

**SUBMISSION to the**  
**INDEPENDENT REVIEW INTO THE FEBRUARY-MARCH 2023 FISH DEATHS IN THE DARLING-BAAKA RIVER, MENINDEE**

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### **Personal Background**

I am a retired Principal Research Scientist who worked for NSW Fisheries for 36 years studying the taxonomy, biology, conservation and aquaculture of Australian native freshwater fish of the inland Murray-Darling River System and the coastal Clarence River System. Key species studied were; Murray Cod (*Maccullochella peelii*), Eastern Freshwater Cod (*M. ikei*), Mary River Cod (*M. mariensis*), Trout Cod (*M. macquariensis*), Silver Perch (*Bidyanus bidyanus*) and Golden Perch (*Macquaria ambigua*). These species are unique and found only in Australia. I identified, described and named *M. ikei* and *M. mariensis* and was the principal scientist in charge of Australia's first conservation project for the endangered Eastern Freshwater Cod.

My research provided the biological basis for: (i) hatchery production for conservation and stock enhancement; (ii) policies and regulations for the management of freshwater species and fisheries; (iii) conservation of threatened species; and (iv) farming techniques for Silver Perch, including the monitoring and management of water quality and the control of infectious diseases.

In this submission, I use the name Barka-Darling in respect of the Barkindji who have called the river "Barka" for thousands of years; the river was named "Darling" by the explorer Charles Sturt in 1829. I have known and worked in the Barka-Darling since 1970. In 2020, I published an autobiography *The Codfather* about my life and career and the final chapter "Goodbye Darling" chronicles the long-term environmental degradation of the Barka-Darling.

### **Statement**

**This submission focuses on: 1. The long-term degradation of the Barka-Darling; 2. The decline and extirpation of key native fish; 3. Two unprecedented ecological disasters involving massive fish kills in 2018 – 2020 and 2023, resulting in the extinction of the aquatic ecosystem; 4. Decades of repeated warnings about mismanagement of the river; and 5. Recommendations to restore the Barka-Darling to a healthy ecosystem.**

The Barka-Darling is part of Australia's history and heritage. For well over 100 years since white settlement and the development of a large pastoral industry, the river's aquatic ecosystem remained reasonably healthy despite some environmental changes (e.g. compaction of soils, changed run-off and flooding patterns, loss of riparian vegetation, desnagging and felting, and removal of rock bars). Although native fish declined markedly in many rivers during the early and mid-1900s, the Barka-Darling remained a stronghold of Murray Cod (*Maccullochella peelii*) and other native fish species.

However, since the 1980s, river regulation, expansion of large-scale irrigation and over-extraction of water, proliferation of the introduced fish Common Carp (*Cyprinus carpio*) and pollution have severely degraded the aquatic environment in the Barka-Darling. Symptoms of this degradation are reduced frequency and extent of flooding, loss of "pulses" of water from different tributaries, increasing periods of low/no flows, loss of macrophytes, extensive algal blooms, poor water quality, regular fish kills (often involving Murray Cod), declining numbers of native fish, increasing incidence of infectious diseases, and the functional loss of wetlands and floodplains.

The native fish fauna of the Barka-Darling is in serious trouble. Murray Cod, Australia's most famous fish and the icon of the Murray-Darling River System (MDRS) has declined dramatically and is now rare or absent from some stretches of the river. It has probably lost the capacity to recover naturally in the Barka-Darling. Silver Perch (*Bidyanus bidyanus*), an ecologically-important omnivorous species, was once widely distributed and highly abundant. It has been severely impacted by Carp

and environmental degradation and is now rarely sampled or seen and may be functionally extirpated. Similarly, the Freshwater Catfish (*Tandanus tandanus*), once extremely abundant and widespread, is near extirpation in all rivers of the MDRS, including the Barka-Darling. Trout Cod (*Maccullochella macquariensis*) is extirpated from the lower reaches. The decline and loss of these fish, as well as invertebrates and aquatic flora represents a significant and alarming loss of biodiversity.

The chronology of degradation of the Barka-Darling since 1970 is summarised in Table 1.

Although fish kills are natural and occur periodically on a localised scale, degradation of the Barka-Darling over many decades has resulted in an aquatic environment that is conducive to extensive fish kills. The series of kills near Menindee in 2018 – 2020 was an unprecedented ecological disaster! Many millions of fish died, including threatened species, and much of the river from Bourke to Wentworth was dry. In *The Codfather*, I contended that these fish kills drove the aquatic ecosystem of the Barka-Darling to extinction. The habitat, species composition and structure were so altered that the ecosystem couldn't function normally. Then came the fish kills in 2023. This was a flood year with conditions that many expected would rejuvenate the river. But NO, fish again died in their millions over many months. The deaths extended from at least Bourke downstream, NOT just near Menindee!

There have been many science-based warnings about the declining health of the Barka-Darling. Concerns increased though the 1980s and key findings of a major NSW Fisheries research project "The NSW Rivers Survey" (1997) were: (i) rivers were in severe stress; (ii) low numbers of Murray Cod, Silver Perch, Freshwater Catfish and other species; and (iii) the fish fauna was dominated by Carp (> 90% of the biomass).

Twenty years ago in 2003, the NSW Fisheries Scientific Committee (FSC) of which I was a member, declared the aquatic community of the Lowland Catchment of the Darling River an ENDANGERED ECOLOGICAL COMMUNITY (EEC). The FSC identified Key Threatening Processes, including "*reduction of water flow through water extraction; Carp; pollution through insecticides and fertilisers*" and warned that "*the EEC is likely to become extinct in nature unless the circumstances and factors threatening its survival cease to operate.*" Since that time, significant expansion of the large-scale irrigation industry based on cotton, and subsequent extraction of water and extensive use of fertilisers, herbicides and pesticides have continued unabated.

The situation in the Barka-Darling parallels one of the World's worst environmental disasters; the Aral Sea (between Kazakhstan and Uzbekistan) in the 1960s and 1970s, where the cost of over-extraction of water for cotton farming was the destruction of soils and inland waters and their associated ecological and human communities and numerous industries.

A Murray-Darling Basin Plan (MDB Plan) was implemented in 2012 with the aim of returning water to the environment. The Plan has been an abject failure, certainly in relation to the Barka-Darling. Various NSW State Government policies (e.g. Water Sharing Plan, Floodplain Harvesting) demonstrate the total disregard some politicians, political parties and bureaucrats have for the health of inland rivers. Despite the science, as well as numerous expressions of concern from scientists and managers, Aborigines, pastoralists, horticulturists, environmentalists, authors and people interested in the river, the degradation and environmental disasters continue.

This Independent Review needs to go beyond just identifying the causes of the 2023 fish deaths at Menindee and providing emergency responses and short-term management options. Unless there are strong recommendations with the capacity to make significant changes to water and land management, environmental degradation and fish kills will continue, the river will not recover, and mismanagement of the Barka-Darling will remain a national disgrace.

## Barka-Darling – Cultural and Environmental Significance

### Aboriginal culture

The Barka-Darling is the lifeblood of the Barkindji. Their submissions to this review will tell the story. The following words from respected Elders sum up the losses to First Nations people.

Badger Bates (proud and respected Barkindji Elder) *“When I was a kid the Barka fed us. It was like a supermarket, we ate yabbies, shrimp, fish and turtles ... I never seen anything like what happened in Menindee in 2018 – 2020 ... If we don’t keep water in the river, it’ll all die ... How can you teach culture from an empty river? And it’s not just blackfellas’ culture, it’s whitefellas’ culture too, everyone got a culture on the Barka ... We must get together and help protect the Barka and tell the government what they are doing is wrong ... They go around with this water sharing plan, but it isn’t worth the piece of paper that it’s written on.”*

Bruce Shillingsworth (Aboriginal activist) *“The impact of the water mismanagement and the corruption and the corporate greed and capitalism in the country has killed our rivers.”*

### The river, its catchment and fish

The Barka-Darling is part of Australia’s largest river system the Murray-Darling. It is an outback river that has played key roles in Australia’ history and heritage, including:

- (i) the evolution of fish and other aquatic organisms for millions of years;
- (ii) Aboriginal history and culture for at least 45,000 years; and
- (iii) the social and economic development of inland Australia since the 1830s.

The Barka-Darling is Australia’s longest river (2,700 km from the headwaters of the Condamine to Wentworth) and its catchment and tributaries include rivers in New South Wales and Queensland such as the Condamine, Ballone, Culgoa, Warrego, MacIntyre, Barwon, Namoi, Gwydir, Macquarie, Severn and Dumaresq. The Barka-Darling has always had variable and unpredictable patterns of flow. Although in the outback and periodically drying to water-holes, recent research has shown that the Barka-Darling historically flowed for 92% of the time, including drought periods. Annual pulses coming from the various tributaries were a common feature of the flow regime.

The Barka-Darling is characterized by steep banks, extensive floodplains, wetlands, flat topography, low rainfall, limited runoff and high evaporation and seepage rates. Floodplains and wetlands are vital components of inland rivers. Periodic inundation of the floodplains and wetlands provide the energy, nutrients and organisms that are essential for biological productivity, good water quality and river health.

The Barka-Darling is home to a unique and amazing fish fauna and other organisms that are superbly adapted to the harsh riverine conditions. The most famous fish and the ICON of the MDRS is the Murray Cod, a large, long-lived fish which grows to over 100 kg. Murray Cod breeds annually and like other species, recruitment is enhanced by inundation of the banks and floodplains which provide habitat and essential food such as zooplankton and insects that are critical for the high survival of larvae and juveniles.

Until the 1980s, the Barka-Darling was the stronghold for Murray Cod and other native fish – **it is no longer**. As the apex predator, Murray Cod played a key role in the structure and

function of the ecosystem and biological diversity. It is thought that the decline and relatively low numbers of Murray Cod in many rivers in the early and mid-1900s, facilitated the population explosion of Carp throughout the MDRS in the mid-1970s. While Murray Cod has recovered strongly in many inland rivers, this skewed relationship between predator and prey still exists in the Barka-Darling.

### **Barka-Darling - Environmental Degradation**

There has been environmental degradation of inland rivers since the mid-1800s. Changes associated with early rural development included removal of riparian vegetation, compaction of soils, altered run-off patterns, desnagging and felting of rivers and removal of rocks bars to facilitate passage of paddlesteamers. Despite these changes associated with the expansion of the wool industry, the fish stocks and aquatic ecosystem of the Barka-Darling and its tributaries remained relatively healthy for over 100 years. This was probably because the flow and flooding regimes, and the structure and function of floodplains and wetlands remained natural.

Impacts of river regulation were becoming evident in the 1960s. The construction of dams on headwaters of rivers altered the temperature, flow and flooding regimes and reduced the pulses that flowed from various tributaries. Most importantly, the frequency and extent of flooding were reduced and conditions suitable for successful fish spawning, survival of larvae and juveniles and recruitment were significantly impacted. The ecosystem in which our native species evolved was changing rapidly

Elderly river people noted the changes in flooding patterns and the loss of regular “pulses” that were a common feature of the river. These pulses would sometimes last for months and played a key role by providing connectivity and maintaining good water quality and ecosystem health.

Further changes followed the population explosion of the introduced Common Carp in the mid-1970s – aquatic plants were lost and turbidity of the water increased. It was estimated that by the 1990s, Carp made up around 90% of the fish biomass in many rivers, including the Barka-Darling. Although numbers of Carp are now lower in some rivers (e.g. Murrumbidgee River), the species still dominates the fish fauna in the Barka-Darling and according to fisheries scientists who work on the river, there has been significant recruitment and increase in numbers of Carp in recent years.

Through the 1980s, the character of the Barka-Darling continued to change with fish and river health declining. Increasing periods of low and no flow and reduced connectivity between pools and lengths of river have serious consequences for water quality and the biology of fish and other aquatic organisms.

In 1991, a huge bloom of algae, including blue-green algae, extended for approximately 1000km along the Barka-Darling. For the first time, the Australian public became aware of a major environmental problem in our inland rivers. Eutrophication and large algal blooms have detrimental effects on water quality, often creating stressful and lethal levels of key variables such as oxygen, pH and ammonia. Poor water quality associated with algal blooms can result in fish kills, and played a key part in the 2018 – 2020 kills near Menindee.

Figure 1. Low flows and algal blooms are now common in the Barka-Darling River. Left, January 2005; right, Culpaulin Station (2019). Photos Stuart Rowland, NSW Fisheries.



This changing character includes the degradation and loss of wetlands. The Menindee Lakes have significant cultural importance to the Barkindji people and are known breeding and recruitment waters for native fish and crustaceans, as well as birds and other terrestrial animals. However, they have been increasingly used as water storages for agriculture. In 2010 and 2016 high river flows delivered water into the lakes and there was good fish recruitment. In 2016/2017, the lakes were rapidly drained to meet environmental flows and irrigation demands downstream and along the Murray River. In addition, there was a proposal to further control and shrink Menindee Lakes under a \$150 million project aimed at delivering water savings and reducing evaporation. Clearly the vital cultural and ecological roles of the lakes are being ignored.

## Native Fish

### Murray Cod

Murray Cod is Australia's most famous fish. In Aboriginal mythology, a large Cod formed the Murray River and the other species of native fish. It was THE FISH to indigenous people. From the early 1800s, Murray Cod also played a key role in white settlement. It was an important food item for explorers and early settlers, and was the basis of a large commercial fishery that supplied fresh fish locally and to large towns and cities. Murray Cod has a mystique and has always been the most sought-after fish. It is the basis of a large, valuable recreational fishery in many parts of the MDRS. Through the 1900s, fishers travelled in their thousands each year to camp on the Barka-Darling, experience the outback and catch Murray Cod. It was a unique Australian experience.

Since the 1990s, there has been a dramatic change and now the Barka-Darling is no longer "the stronghold of Murray Cod and native species". Recreational fishers do not visit the river in their thousands each year to catch Murray Cod; the fishing is much better in other rivers. Murray Cod has recovered in the Murrumbidgee, parts of the Murray, the Lachlan, The Macquarie, the Border Rivers, rivers on the Northern Tablelands and Victorian rivers such as the Ovens and Goulburn. Disregarding for a moment the importance of the loss of icon and apex predator in the Barka-Darling, we have also lost a major tourist attraction of the western region of NSW.

Figure 2. Recreational fishers with Murray Cod caught in the Barka-Darling. Top left, 1962; top right, 1978; bottom, 1989. Photos Stuart Rowland.



Over the last three decades, Murray Cod recovered in many NSW waters following the implementation in 1992 of strong fisheries regulations that reduce fishing mortality and protect breeding adults. In addition, strategic stocking of hatchery-reared fish has improved stocks where natural recruitment was limited or in areas where native species were extirpated. The same management strategies apply to native fishes in the Barka-Darling, but instead of recovery, Murray Cod, Silver Perch and Freshwater Catfish have declined dramatically.

Our native fishes are excellent biological indicators of river health. Over the last three decades, the incidence of fish kills in the Lower Barka-Darling has been increasing. Repeated fish kills in an area or river system is a serious threat, particularly to long-lived fishes like Murray Cod. It has a complex reproductive strategy involving annual spawning at the same time each spring, relatively low fecundity, paternal care of eggs and larvae that requires experience and endurance, and a reliance on numerous adults and consecutive generations breeding each season. Under normal circumstances this strategy confers a biological advantage; however, when numbers of adults across multiple generations are seriously depleted, Murray Cod loses its biological advantage and has difficulty in recovering from low

numbers. Unlike the highly fecund Golden Perch, it is not a migratory species and so recruitment from other rivers or between stretches of river is limited.

**In my opinion, Murray Cod has probably lost the capacity to recover naturally in the Barka-Darling and is facing extirpation in this river.**

Figure 3. Numerous fish kills involving adult Murray Cod have reduced reproductive output and the species' capacity to recover naturally in the Barka-Darling. Left, dead adult Murray Cod in 2004; right, dead Murray Cod in the Lower Barka-Darling in 2019. Note the algal-laden water. Photos NSW Fisheries, Rachel Strachan.



### Silver Perch

There are serious concerns about Silver Perch and it is currently classified as vulnerable (I strongly disagree with this classification). It is an important species ecologically because of its omnivorous diet and previous high abundance in numerous types of habitats. Silver Perch was once widely distributed and schools of thousands were regularly seen in most rivers, including the Barka-Darling. During my first two trips to the Barka-Darling in 1970, I saw schools containing thousands of Silver Perch in clear water near the surface and associated with beds of the macrophyte Ribbonweed (*Vallisneria* spp.).

The species was very popular with Barkindji and other Aboriginal nations and like Murray Cod, played an important role in their mythology and culture. In the 1960s, Silver Perch was considered the native fish "least affected by changes caused by river regulation", but by the late 1980s it was evident that the species was in serious trouble. Silver Perch has been severely impacted by Carp and environmental degradation, and is probably functionally extirpated in the Barka-Darling; it is also at risk of extinction across the whole of the MDRS. The species "hangs on" with the aid of stock enhancement in some impoundments that are free of Carp.

**In my opinion, Silver Perch should be classified as Critically Endangered.**

### Freshwater Catfish

Similarly, the Freshwater Catfish was an abundant and wide-spread species in all rivers of the MDRS. It was readily caught by Aborigines, often from the extensive macrophyte beds once common in our inland rivers. Catfish was a key part of the diet of the Barkindji people;

however, the species declined dramatically through the 1980s and 1990s and it is now rare. Catfish may be functionally extirpated in the Barka-Darling and other rivers of the Northern MDB. River populations of Catfish are classified as endangered. There are, however, healthy, self-sustaining populations of Freshwater Catfish in some impoundments that are free of Carp.

### Trout Cod

According to Aborigines, Trout Cod was found in the lower reaches of the Barka-Darling, from Menindee downstream to Wentworth and into the Murray River. It was usually associated with rock bars that were once numerous in the river. However, following the removal of this habitat type in the early 1900s to facilitate the passage of paddlesteamers, Trout Cod disappeared from the Barka-Darling.

The species was close to extinction in the 1980s when NSW Fisheries and Victorian Fisheries commenced major conservation projects based on stocking of hatchery-reared fingerlings. Despite recovery in many rivers in the southern parts of the MDRS, Trout Cod remains extirpated from the Barka-Darling.

### Infectious diseases

There is a profound and inverse relationship between environmental quality and the physiological condition and disease status of fish. The infectious diseases of native fish are well known and their role in kills has long been recognised. Murray Cod and Silver Perch are very susceptible to infestations of the ectoparasites *Chilodonella hexasticha* (causes the disease Chilodonellosis), *Ichthyophthirius multifiliis* (Ichthyophthiriosis or Ich) and the fungus *Saprolegnia parasitica* (Saprolegniosis and Winter Saprolegniosis). There is evidence that some of these pathogens were introduced to Australia and so native species have limited natural immunity.

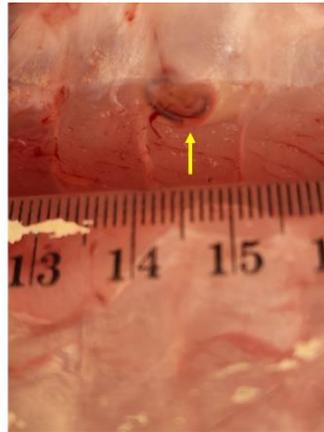
Between 1978 and 1985, my sampling suggested that the incidence of parasites and diseases in the Barka-Darling and other inland rivers was relatively low. However, in the mid-1980s, there was a dramatic increase in Anchor Worm (*Lernaea cyprinacea*) as Carp spread extensively throughout the MDRS. It is an effective vector of Anchor Worm and heavy infestations stress and debilitate native fish, reduce reproductive output and can cause mortalities.

In 2012, the notifiable disease Epizootic Ulcerative Syndrome (EUS; also called Red Spot Disease) caused by the fungus *Aphanomyces invadans*, was recorded for the first time on Murray Cod, Golden Perch, Silver Perch and Spangled Perch in the Barka-Darling between Bourke and Brewarrina. EUS has been reported in Bony Herring. Infestations of *A. invadans* can result in large ulcers and the disease severely stresses native fish and may cause high mortalities, particularly in fingerlings.

The nematode, *Eustrongylides* has been recently reported in Murray Cod. It is a zoonotic internal parasite that can penetrate fish muscle and so the consumption of raw or undercooked fish flesh poses a threat to humans. Infestations of *Eustrongylides* are associated with anthropogenic habitat alteration and are reported to affect reproductive success of infested hosts.

**The increasing incidence of infectious diseases in the Barka-Darling is both a symptom of a degraded aquatic environment and a serious risk to fish and ecosystem health in the future.**

Figure 4. Increasing incidence of infectious diseases in the Barka-Darling reflects the severely degraded environment. Top left, Anchor Worm is a common and debilitating parasite of native fish; top right, *Eustrongylides* is a zoonotic parasitic nematode recently reported from Murray Cod; bottom, Murray Cod and Golden Perch with the fungal disease Epizootic Ulcerative Syndrome in 2012. Photos Stuart Rowland, Professor Shokoofeh Shamsi and Dr Craig Boys.



## **Fish Kills, Ecological Disaster and Extinction**

### 2018 – 2020 fish kills

In 2018 – 2020 there was an unprecedented ecological disaster not seen or reported in Aboriginal history or since white settlement. A series of extensive fish kills in the Lower Barka-Darling commenced in December 2018. Millions of fish died, including the iconic Murray Cod and Bony Herring or *Nhaampa* which is the totem of the Barkindji people. The riverbed was dry for much of its length from Bourke to Wentworth, as were major wetlands such as Lake Menindee. Fish continued to die throughout 2019 and into early 2020.

Although this event occurred during a long drought, numerous science-based reports determined that low flows, high water temperatures, algal blooms and poor water quality were the main factors contributing to the actual fish kills. The sequence of events was described in a number of reports, and in my book *The Codfather*. The dynamics of water quality variables, particularly dissolved oxygen and its role in the fish kills were described and are well known in science. The possible role of three other variables, pH, ammonia and hydrogen sulphide were also discussed in *The Codfather*. These variables cause stress and mortality under aquaculture conditions, and I suggested they were likely to have played roles in the 2018 – 2020 fish kills because of the low/no flows, poor water quality, algal blooms and extremely high organic loads.

Figure 5. Massive fish kills in the Barka-Darling River near Menindee in the period 2018 -2020. Left, Dead Murray Cod and other species in the soupy, algae-laden water; right, dead Bony Herring or *Nhaampa* the totem of the Barkindji people. Photos courtesy of Rob McBride, Tolarno Station.



I hypothesised in *The Codfather* that the ecological disaster in 2018 - 2020, after decades of degradation, drove the ecosystem to **extinction**!! The species composition and the structure and function of the ecological community in the Barka-Darling have changed dramatically within a 50-year period.

Characteristics of the ecosystem in 1970 and 2023 are summarised in Table 2.

The fish kills in 2018 – 2020 under drought conditions were thought to be a unique ecological disaster, but within just three years, there was another extensive series of fish kills, this time under flood conditions following an extended monsoonal season. The kills in 2023 that occurred over many hundreds of kilometres of river support my hypothesis of a non-functional ecosystem.

### 2023 fish kills

In mid-March 2023, an estimated 20 million fish died in the Barka-Darling at Menindee. A majority of the fish were the native Bony Herring (*Nematalosa erebi*; previously called Bony Bream, member of the Herring family Clupeidae). This species is the totem of the Barkindji people. Press releases, photographs, public statements and the focus of this current review suggest the fish kill was a localised event centering on the river and lakes near Menindee.

This environmental disaster was **NOT** confined to the Lower Barka-Darling. According to station owners and river people, some of whom have lived on the Barka-Darling for generations, there was an unprecedented and extensive fish kill in the river from at least as far upstream as Bourke. Verbal reports described blackwater flowing from the Namoi River in December 2022, and then in January 2023, large numbers of dead fish were seen on the inundated floodplains in the Bourke to Louth section of the Barka-Darling. As the floodwaters receded, many fish were washed into the river. Around this time, thousands of yabbies were seen leaving the river and there were millions of dead shrimp lining the riverbanks and floodplain. These observations were made many weeks before the fish kill was reported at Menindee.

Figure 6. Fish kills in the Upper Barka-Darling in 2023. Left, dead fish, mainly Bony Herring, floating past Talowla Station on the Barka-Darling River in January 2023; right, thousands of dead fish, including Herring and Spangled Perch (*Leiopotherapon unicolor*) scattered on the floodplain March 2023. Photos David Junk, Talowla Station.



In the following months, large numbers of dead fish were observed floating down the river. At Talowla Station, near the Warrego/Barka-Darling junction, between Bourke and Louth, a rough count of 120 dead fish/minute was made “floating past” during daylight hours. It was estimated that well over one million dead fish, mainly Bony Herring and Carp floated past this property in a week. No dead Murray Cod, Silver Perch or Freshwater Catfish were observed; David Junk, owner of Talowla Station said “Cod, silvers and catfish don’t live here anymore.” He observed only four dead Golden Perch in a two-week period and said he had heard of only two dead Murray Cod some distance upstream, further highlighting how few of these species remain in this section of the Barka-Darling. It is well known that many dead fish do not float after death, but sink to the edges or bottom, so such observations largely under-estimate the number of dead fish.

Flood conditions in the spring and summer of 2022 resulted in exceptionally high recruitment of Carp, Bony Herring and Spangled Perch leading to enormous biomasses in parts of the river and on floodplains. Fish were often seen gasping at the surface in thousands. Huge demands on oxygen would have ensured as live fish, dead fish and organic matter moved from the floodplains into a restricted environment within the river banks probably triggering widespread hypoxia or probably anoxic conditions.

The massive fish kill from Bourke downstream past Louth and onto Tilpa went unreported by press and NSW Department of Primary Industries. This lack of awareness and/or acknowledgement is cause for serious concern and perhaps reflects an overall apathy about the Barka-Darling as a whole and its aquatic ecological community.

### **Loss of Biodiversity**

Besides the decline and loss of the large-bodied fish, there have been serious losses of other fish and invertebrate species. The Darling River Snail (*Notopala sublineata*) is critically endangered and reported from only a few sites in irrigation pipes. Mussels that were once a vital part of the ecosystem, as well as an important food item for the Barkindji, have died in their millions during both fish kills.

The aquatic flora has shifted from macrophytes to phytoplankton since the introduction of Carp. Its feeding habits uproot large plants such as Ribbonweed, Milfoil, and Pondweed, and the extensive beds that once dominated the Barka-Darling and other rivers have disappeared. The flora is now dominated by phytoplankton, including blue-green algae. The general character of the Barka-Darling has changed from clean, flowing water to one of near constantly high turbidity cause by clay colloids and phytoplankton.

The changes to the fish and other fauna, as well as the flora over the last 50 years in the Barka-Darling represent a significant loss of biodiversity and has serious implications for ecosystem recovery.

### **Science and Warnings**

There has been significant long-term research into Australian native freshwater fish and rivers. Serious concerns about the decline of fish and fisheries in the 1950s, led to the establishment of the NSW Fisheries' Inland Fisheries Research Station at Narrandera in 1960 and commencement of research into the biology of key species. Early findings suggested that environmental factors, including river regulation had contributed to the decline of fish stocks. By the early 1980s, techniques for hatchery production were developed in NSW and Victoria and recovery efforts based on conservation and stock enhancement programs had commenced. Research into native fish continues today, providing the basis for management of freshwater species in the MDRS and coastal drainages. In the 1980s and 1990s, management actions involved implementation of threatened species legislation and new fisheries regulations (closed seasons, bag limits, size limits) to protect key native species across the MDRS, including the Barka-Darling.

Despite the strong fisheries management and recovery of some species, including Murray Cod, in many rivers, degradation continued in the Barka-Darling and has now reached the point of being an ecological disaster. While causes are multi-factorial, over-extraction of water for large-scale irrigation has been identified in numerous scientific papers and reports as a key contributing factor.

### **The Aral Sea**

The situation in the Barka-Darling parallels one of the World's worst environmental disasters – the Aral Sea (between Kazakhstan and Uzbekistan). Commencing in 1960, water was diverted to irrigate cotton and by 1977 the Sea was just 10% of its original size; it is now basically a desert. A once thriving fishing industry was devastated and the soils severely degraded. The cost of over-extraction and mismanagement was the destruction of inland waters and their associated ecological and human communities and industries.

This is happening in Australia right now. History tells us that no irrigation era has survived beyond a century. Soils become barren, water supplies are degraded and lost, and eventually the irrigation industries fail or move. Unfortunately, the cost is a collapsed freshwater ecosystem and destroyed rivers. We are ignoring history at our peril.

### NSW River Survey

In response to concerns about fish and river health, a large-scale research project “The NSW River Survey” commenced in the early 1990s. It was led by Dr John Harris and Dr Peter Gehrke of NSW Fisheries. There was extensive sampling throughout the MDRS using non-destructive electro-fishing and other techniques. This was the first time that fish stocks had been quantified across the Basin. Important findings published in 1997 included: (i) rivers were in severe stress; (ii) relatively low numbers of Murray Cod, Silver Perch, Freshwater Catfish and other fish species; (iii) Carp made up over 90% of the biomass in some rivers.

### Fisheries Scientific Committee – *Endangered Ecological Community*

The Fisheries Scientific Committee (FSC) was established under Part 7A of the *Fisheries Management Act 1994*. It is an independent body in NSW that makes recommendations and determinations to the State Government on threatened species, populations and communities.

In 2003, following an extensive scientific review, the FSC determined that the “Aquatic Ecological Community in the Natural Drainage System of the Lowland Catchment of the Darling River” was an ***Endangered Ecological Community (EEC)***. The area was defined by all natural creeks, rivers, streams and associated lagoons, billabongs, lakes, flow diversions to anabranches, the anabranches, and the floodplains of the Darling River within the State of New South Wales, including Menindee Lakes and the Barwon River. All waters below an elevation of 500 metres were included, as were all tributaries of the Darling and Barwon rivers in NSW.

The FSC identified the following threats to the survival of the EEC: instream structure such as dams and weirs and water extraction; clearing of riparian vegetation; access of stock to the riparian zone; removal of snags; introduced species; some types of agriculture through reduction of river flow by water extraction and pollution through pesticides.

***The FSC warned “... the Aquatic Ecological Community in the Natural Drainage of the Lowland Catchment of the Barwon-Darling River is likely to become extinct in nature, unless the circumstances and factors threatening its survival cease to operate.”***

As required by legislation, Threat Abatement Plans were developed and implemented by NSW Fisheries to further protect fish stocks and aquatic habitats. Despite warnings from the FSC and the management actions by NSW Fisheries, water extraction for large-scale irrigation and

the use of agricultural chemicals have continued unabated, principally as a result of the ongoing expansion of the cotton industry.

### Cotton industry

Australia's cotton industry really started in earnest in the early 1970s. Cotton is grown on the Barka-Darling and other river valleys in its catchment, e.g. Namoi, Gwydir, MacIntyre/Barwon, Ballone/Culgoa, Condamine. Around 66% is grown in NSW, 33% in Queensland, and the northern Murray-Darling Basin (MDB) produces 93% of the total crop. Around 90% of Australia's cotton is irrigated. Water requirements are 6 – 7 ML/ha and in 2011/2012, a record 583,000 ha was planted to produce 5 million bales. The industry earns around \$2 billion/year.

Cotton farming has developed into a large, economically successful industry. Despite its significant economic contributions to the Nation and some regional communities, the cotton industry has a long history of controversy including illegal earthworks for storage and diversion of water, pollution, fish kills associated with use of pesticides, tampering of meters, illegal pumping and over-extraction of water.

Even as early as the 1990s, some government representatives acknowledged that there had been an over-allocation of water to the irrigation industry. However, governments continued to support the expansion of this large-scale industry based on a chemically-dependent monoculture.

### Murray-Darling Basin Plan

The MDRS is a large, complex system and there is no doubt that its management has been and remains very difficult. The Murray-Darling Basin Authority developed a \$13 billion Plan (MDB Plan) in conjunction with the States and many stakeholders. It was an attempt to provide a basis for management, with a major objective of "returning water to the environment." Clearly the MDB Plan has been an abject failure, certainly in relation to the aquatic environment of the Barka-Darling. There are serious questions about various aspects of the Plan – its legality under the *Water Act 2007*, the actual targets for water taken for agriculture and mining and the water to be returned to the environment, lack of cooperation between the Commonwealth and the States etc.

### Conflict between Fisheries and Agriculture

NSW Fisheries has unique and specialised roles which involve research, compliance, management of commercial and recreational fisheries, wild stocks of fish, crustaceans and molluscs and aquatic habitats, the development and management of aquaculture and the conservation of threatened species. When agriculture and fisheries were first combined in NSW in 1983, conflict between "green" fisheries and "brown" agriculture began. Major problems have arisen world-wide when fisheries and the environment have competed with irrigated industries for water.

The following are some examples during my career. In the early 1990s, I was asked by a senior agriculture staff manager not to investigate or supply Fisheries Officers with environmental and biological information in association with fish kills suspected to be linked to pollution from cotton farms in the northern parts of the MDRS. I reminded the staff member of the departmental responsibilities to protect fish and aquatic habitats under fisheries legislation.

During the fish kills at Menindee in 2019, the Minister stated that he had been advised by his department “the fish kills were caused by the drought”. This was clearly in conflict with the long history of degradation of the Barka-Darling and fisheries research, many findings of which are documented in scientific papers and NSW Fisheries reports. Other areas of conflict involve the Water Sharing Plan (2012) and recent proposed floodplain harvesting legislation.

### **Need for Change**

Freshwater is one of the most important resources for life on Earth. Despite this, biodiversity is being lost and freshwater ecosystems are being degraded and destroyed at an alarming rate throughout the World, including in Australia!

The Barkindji people have lost millions of their totem *Nhaampa*, Murray Cod, other fish and key food items and drinking water. The Barka-Darling is the lifeblood of the communities and their social and psychological well-being is dependent on a healthy river. This loss of life’s fundamentals would not be tolerated in Sydney, Melbourne, Canberra, other large cities and regional towns, but the demise of the Barka-Darling that was forecast decades ago, has actually happened.

Unfortunately, one large-scale textile industry has been favoured over other agricultural industries, as well as Aborigines, river communities, tourism, recreational fishing, river ecology and the nation as a whole. As the late Professor Peter Cullen who directed the Cooperative Research Centre of Freshwater Ecology said “*Communities must demand that political leaders take control and responsibility for putting in place management regimes that benefit all of the communities not just a favoured few.*”

***The degradation of the Barka-Darling over many decades demonstrates an ignorance of, or complete disregard by some politicians, political parties and bureaucrats for inland aquatic ecosystems, their fauna and flora, and associated indigenous people, river communities and agricultural industries.***

The current situation in the Barka-Darling provides a clear and loud warning for other rivers in south-eastern Australia including the Lachlan, Murrumbidgee, Murray, Ovens and Goulburn all of which are facing increasing demands on their water from the large-scale irrigation of cotton, nuts and other water-dependent crops.

Any decision regarding water management in the MDRS must be made in light of the predicted implications of Climate Change – higher temperatures, more extreme weather events, drier conditions and less water. Scientists predict that there will be less water in the MDRS in the future.

I make a series of recommendations that may lead to the restoration of a healthy ecosystem in the Barka-Darling – see the following page.

Some recommendations associated with management of river flow and fisheries could be implemented in the short-term, but in my opinion, **a Royal Commission is needed** to provide a basis of truth and facts that are required for significant long-term change and cooperation between the Commonwealth and State governments.

## Recommendations to restore a healthy ecosystem in the Barka-Darling

1. Implementation of a Royal Commission for the following reasons;
  - a. Long-term and continuing degradation of the Barka-Darling
  - b. The ecological disasters of massive fish kills in 2018 – 2020 and 2023
  - c. Repeated warnings from scientists, Fisheries Scientific Committee, Aborigines, pastoralists, other river people, authors and environmentalists
  - d. Over-allocation of irrigation licences and over-extraction of water
  - e. Failure of the Basin Plan to deliver any significant environmental improvements
  - f. Lack of cooperation between the Commonwealth and all States
  - g. Alleged corruption and fraud by some large-scale irrigators
  - h. Perceived problems with inter-basin transfer of water allocations and trading of water by individuals and companies not involved directly in agriculture
  - i. Responsibilities of the Commonwealth and States for management of the Basin
  - j. Questions about the legal status of the Plan under the *Water Act 2007*
2. Restoration and Management of Flow
  - a. Introduce an immediate moratorium on the issuing of new licences for water extraction
  - b. Introduce more stringent limits of water flow/water levels as trigger points for up-stream pumping
  - c. Commence a phase-out of large-scale irrigation in the Barka-Darling and its tributaries
3. Fisheries conservation and management actions
  - a. Undertake a conservation stocking program for Murray Cod and Silver Perch across the Barka-Darling, ensuring appropriate hatchery and genetic protocols are followed
  - b. Develop a commercial fishery for Carp based on the electro-fishing to enable the selective harvesting of Carp and release of native fish
  - c. Finalise evaluation of the Carp virus as a potential biological control for Carp
4. NSW Fisheries
  - a. Remove NSW Fisheries from NSW Department of Primary Industries to form a separate department to reduce intra-departmental conflict between Fisheries and Agriculture and to allow fisheries executives, scientists and managers to provide “frank and independent” advice directly to the Fisheries Minister and Government.

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7 July 2023

**Table 1. Chronology of key events, changes and environmental degradation of the Barka-Darling River since 1970**

<b>Period</b>	<b>Events, changes and environmental degradation</b>
1970	Fish fauna dominated by native species; no Carp <b>Murray Cod</b> apex predator and ICON of MDRS <b>Barka-Darling is the stronghold of native fish</b> Turbidity low; regular flows, pulses and flooding Flora dominated by macrophytes (Ribbonweed, Pondweed, Milfoil, Lillies) Abundant invertebrates
1974/1975	Large floods; population explosion of Carp
1978 – 1985	NSW Fisheries research: (i) development of hatchery and stocking techniques for native fish; (ii) stocking for conservation and stock enhancement; (iii) biology of Murray Cod; (iv) new species Eastern Freshwater Cod and Mary River Cod
1980s	<b>Increasing concerns about fish stocks and health of the Barka-Darling</b> Increasing periods of no/low flow; increasing algal blooms and fish kills; increasing distribution and abundance of Carp High turbidity now permanent
1991	<b>Algal bloom from Bourke to Wentworth – unprecedented</b> <b>Fisheries regulations to protect native species</b>
1990s	NSW Fisheries research <b>“Fish and Rivers in Stress the NSW Rivers Survey”</b> Key findings: (i) rivers in severe stress; (ii) low numbers of Murray Cod, Silver Perch and Freshwater Catfish; (iii) fish fauna dominated by Carp (>90% of biomass) Increasing periods of no/low flow; increasing algal blooms and fish kills
2003	<b>NSW Fisheries Scientific Committee (FSC)</b> declares the Lowland Catchment of the Darling River an <b>Endangered Ecological Community (EEC)</b> Key Threatening Processes included: reduction of river flow through water extraction; Carp; pollution through insecticides and fertilisers FSC warned <b>“the EEC is likely to become extinct in nature unless the circumstances and factors threatening its survival cease to operate.”</b>
2000s	Threat Abatement Plan by NSW Fisheries as required under threatened species legislation 10-fold increase of water extracted for irrigation <b>Numerous, localised fish kills involving Murray Cod</b>
2012	First record of the notifiable disease <b>Epizootic Ulcerative Syndrome</b> in Murray Cod, Golden Perch, Spangled Perch, Bony Herring (between Brewarrina and Bourke)
2018 – 2020	<b>Unprecedented ecological disaster!</b> Fish kills near Menindee; many millions native fish and Carp dead River dry between Bourke to Wentworth; large algal blooms; poor water quality – stressful and lethal levels of dissolved oxygen and probably ammonia, pH, hydrogen sulphide <b>ECOSYSTEM EXTINCT</b> – vastly altered structure, function and species composition (extirpated species, threatened species, decline of top predator), flora dominated by phytoplankton, altered hydrology
2023	<b>Ecological disaster; fish kills Bourke to Menindee; large floods</b>

**Table 2. Changes to the Barka-Darling aquatic ecosystem**

<b>Characteristic</b>	<b>Prior to the 1970s</b>	<b>2023</b>
Hydrology	Flow 92% of time Periodic freshes, floods and inundation of floodplains Regular pulses from various tributaries No-flow periods uncommon No/limited regulation of flow by dams Limited water extraction	Reduced flows Reduced frequency and extent of flooding  Pulses rare Long periods of low/no flow Flow controlled Water extracted for irrigation
Water Quality	Suspended solids low; turbidity typically low, often 1 – 3 metres visibility into water except during freshes and floods  Dissolved Oxygen; normal diurnal and seasonal variations	Suspended solids and turbidity constantly high  Hypoxic and anoxic conditions common
Fish	Native fish dominant  Fish kills uncommon, localised  Infectious diseases uncommon	Carp dominant (> 90% biomass)  Fish kills common since the 1980s Extensive fish kills 2018 – 2020 and in 2023  Diseases common; Anchor Worm common since mid-1970s EUS new disease (2012) #
Flora	Macrophytes very common and extensive; Ribbonweed, Milfoil, Pondweed, Lilies  Phytoplankton blooms very rare	Macrophytes rare, absent from most areas  Phytoplankton dominant; blooms common; blue-green algae common; significant adverse effects on water quality
Invertebrates	Numerous species, high abundance Zooplankton, insects Snails Mussels Shrimp, Yabbies	Significant declines of most species  Darling River Snail critically endangered Mussels now uncommon Millions dead shrimp in fish kills
Biodiversity	High	Low: extirpated populations; endangered and vulnerable species; decline of fish; change of flora; decline invertebrates

# EUS – Epizootic Ulcerative Syndrome; a fungal disease previously recorded only from coastal drainages in NSW and Queensland.