评估案例

Table S4-3 Case study on the effectiveness of aquaculture management bird control measures in aquaculture systems

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 水下庇护所<br>Underwater shelters | 4 | 75% | 英国 UK 2 | 立方体框架结合内部树枝，提供复杂躲避空间，顶部遮荫和水下安装对应，减少水面反光，减少鸬鹚捕食效率。<br>A cubic frame combined with internal branches provides complex shelter space, with shading on top and underwater installation to reduce surface reflections and decrease cormorant predation efficiency. | Russell et al., 2008; Russell et al., 2022 |
| | | | 比利时 Belgium 1 | 立方体框架，四面围网，顶部覆盖不透明布，内部放置松枝以增加结构复杂性，提供垂直和水平方向的物理遮蔽。<br>A cubic frame with netting on all four sides and an opaque fabric cover on top, with pine branches placed inside to increase structural complexity, providing physical shelter in both vertical and horizontal directions. | Lemmens et al., 2016; |
| | | | 澳大利亚 Australia 1 | 220个旧轮胎切割后沉入池中，形成两个人工礁区，为虾类提供隐蔽所。<br>220 old tires, cut and sunk into the pool, form two artificial reef areas, providing shelter for shrimp. | Farrell & Leonard, 2001; |
| 养殖布局调整<br>Farm layout adjustment | 5 | 60% | 英国 UK 5 | 根据贻贝生长阶段，分阶段调整其养殖的潮位，以减少被水鸟捕食。<br>Adjust the tidal level of mussel farming in stages based on the growth stage of mussels to reduce predation by waterfowl. | Caldow et al., 2004 |
| 工人巡逻<br>Manual patrol | 2 | 100% | 英国 UK 1 | 工人出现可使鸭群减少 95%。<br>The presence of workers can reduce duck flocks by 95%. | Ross, 2000 |
| | | | 比利时Belgium 1 | 渔场主到访池塘鸟类被惊飞。<br>The fish farm owner visited the pond and the birds were startled away. | Draulans & Vessem, 1985; |

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 设施沉水<br>Facilities submerged in water | 1 | 100% | 加拿大 Canada 1 | 浮子移至养殖设备上方, 通过松绳使设备下沉6cm, 减少鸟类停留。<br>Move the floaters above the aquaculture equipment, and lower the equipment by 6 cm through slackening the rope to reduce bird perching. | Comeau et al., 2009 |
| 训练鱼躲避鸟<br>Train fish to avoid birds | 1 | 0% | 加拿大 Canada 1 | 塑料潜鸟模型模拟潜鸟游动, 对靠近的鱼产生电击, 鱼学会侧向躲避模型 后释放到养殖区。<br>Use a plastic diving bird model to simulate diving bird movement, delivering electric shocks to nearby fish. The fish learn to avoid the model sideways and are later released into the aquaculture area. | Fraser, 1974 |

表S4-4 水产养殖系统听觉干扰防鸟措施有效性评估案例

Table S4-4 Case study on the effectiveness of auditory bird control measures in aquaculture systems

| 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|
| 水下声音威慑<br>underwater sound deterrence | 4 | 100% | 英国 UK 4 | 播放船只引擎声, 模拟真实威胁, 使鸭群误以为有船靠近。<br>Play engine sounds of boats to simulate a real threat, making duck flocks believe a boat is approaching. | Ross, 2001; Ross, 2000 |
| 气枪<br>air gun | 1 | 0% | 以色列 Israel 1 | 在鱼塘区域持续整夜循环播放高分贝气枪声。<br>Continuously play the sound of a high-decibel gas cannon throughout the night in the pond area. | Spanier, 1980 |
| 鸟类遇险呼叫声<br>Bird-distress call | 5 | 60% | 美国 USA 4<br>以色列 Israel 1 | 在鱼塘区域循环播放幼鸟和成鸟的惊叫组合。<br>Cycle the sounds of distress calls from both chicks and adult birds in the pond area. | Andelt & Hopper, 1996;<br>Spanier, 1980 |

表S4-5　水产养殖系统复合措施和致死性防鸟措施有效性评估案例

Table S4-5　Case study on the effectiveness of composite and lethal bird control measures in aquaculture systems

| 措施类型<br>Measure type | 措施<br>Measure | 案例数量<br>Case count | 有效比例<br>Effective proportion | 国家(数量)<br>Country (Count) | 措施详解<br>Detailed explanation of measure | 参考文献<br>Reference |
|---|---|---|---|---|---|---|
| 视觉与听觉组合<br>Visual and auditory combination | 烟火 | 8 | 87.5% | 美国 USA 8 | 在鸟类夜间栖息地使用烟花类爆音装置驱赶夜栖鸟类。<br>Use firecracker-like noise devices in the birds' night roosting areas to drive away roosting birds. | Mott et al., 2006; Woolley & Hopper, 1997 |
| | 人形发声模型 | 4 | 75% | 美国 USA 4 | 人偶突然充气、摇晃模拟人类活动并发出警戒声。<br>Inflate and shake a mannequin suddenly to simulate human activity and emit warning sounds. | Stickley & Mott, 1995; Woolley & Hopper, 1997 |
| | 船只驱赶 | 3 | 66.7% | 英国 UK 3 | 船只在水面驱赶鸭群。<br>The boat drives the duck flock across the water surface. | Ross, 2000 |
| | 车辆惊扰 | 1 | 0% | 比利时Belgium 1 | 车辆经过意外干扰。<br>The vehicle passes through an unexpected disturbance. | Draulans & Vessem, 1985 |
| | 风吹反光带 | 1 | 100% | 埃及 Egypt 1 | 将反光带布置在水面上方2.5米，风中产生密集的闪光和噼啪声。 | Rajhi, 2018 |
| 视觉与物理 | 机械干扰 | 2 | 100% | 美国 USA 2 | 机械臂转动产生视觉和运动干扰，使鸟类不敢靠近。<br>Reflective tape is placed 2.5 meters above the water surface, creating dense flashes and popping sounds in the wind. | Cunningham et al., 2024 |
| | 防鸟绳和气球 | 1 | 100% | 美国 USA 1 | 黄色绳索与红色浮子形成物理和视觉障碍，氦气球强化威慑效果。<br>The yellow rope and red buoys create physical and visual barriers, while the helium balloons enhance the deterrent effect. | Mott & Flynt, 1993 |
| 视觉、听觉与管理 | 工人巡逻和稻草人 | 1 | 100% | 美国 USA 1 | 人偶突然充气、摇晃模拟人类活动并发出警戒声，配合巡逻驱赶。<br>Inflate and shake a mannequin suddenly to simulate human activity and emit warning sounds, in coordination with patrols to drive birds away. | Stickley & King, 1993 |
| 致死性措施<br>Lethal Measures | 射击<br>Shooting | 2 | 50% | 美国 USA 2 | 射击驱散鸟类。<br>Shooting to disperse birds. | Taylor & Strickland, 2008 |

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